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ASTIN Bulletin

46(3), 2016

ALONSO GARCÍA, JENNIFER; DEVOLDER, PIERRE. *Guarantee valuation in notional defined contribution pension systems*. 677–707. The notional defined contribution pension scheme combines pay-as-you-go financing and a defined contribution pension formula. The return on contributions is based on an index set by law, such as the growth rate of GDP, average wages or contribution payments. The volatility of this return compromises the system's pension adequacy and therefore guarantees may be needed. Here, we provide a minimum return guarantee to the pension contributions. The price is calculated in a utility indifference framework. We obtain a closed-form solution for a general dependence structure with exponential preferences and in presence of stochastic short interest rates.

AVANZI, BENJAMIN; TU, VINCENT; WONG, BERNARD. *On the interface between optimal periodic and continuous dividend strategies in the presence of transaction costs*. 709–746. In the classical optimal dividends problem, dividend decisions are allowed to be made at any point in time – according to a continuous strategy. Depending on the surplus process that is considered and whether dividend payouts are bounded or not, optimal strategies are generally of a band, barrier or threshold type. In reality, while surpluses change continuously, dividends are generally paid on a periodic basis. Because of this, the actuarial literature has recently considered strategies where dividends are only allowed to be distributed at (random) discrete times – according to a periodic strategy. In this paper, we focus on the Brownian risk model. In this context, the optimal continuous and periodic strategies have previously been shown (independently of one another) to be of barrier type. For the first time, we consider a model where both strategies are used. In such a hybrid strategy, decisions are allowed to be made either at any time (continuously), or periodically at a lower cost. This proves optimal in some cases. We also determine under which combination of parameters a pure continuous, pure periodic or hybrid (including both continuous and periodic dividend payments) barrier strategy is optimal. Interestingly, the hybrid strategy lies in-between periodic and continuous strategies, which provides some interesting insights. Results are illustrated.

AVANZI, BENJAMIN; TU, VINCENT; WONG, BERNARD. *Robust stability, stabilisation and h-infinity control for premium-reserve models in a markovian regime switching discrete-time framework*. 747–778. The premium pricing process and the medium- and long-term stability of the reserve policy under conditions of uncertainty present very challenging issues in relation to the

insurance world. Over the last two decades, applications of Markovian regime switching models to finance and macroeconomics have received strong attention from researchers, and particularly market practitioners. However, relatively little research has so far been carried out in relation to insurance. This paper attempts to consider how a linear Markovian regime switching system in discrete-time could be applied to model the medium- and long-term reserves and the premiums (abbreviated here as the P-R process) for an insurer. Some recently developed techniques from linear robust control theory are applied to explore the stability, stabilisation and robust H8-control of a P-R system, and the potential effects of abrupt structural changes in the economic fundamentals, as well as the insurer's strategy over a finite time period. Sufficient linear matrix inequality conditions are derived for solving the proposed sub-problems. Finally, a numerical example is presented to illustrate the applicability of the theoretical results.

CAI, JUN; LEMIEUX, CHRISTIANE; LIU, FANGDA. *Optimal reinsurance from the perspectives of both an insurer and an reinsurer*. 815–849. Optimal reinsurance from an insurer's point of view or from a reinsurer's point of view has been studied extensively in the literature. However, as two parties of a reinsurance contract, an insurer and a reinsurer have conflicting interests. An optimal form of reinsurance from one party's point of view may be not acceptable to the other party. In this paper, we study optimal reinsurance designs from the perspectives of both an insurer and a reinsurer and take into account both an insurer's aims and a reinsurer's goals in reinsurance contract designs. We develop optimal reinsurance contracts that minimize the convex combination of the Value-at-Risk (VaR) risk measures of the insurer's loss and the reinsurer's loss under two types of constraints, respectively. The constraints describe the interests of both the insurer and the reinsurer. With the first type of constraints, the insurer and the reinsurer each have their limit on the VaR of their own loss. With the second type of constraints, the insurer has a limit on the VaR of his loss while the reinsurer has a target on his profit from selling a reinsurance contract. For both types of constraints, we derive the optimal reinsurance forms in a wide class of reinsurance policies and under the expected value reinsurance premium principle. These optimal reinsurance forms are more complicated than the optimal reinsurance contracts from the perspective of one party only. The proposed models can also be reduced to the problems of minimizing the VaR of one party's loss under the constraints on the interests of both the insurer and the reinsurer.

CHEN, AN; HIEBER, PETER. *Optimal asset allocation in life insurance: the impact of regulation*. 605–626. In a typical equity-linked life insurance contract, the insurance company is entitled to a share of return surpluses as compensation for the return guarantee granted to the policyholders. The set of possible contract terms might, however, be restricted by a regulatory default constraint – a fact that can force the two parties to initiate sub-optimal insurance contracts. We show that this effect can be mitigated if regulatory policy is more flexible. We suggest that the regulator implement a traffic light system where companies are forced to reduce the riskiness of their asset allocation in distress. In a utility-based framework, we show that the introduction of such a system can increase the benefits of the policyholder without deteriorating the benefits of the insurance company. At the same time, default probabilities (and thus solvency capital requirements) can be reduced.

CHRISTIANSEN, MARCUS C; SCHINZINGER, EDO. *A credibility approach for combining likelihoods of generalized linear models*. 507–530. Generalized linear models are a popular tool for the modelling of insurance claims data. Problems arise with the model fitting if little statistical information is available. In case that related statistics are available, statistical inference can be

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improved with the help of the borrowing-strength principle. We present a credibility approach that combines the maximum likelihood estimators of individual canonical generalized linear models in a meta-analytic way to an improved credibility estimator. We follow the concept of linear empirical Bayes estimation, which reduces the necessary parametric assumptions to a minimum. The concept is illustrated by a simulation study and an application example from mortality modelling.

GORDIENKO, EVGUENI; VÁZQUEZ-ORTEGA, PATRICIA. *Simple continuity inequalities for ruin probability in the classical risk model*. 801–814. A simple technique for continuity estimation for ruin probability in the compound Poisson risk model is proposed. The approach is based on the contractive properties of operators involved in the integral equations for the ruin probabilities. The corresponding continuity inequalities are expressed in terms of the Kantorovich and weighted Kantorovich distances between distribution functions of claims. Both general and light-tailed distributions are considered.

MACDONALD, BONNIE-JEANNE; OSBERG, LARS; MOORE, KEVIN D. *How accurately does 70% final employment earnings replacement measure retirement income (in)adequacy? Introducing the living standards replacement rate (LSRR)* 627–676. Will 70% of a worker's final annual employment earnings sustain living standards after retirement? Despite increasing skepticism, the most dominant measure of retirement income adequacy by financial planners, pensions plan advisors, academics and public policy makers is the "final employment earnings replacement rate", where 70% is considered the right target to ensure living standards remain at approximately the same level after retirement. Using Statistics Canada's LifePaths dynamic population micro-simulation model, this paper asks whether those individuals from the 1951–1958 Canadian birth cohort who attain roughly a 70% final employment earnings replacement rate (as conventionally measured) at retirement do, in fact, achieve approximate continuity in their living standards. We find that the conventional final earnings replacement rate measure has little predictive value for living standards continuity between working-life and retirement. The primary reason is that employment earnings in a single year is not a reliable representation of a worker's standard of living – it relies on an inadequate pre-retirement measurement period, does not incorporate important components of consumption sources (such as home equity), and ignores household size (particularly children). As a result, we find that the correlation between the conventional earnings replacement rate and actual living standards continuity is relatively low (0.11). The paper therefore suggests an alternative metric for assessing how well a worker's living standard is maintained after retirement – i.e., the Living Standards Replacement Rate, or the LSRR. The LSRR provides a more accurate, understandable and consistent measure of retirement income adequacy.

MILEVSKY, MOSHE ARYE; SALISBURY, THOMAS S. *Equitable retirement income tontines: mixing cohorts without discriminating*. 571–604. There is growing interest in the design of pension annuities that insure against idiosyncratic longevity risk while pooling and sharing systematic risk. This is partially motivated by the desire to reduce capital and reserve requirements while retaining the value of mortality credits; see for example, Piggott *et al.* (2005) or Donnelly *et al.* (2014). In this paper, we generalize the natural retirement income tontine introduced by Milevsky and Salisbury (2015) by combining heterogeneous cohorts into one pool. We engineer this scheme by allocating tontine shares at either a premium or a discount to par based on both the age of the investor and the amount they invest. For example, a 55-year old allocating $10,000 to the tontine might be told to pay $200 per share and receive 50 shares, while a 75-year old

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allocating $8,000 might pay $40 per share and receive 200 shares. They would all be mixed together into the same tontine pool and each tontine share would have equal income rights. The current paper addresses existence and uniqueness issues and discusses the conditions under which this scheme can be constructed equitably – which is distinct from fairly – even though it isn't optimal for any cohort. As such, this also gives us the opportunity to compare and contrast various pooling schemes that have been proposed in the literature and to differentiate between arrangements that are socially equitable, vs. actuarially fair vs. economically optimal.

YIN, CUIHONG; LIN, X SHELDON. *Efficient estimation of Erlang mixtures using ISCAD penalty with insurance application*. 779–799. The Erlang mixture model has been widely used in modeling insurance losses due to its desirable distributional properties. In this paper, we consider the problem of efficient estimation of the Erlang mixture model. We present a new thresholding penalty function and a corresponding EM algorithm to estimate model parameters and to determine the order of the mixture. Using simulation studies and a real data application, we demonstrate the efficiency of the EM algorithm.

Australian Journal of Actuarial Practice

4, 2016

BUTT, ADAM; FARMER, JIM; PITT, DAVID; SALMONA, MICHELLE. *A survey of actuarial graduates' views on their education*. 35–49. This paper presents the results of a survey of recent graduates of some Australian university actuarial programs. The survey aimed to shed light on graduates' views relating to their education since leaving university. The findings from our work can be used by those currently reviewing actuarial education programs in Australia. There is a strong view that the technical content of Part I courses is useful in the employment areas targeted by those courses, but there are concerns with the level of feedback provided to students. The Part II results indicated a much higher satisfaction with the content than the Part I courses in preparing students for employment. The Part III courses were not rated as highly as the Part I and II courses, and the teaching quality and feedback were particularly criticised, but they score well on relevance to employment. Well over 50% of graduates considered non-technical training as very important for their readiness for employment. While there is considerable support for provision of training in some non-technical skills, in most cases there is no clear majority opinion as to how this should be provided.

CHAI, CELESTE. *The tale of negative yields*. 51–56. In recent times, a new and topical trend has emerged: negative interest rates. Interest rate related securities, such as bonds, rely on central

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banks' deposit rates as a benchmark. When these deposit rates fall below positive, there is a corresponding drag on the yields of these assets. In this topsy-turvy world where investors are paid interest to take out a mortgage and businesses to take out a loan, how do negative interest rates affect different market participants? Do negative rates achieve their desired economic outcome, and can they be expected to linger? To answer these questions, this article presents a detailed background of negative rates. Next the article provides an assessment of the current economic situation relating to negative rates, focusing in particular on Europe and Japan. Finally, the potential impacts to Australia and life insurers are considered and suggestions are made to address these challenges.

SHI, XU; BROWNE, BRIDGET. *A "simple" stochastic model for longevity risk revisited through bootstrap*. 21–34. Life insurers subject to mortality risk often find it necessary, in addition to having a central projection of future mortality rates, to quantify the potential variation around that central estimate. Most existing methods to achieve this are dependent on the method used to generate the central estimate itself; however, sometimes the central estimates are derived from a deterministic mortality model or from an unknown stochastic model. In this case a variation measure is not directly available from the forecasting model. In this paper we will first modify a simple stochastic model that can be used to attach variation to any best estimate by taking a non-parametric approach. Second, based upon the modelling results, we present simulation of cash flows for a sample annuity product. Lastly, we compare this model with a recently published stochastic mortality forecast and current regulatory capital requirements in Australia. Our method results in very similar prediction intervals to the recent forecast for age-specific mortality rates. We further find that the current approach to determining regulatory capital requirements may not be meeting the intended objective.

SNEDDON, THOMAS; ZHU, ZILI; O'HARE, COLIN. *Modelling defined contribution retirement outcomes: a stochastic approach using Australia as a case study*. 5–19. In this paper we present a stochastic forecast model in a defined contribution pension system for projecting the accumulation and decumulation phases from an individual fund perspective. We use the Australian superannuation system as the context to demonstrate this "SUPA" (Simulation of Uncertainty for Pension Analysis) model. The SUPA model can be used to simulate the evolution of superannuation fund balances across time during the accumulation and decumulation phases. The model comprises four elements: (1) a stochastic projection of investment returns; (2) a stochastic projection of income levels (upon which contributions to the fund are based); (3) a projection of levels of withdrawal in retirement; and (4) a stochastic projection of increasing longevity (life table). The combination of these four elements within the SUPA model is described in detail in this paper. One application of the model is demonstrated through a case study involving recent Australian legislative amendments. In this example, we show how the model can be used to forecast likely outcomes (i.e. whether individuals will have sufficient funds in retirement), under the current superannuation structure and a previous structure. This will demonstrate how the SUPA model can be used to model the potential impact of any changes to a superannuation system.

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European Actuarial Journal

6(2), 2016

ALBRECHER, HANSJÖRG; EMBRECHTS, PAUL; FILIPOVIC, DAMIR. *Old-age provision: past, present, future*. 287–306. This is a summary of the main topics and findings from the Swiss Risk and Insurance Forum 2015. That event gathered experts from academia, insurance industry, regulatory bodies, and consulting companies to discuss the past and current developments and necessary next steps for dealing with old-age provision. Topics include the pension funding gap, demographic and societal challenges, the valuation of pension liabilities, economic and regulatory capital models, and the role of financial markets.

CERCHIARA, ROCCO ROBERTO; DEMARCO, VALENTINA. *Undertaking specific parameters under Solvency II: reduction of capital requirement or not?* 351–376. Solvency II regulation provides different approaches for the calculation of the solvency capital requirement (SCR): standard formula with simplification, standard formula, standard formula with undertaking specific parameters (USP), partial internal model and full internal model. In particular this regulation describes a subset of the Standard Formula market parameters (standard deviations) that may be replaced by USP, in order to calculate the SCR deriving from premium and reserving risks of a non-life insurance company. This paper aims to explain the data requirements, methodologies and results according the so-called standardized methods proposed in the Solvency II regulation for the USP. Applying the standardized methods to three companies respectively of small, medium and large sizes and developing some sensitivity analysis, regarding the change in data from year to year, peaks and other issues which standardized methods look sensitive, the paper shows when the USP could reduce the SCR in comparison with the Standard Formula approach.

CÔTÉ, MARIE-PIER; GENEST, CHRISTIAN; ABDALLAH, ANAS. *Rank-based methods for modeling dependence between loss triangles*. 377–408. In order to determine the risk capital for their aggregate portfolio, property and casualty insurance companies must fit a multivariate model to the loss triangle data relating to each of their lines of business. As an inadequate choice of dependence structure may have an undesirable effect on reserve estimation, a two-stage inference strategy is proposed in this paper to assist with model selection and validation. Generalized linear models are first fitted to the margins. Standardized residuals from these models are then linked through a copula selected and validated using rank-based methods. The approach is illustrated with data from six lines of business of a large Canadian insurance company for which two hierarchical dependence models are considered, i.e., a fully nested Archimedean copula structure and a copula-based risk aggregation model.

DICKSON, DAVID C M; QAZVINI, MARJAN. *Gerber-Shiu analysis of a risk model with capital injections*. 409–440. We consider the risk model with capital injections studied by Nie *et al.* (Annals of Actuarial Science (2011) 5:195–209; Scandinavian Actuarial Journal 2015: 301–318). We construct a Gerber-Shiu function and show that whilst this tool is not efficient for finding the ultimate ruin probability, it provides an effective way of studying ruin related quantities in finite time. In particular, we find a general expression for the joint distribution of the time of ruin and the number of claims until ruin, and find an extension of Prabhu's (Annals of Mathematical Statistics (1961) 32: 757–764) formula for the finite time survival probability in the classical risk model. We illustrate our results in the case of exponentially distributed claims and obtain some

interesting identities. In particular, we generalise results from the classical risk model and prove the identity of two known formulae for that model.

FARDILHA, TIAGO; DE LOURDES CENTENO, MARIA; ESTEVES, RUI. *Tariff systems for fleets of vehicles: a study on the portfolio of Fidelidade*. 331–349. In Portugal, insurance policies for fleets of vehicles are, in general, similar to policies for individual vehicles. Such is the case of the insurance company at hand. The experience rating system is practically the same as in individual motor insurance and is applied independently to each vehicle, thus having no effect on the premium paid by other vehicles in the fleet. This experience rating system is inefficient since it ignores the potential fleet-specific risks in the a posteriori tariff. We considered two credibility-based experience rating schemes proposed by Desjardins, Dionne and Pinquet in 2001 [Desjardins D, Dionne G, Pinquet J (2001) Experience rating schemes for fleets of vehicles, ASTIN Bulletin (2001) 31(1): 81–105]. One is based on the claims numbers at fleet level and the other is based on the claims numbers at vehicle level. We applied both models in order to calculate experience rating coefficients for the vehicles in the portfolio of fleets of the insurer. We propose different estimators for the structure parameters of the model, which in our opinion handle better the heterogeneity of the time exposures of our data set.

JENSEN, NINNA REITZEL. *Scenario-based life insurance prognoses in a multi-state Markov model*. 307–330. Traditional life insurance and pension prognoses from the policyholder's perspective do not illustrate financial riskiness or the effect of financial guarantees adequately. We address this issue by introducing stochastic scenarios. Our model applies to participating life insurance as well as unit-linked insurance, and it is formulated in a general multi-state Markov model. In addition to illustrating financial riskiness, our model allows for tailor-made best-estimate prognoses in any financial market. We illustrate the use of our model by conducting scenario analysis based on Monte Carlo simulation, but the model applies to scenarios in general and to worst-case and best-estimate scenarios in particular. Our paper offers moderate mathematical complexity and a common framework for the valuation of life insurance payments across product types, and it fills the existing gap in the literature with respect to prognoses from the policyholder's perspective.

LEMAIRE, JEAN; PARK, SOJUNG CAROL; WANG, KILI C. *Letter to the Editor: Further comments on the paper "Setting a bonus-malus scale in the presence of other rating factors" by Taylor [(1997)]* 495–499. Comments on the paper: Taylor G (1997) Setting a bonus-malus scale in the presence of other factors. ASTIN Bulletin (1997) 27: 319–327, following its development by Lemaire, Park and Wang (2015) [Lemaire, J., Park, S.C., Wang, Kili C. (2015). The impact of covariates on a bonus-malus system: an application of Taylor's model, European Actuarial Journal (2015) 5(1): 1–10.]

PELSSER, ANTOON A J; SCHWEIZER, JANINA. *The difference between LSMC and replicating portfolio in insurance liability modeling*. 441–494. Solvency II requires insurers to calculate the 1-year value at risk of their balance sheet. This involves the valuation of the balance sheet in 1 year's time. As for insurance liabilities, closed-form solutions to their value are generally not available, insurers turn to estimation procedures. While pure Monte Carlo simulation set-ups are theoretically sound, they are often infeasible in practice. Therefore, approximation methods are exploited. Among these, least squares Monte Carlo (LSMC) and portfolio replication are prominent and widely applied in practice. In this paper, we show that, while both are variants of regression-based Monte Carlo methods, they differ in one significant aspect. While the replicating

portfolio approach only contains an approximation error, which converges to zero in the limit, in LSMC a projection error is additionally present, which cannot be eliminated. It is revealed that the replicating portfolio technique enjoys numerous advantages and is therefore an attractive model choice.

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Geneva Papers on Risk and Insurance

41(3), 2016

BOTZEN, WILLEM JAN WOUTER; BOUWER, LAURENS M. *Weather indicators for insured hailstorm damage to motor vehicles and potential climate change impacts*. 512–527. Projections of the potential effects of climate change on damage caused by local extreme weather events are important for the design of appropriate policies for greenhouse gas emission reduction and insurers' adaptation responses to changing risks. This study estimates the relationships between daily insured damage from hailstorms to motor vehicles and several weather indicators, using statistical models with a high spatial resolution. We account for temporal dynamics and changes in exposure to hailstorms. The best-fitting model includes indicators of local daily maximum temperatures and regional spatially averaged precipitation. The projected increase in hailstorm damage of up to 33 per cent during the hail season as a result of anthropogenic climate change by the year 2050 is smaller than the increase found in previous studies.

CHEN, TSAI-JYH. *Corporate reputation and financial performance of life insurers*. 378–397, 528. This paper analyses empirically the relationship between corporate reputation and the financial performance of life insurers. First, it investigates the factors contributing to the corporate reputation of life insurers and finds that financial strength as well as underwriting service quality are crucial determinants. Second, this study shows that corporate reputation has a significantly positive impact on profitability because it helps to bring in new business and premiums for investment. Third, underwriting and investment constructs of insurance operations are linked to analyse the sources for profitability. Additionally, this paper finds that a sustained reputation may increase profitability over time, because reputation built previously can keep an insurer in a favourable position in future market competition. The empirical findings of this paper suggest that life insurers can improve their profitability through promoting corporate reputation, which highly relies on the service quality of underwriting.

LAAS, DANIELA; SCHMEISER, HATO; WAGNER, JOËL. *Empirical findings on motor insurance pricing in Germany, Austria and Switzerland*. 398–431. This paper focuses on recent developments in motor insurance pricing in Germany, Austria and Switzerland. Through the analysis of responses to a recent comprehensive survey of industry representatives, we examine the various premium components and the processes involved in premium adaptation. New findings on the use of different tariff criteria, on the tools used for market-based and customer-specific pricing, and on the information considered for customer valuation are reported. We also address the integration of the insurance sales staff in the pricing process. With regard to premium adjustments and the introduction of new tariffs, we examine the frequency, time required and costs incurred.

With this paper, we contribute to a strand of literature where little academic research has been done so far. In addition, our results entail managerial implications for improving industry practices in insurance pricing.

LEE, BONG-JOO; KIM, DAE-HWAN. *Moral hazard in insurance claiming from a Korean natural experiment*. 455–467. This paper presents evidence on moral hazard in auto insurance using a panel data set on all auto insurance companies in Korea. In January 2010, Korean financial regulatory authorities suddenly changed the automobile bonus-malus system such that the threshold of the premium surcharge for collision coverage was increased by 300 per cent, while insured parties' payments of loss remains unchanged. One year later, however, claimants were required to bear 20 per cent of the loss. This sudden and exogenous regulatory change provides an ideal environment to analyse moral hazard because of the natural setting of the experiment. The empirical results obtained through a fixed-effects model indicate that a rise in the threshold led to a rapid increase in the loss ratio, and the subsequent imposition of coinsurance requirements decreased the loss ratio even after controlling for the number of accidents and claims.

LUCIANO, ELISA; OUTREVILLE, JEAN-FRANÇOIS. *Life insurance ownership by Italian households: a gender-based differences analysis*. 468–490. The purpose of this study is to analyse, for men and women, the microeconomic determinants of life insurance purchases. Indeed, only a few papers have tried to justify rigorously the gender-based differences in life insurance ownership. On the basis of survey data collected by the Bank of Italy in 2012 (the Survey on Income and Households), we estimate the propensity to buy and the willingness to pay for a life insurance contract. We examine the differences between two types of contracts, that is, traditional life and term life insurance and show that, in all cases, women are less likely to be insured than are men. The demand for insurance is highly correlated with income, family structure and employment status. Geographical variables within Italy significantly affect the demand too. We introduce novel variables that measure the financial status of households and their proximity to the financial market or, similarly, their familiarity with financial market opportunities. These determinants turn out to be significant and affect demand almost as much as traditional variables. To study policy implications, we calculate the probabilities of having either traditional life or term insurance, under several scenarios for the determinants of demand. Again, financial market proximity plays a key role.

SCHOENMAKER, DIRK; SASS, JAN. *Cross-border insurance in Europe: challenges for supervision*. 351–377. At the start of Solvency II in January 2016, there is no overview of the insurance market in Europe. This paper develops a methodology to link various data sets on foreign branches and subsidiaries. The result is a new and comprehensive data set of cross-border insurance in Europe. We find that cross-border business in insurance is higher than in banking. We also find that the share of cross-border insurance has increased over the last decade, notwithstanding the global financial crisis. EIOPA, the European supervisory authority, plays a coordinating role among the national supervisors in the approval of internal models under Solvency II. Game theory suggests that there are limits to the coordination model. The increasing share of cross-border insurance, documented in this paper, may tilt the supervisory balance from coordination towards centralisation in an Insurance Union.

YAMASAKI, TAKASHI. *Do typhoons cause turbulence in property-liability insurers' stock prices?* 432–454. The aim of this paper is to clarify how natural disasters influence the stock prices of

property-liability insurance companies. Examining a series of typhoons that made landfall in Japan, this paper shows that the stock prices of property-liability insurers, on average, increase around typhoon landfalls. However, cross-sectional results indicate that specific insurer or typhoon characteristics can temper the increase. First, a property-liability insurer's stock price reacts more positively around typhoons of greater scale and more negatively around typhoons with longer intervals from the previous typhoon landfall, with longer times to landfall, or that cause more serious residential damage. Second, a property-liability insurer's stock price reacts according to its profitability or business structure. In addition, insurers with a larger capital buffer or of greater financial soundness are evaluated relatively higher around typhoon landfall since the deregulation of the insurance industry.

ZERRIAA, MOUNA; NOUBBIGH, HEDI. *Determinants of life insurance demand in the MENA region*. 491–511. This paper investigates the determinants of life insurance consumption in the Middle East and North Africa (MENA) region using a sample of 17 countries over the period 2000–2012. We use two measures of life insurance demand: insurance density and insurance penetration. The research results suggest that consumption increases with income, inflation and interest rates. The country's level of financial development also enhances life insurance sales, whereas social security expenditures dampen them. Moreover, life expectancy and educational attainment appear to stimulate life insurance demand, whereas young dependency tends to decrease consumption. Urbanisation does not appear to influence life insurance demand. We also find evidence that life insurance demand is lower in predominantly Islamic countries.

Geneva Papers on Risk and Insurance

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DOFF, RENÉ. *The final Solvency II framework: will it be effective?* 587–607. With Solvency II ready for implementation as per 2016, it is a good time to analyse the effectiveness of the framework. We build on earlier analyses of the preliminary framework dating from 2009. In the meantime many improvements have been implemented. We use 12 criteria to assess the effectiveness of Solvency II, and conclude that overall, Solvency II is effective. Not surprisingly, Solvency II is a major step ahead compared with the current supervisory framework. However, violations to some criteria remain. While some violations are because of simplifications, others are because of a lack of focus on particular risks (government bonds, inflation risk, liquidity risk). To resolve some of these violations, we propose specific prescribed and targeted stress tests through the own risk and solvency assessment and a more detailed focus on the effectiveness of governance structures.

ELING, MARTIN. *Costs and benefits of financial regulation: an empirical assessment for insurance companies*. 529–554. We analyse the costs and benefits of financial regulation based on a survey of 76 insurers from Austria, Germany and Switzerland. Our analysis includes both established and new empirical measures for regulatory costs and benefits. This is the first paper that tries to take costs and benefits combined into account using a latent class regression with covariates. Moreover, we analyse regulatory costs and benefits not only on an industry level, but also at the company level. This allows us to empirically test fundamental principles of financial regulation such as proportionality: the intensity of regulation should reflect the firm-specific amount and

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complexity of the risk taken. Our findings do not support the proportionality principle; for example, regulatory costs cannot be explained by differences in business complexity. One potential policy implication is that the proportionality principle needs to be more carefully applied to financial regulation.

MILLO, GIOVANNI. *The S-curve and reality*. 608–625. We challenge the common wisdom that the income elasticity of insurance is higher, ceteris paribus, in developing countries (the so-called S-curve hypothesis). Focusing on non-life insurance, we show that the available evidence is contradictory and heavily dependent on methodology. Based on a recent approach to consistent inference on the income elasticity of insurance, we show counterexamples to the theory. Although not supporting it in general, we argue that it could still be relevant for explaining the behaviour of particular lines of business.

MILLS, EVAN. *An insurance perspective on U.S. electric grid disruption costs*. 555–586. Large yet infrequent disruptions of electrical power can impact tens of millions of people in a single event, triggering significant economic damages, portions of which are insured. Small and frequent events are also significant in the aggregate. This article explores the role that insurance claims data can play in better defining the broader economic impacts of grid disruptions in the U.S. context. We developed four case studies, using previously unpublished data for specific actual grid disruptions. The cases include the 1977 New York City blackout, the 2003 Northeast blackout, multi-year national annual lightning-related electrical damage and multi-year national line-disturbance events. Insured losses represent between 3 and 64 per cent of total loss costs across the case studies. The household sector emerges as a larger locus of costs than indicated in previous studies, and short-lived events emerge as important sources of loss costs.

PARK, SOJUNG CAROL; LEMAIRE, JEAN. *The opaqueness of structured bonds: evidence from the U.S. insurance industry*. 650–676. It has been argued that the opaqueness of structured bonds, such as mortgage-backed securities, asset-backed securities and collateral debt obligations, was one of the major causes of the recent financial crisis that started in late 2007. We analyse the evolving nature of information asymmetry inherent in various types of structured bonds by examining the U.S. insurers' assets. We show that, prior to 2004, structured bonds were not associated with greater information asymmetry; however, holding more multi-class structured bonds, especially privately placed bonds, increased the information asymmetry when evaluating insurers' assets post-2004. The effect of information asymmetry was more significant with life insurers than with non-life insurers. In addition, by investigating the rating grades of such structured bonds, we find that the market views higher-grade, privately placed, multi-class structured bonds as having the highest information asymmetry among all types of structured bonds post 2004, an effect which is, again, more significant with life insurers. This result shows that structuring complexities and unreliable ratings make structured bonds more opaque than just securitisation itself.

STEIN, DANIEL; TOBACMAN, JEREMY. *Weather insurance savings accounts*. 677–700. Better insurance against rainfall risk could improve the security of hundreds of millions of agricultural households around the world. This paper theoretically and experimentally analyses an innovative financial product called a Weather Insurance Savings Account (WISA), which combines savings and rainfall insurance. We index the insurance share of the WISA by [0,1] and use a standard model of intertemporal insurance demand to study preferences over. We then use a laboratory experiment to elicit participants' valuations of pure insurance, pure savings, and intermediate

WISA types. Contrary to the standard model, within-subject comparisons show that many participants prefer both pure insurance and pure savings to any interior mixture of the two. Additional experimental and observational evidence distinguishes between several alternative explanations. One possibility that survives our additional tests is diminishing sensitivity to losses, as in prospect theory.

STRUPCZEWSKI, GRZEGORZ; THION, MICHAL. *Corporate insurance versus risk retention: an empirical analysis of medium and large companies in Poland*. 626–649. The aim of the article is to identify the determinants of what risk retention technique companies select in the context of property insurance demand. The analysis was based on the assumption that it is possible to seek motives for retention among the determinants of companies' demand for insurance. Empirical data collected from a survey of a representative sample of medium and large enterprises operating in Poland provided valuable feedback for the research. An econometric model was built to identify factors considered when a company is deciding to employ partial insurance or total non-insurance, and determinants of the selection of risk retention technique. It considers not only company financial figures, but also information on the current insurance programme it has in place and the satisfaction it expresses with regard to its insurance services.

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ALAI, DANIEL H; LANDSMAN, ZINOVIY M; SHERRIS, MICHAEL. *Modelling lifetime dependence for older ages using a multivariate Pareto distribution*. 272–285. The main driver of longevity risk is uncertainty in old-age mortality, especially surrounding potential dependence structures. We investigate a multivariate Pareto distribution that allows for the exploration of a variety of applications, from portfolios of standard annuities to joint-life annuity products for couples. Given the anticipated continued increase of supercentenarians, the heavy-tailed nature of the Pareto distribution is appropriate for this application. In past work, it has been shown that even a little dependence between lives can lead to much higher uncertainty. Therefore, the ability to assess and incorporate the appropriate dependence structure, whilst allowing for extreme observations, significantly improves the pricing and risk management of life-benefit products.

ALONSO GARCÍA, J; DEVOLDER, PIERRE. *Optimal mix between pay-as-you-go and funding for DC pension schemes in an overlapping generations model*. 224–236. Public pension systems are usually pay-as-you-go financed, that is, current contributions cover the pension expenditures. However, some countries combine funding and pay-as-you-go within the first pillar. This article studies a mixed system where a part of the individual's contribution accrues funded rights whereas the other part accrues pay-as-you-go rights. Diversification conditions between these two financing techniques are derived in a mean-variance framework for two distinct contexts: for a cohort entering the system (named ex-ante case) and for multiple cohorts coexisting at the same period of time (named ex-post case). The diversification benefits in presence of a liquidity constraint which ensures that the income from contributions is sufficient to cover the pension

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expenditures are also studied. We show that, on the one hand, diversification benefits individuals when the economy is dynamically efficient for the ex-ante case. On the other hand, diversification is unattractive when pay-as-ou-go and funding are positively correlated for the ex-post case.

ASAMOAH, KWADWO. *On the credibility of insurance claim frequency: Generalized count models and parametric estimators*. 339–353. We analyze the concept of credibility in claim frequency in two generalized count models – Mittag-Leffler and Weibull count models – which can handle both underdispersion and overdispersion in count data and nest the commonly used Poisson model as a special case. We find evidence, using data from a Danish insurance company, that the simple Poisson model can set the credibility weight to one even when there are only three years of individual experience data resulting from large heterogeneity among policyholders, and in doing so, it can thus break down the credibility model. The generalized count models, on the other hand, allow the weight to adjust according to the number of years of experience available. We propose parametric estimators for the structural parameters in the credibility formula using the mean and variance of the assumed distributions and a maximum likelihood estimation over a collective data. As an example, we show that the proposed parameters from Mittag-Leffler provide weights that are consistent with the idea of credibility. A simulation study is carried out investigating the stability of the maximum likelihood estimates from the Weibull count model. Finally, we extend the analyses to multidimensional lines and explain how our approach can be used in selecting profitable customers in cross-selling; customers can now be selected by estimating a function of their unknown risk profiles, which is the mean of the assumed distribution on their number of claims.

BARTELS, MARIANA; ZIEGELMANN, FLAVIO AUGUSTO. *Market risk forecasting for high dimensional portfolios via factor copulas with GAS dynamics*. 66–79. In this paper we propose forecasting market risk measures, such as Value at Risk (VaR) and Expected Shortfall (ES), for large dimensional portfolios via copula modeling. For that we compare several high dimensional copula models, from naive ones to complex factor copulas, which are able to simultaneously tackle the curse of dimensionality and introduce a high level of complexity into the model. We explore both static and dynamic copula fitting. In the dynamic case we allow different levels of flexibility for the dependence parameters which are driven by a GAS (Generalized Autoregressive Scores) model, in the spirit of Oh and Patton (2015) [D H Oh; A J Patton (2015), Modelling dependence in high dimensions with factor copulas, Journal of Business Economics and Statistics, forthcoming]. Our empirical results, for assets negotiated at Brazilian BOVESPA stock market from January, 2008 to December, 2014, suggest that, compared to the other copula models, the GAS dynamic factor copula approach has a superior performance in terms of AIC (Akaike Information Criterion) and a non-inferior performance with respect to VaR and ES forecasting.

BAYRAKTAR, ERHAN; YOUNG, VIRGINIA R. *Optimally investing to reach a bequest goal*. 1–10. We determine the optimal strategy for investing in a Black-Scholes market in order to maximize the probability that wealth at death meets a bequest goal b, a type of goal-seeking problem, as pioneered by Dubins and Savage (1965, 1976). The individual consumes at a constant rate c, so the level of wealth required for risklessly meeting consumption equals c/r, in which r is the rate of return of the riskless asset. Our problem is related to, but different from, the goal-reaching problems of Browne (1997). First, Browne (1997, Section 3.1) maximizes the probability that wealth reaches $b < c/r$ before it reaches $a < b$. Browne's game ends when wealth reaches b. By contrast, for the problem we consider, the game continues until the individual dies or until wealth reaches 0; reaching b and then falling below it before death does not count.

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Second, Browne (1997, Section 4.2) maximizes the expected discounted reward of reaching $b > c/r$ before wealth reaches c/r. If one interprets his discount rate as a hazard rate, then our two problems are mathematically equivalent for the special case for which $b > c/r$, with ruin level c/r. However, we obtain different results because we set the ruin level at 0, thereby allowing the game to continue when wealth falls below c/r.

BI, JUNNA; LIANG, ZHIBIN; XU, FANGJUN. *Optimal mean-variance investment and reinsurance problems for -the risk model with common shock dependence*. 245–258. In this paper, we study the optimal investment-reinsurance problems in a risk model with two dependent classes of insurance business, where the two claim number processes are correlated through a common shock component. Under the criterion of mean-variance, two cases are considered: One is the optimal mean-variance problem with bankruptcy prohibition, i.e., the wealth process of the insurer is not allowed to be below zero at any time, which is solved by standard martingale approach, and the closed form solutions are derived; The other is the optimal mean-variance problem without bankruptcy prohibition, which is discussed by a very different method – stochastic linear-quadratic control theory, and the explicit expressions of the optimal results are obtained either. In the end, a numerical example is given to illustrate the results and compare the values in the two cases.

BOONEN, TIM J; TAN, KEN SENG; ZHANG, SHENG CHAO. *The role of a representative reinsurer in optimal reinsurance*. 196–204. In this paper, we consider a one-period optimal reinsurance design model with nn reinsurers and an insurer. For very general preferences of the insurer and that all reinsurers use a distortion premium principle, we establish the existence of a representative reinsurer and this in turn facilitates solving the optimal reinsurance problem with multiple reinsurers. The insurer determines its optimal risk that it wants to reinsure via this pricing formula. The risk to be reinsured is then shared by the reinsurers via tranching. The optimal ceded loss functions among multiple reinsurers are derived explicitly under the additional assumptions that the insurer's preferences are given by an inverse-S shaped distortion risk measure and that the reinsurers' premium principles are some functions of the Conditional Value-at-Risk. We also demonstrate that under some prescribed conditions, it is never optimal for the insurer to cede its risk to more than two reinsurers.

BRAHIMI, BRAHIM; ABDELLI, JIHANE. *Estimating the distortion parameter of the proportional hazards premium for heavy-tailed losses under Lévy-stable regime*. 135–143. Estimating the distorted parameter in the case of non negative heavy-tailed losses has been treated in Brahimi *et al.* (2011) [B Brahimi; D Meraghni; A Necir; R Zitikis (2011), Estimating the distortion parameter of the proportional-hazard premium for heavy-tailed losses, Insurance: Mathematics and Economics 49: 325–334]. In this paper, we extend this work to the case of the real heavy-tailed losses. We derive an asymptotic distribution of the estimator. We construct a practically implemented confidence interval for the distortion parameter and illustrate the performance of the interval in a simulation study with application to real data.

CARR, PETER; MADAN, DILIP B; MELAMED, MICHAEL; SCHOUTENS, WIM. *Hedging insurance books*. 364–372. Complex insurance risks typically have multiple exposures. If available, options on multiple underliers with a short maturity can be employed to hedge this exposure. More precisely, the present value of aggregate payouts is hedged using least squares, ask price minimization, and ask price minimization constrained to long only option positions. The proposed hedges are illustrated for hypothetical Variable Annuity contracts invested in the

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nine sector ETF's of the US economy. We simulate the insurance accounts by simulating risk-neutrally the underliers by writing them as transformed correlated normals; the physical and risk-neutral evolution is taken in the variance gamma class as a simple example of a non-Gaussian limit law. The hedges arising from ask price minimization constrained to long only option positions delivers a least cost and most stable result.

COUSIN, ARESKI; JIAO, YING; ROBERT, CHRISTIAN Y; ZERBIB, OLIVIER DAVID. *Asset allocation strategies in the presence of liability constraints*. 327–338. The performance of portfolio managers is usually assessed by comparing their allocation strategies to a benchmark portfolio. A major issue for portfolio managers of liability driven institutions is that no benchmark is given to them, although they face mid-term objectives with short term constraints. No performance attribution methodology may then be used to serve as a reference. Assessing the performance of the asset manager as an agent, represents a major stake for the institution as a principal delegating a mandate of asset management. We propose an optimal asset allocation approach taking into account liability constraints to build a benchmark. This benchmark will be used to compare the ex-post effective performance of the asset manager to the effective performance of the ex-ante optimal dynamic asset allocation.

FLAM, SJUR DIDRIK. *Borch's theorem, equal margins, and efficient allocation*. 162–168. The economic concept of margin guides or justifies the sharing of risks and resources. Broadly, by Borch's theorem, competing claimants, ends or users ought see equal margins along any efficient allocation. However helpful this maxim, its application is often hampered, and occasionally misguided, by concerns with the differentiability of objectives – or with the interiority of solutions. Circumventing such concerns, this paper introduces a quite applicable, generalized notion, called essential margin. Presuming transferable or quasi-linear utility, the coincidence of such margins supports efficiency, competitive equilibria, and core solutions. The said coincidence also defines deductibles and prioritized claims, seen in finance and insurance.

GARRIDO, JOSÉ; GENEST, CHRISTIAN; SCHULZ, J. *Generalized linear models for dependent frequency and severity of insurance claims*. 205–215. Traditionally, claim counts and amounts are assumed to be independent in non-life insurance. This paper explores how this often unwarranted assumption can be relaxed in a simple way while incorporating rating factors into the model. The approach consists of fitting generalized linear models to the marginal frequency and the conditional severity components of the total claim cost; dependence between them is induced by treating the number of claims as a covariate in the model for the average claim size. In addition to being easy to implement, this modeling strategy has the advantage that when Poisson counts are assumed together with a log-link for the conditional severity model, the resulting pure premium is the product of a marginal mean frequency, a modified marginal mean severity, and an easily interpreted correction term that reflects the dependence. The approach is illustrated through simulations and applied to a Canadian automobile insurance dataset.

GÓMEZ DÉNIZ, EMILIO. *Bivariate credibility bonus-malus premiums distinguishing between two types of claims*. 117–124. We propose a modification of the bonus-malus system of tarification that is commonly applied in automobile insurance. Under the standard system, the premium assigned to each policyholder is based only on the number of claims made. Therefore, a policyholder who has had an accident producing a relatively small amount of loss is penalised to the same extent as one who has had a more costly accident. This outcome would seem to be unfair. Accordingly, we present a statistical model which distinguishes between two different types of

claims, incorporating a bivariate distribution based on the assumption of dependence. We also describe a bivariate prior distribution conjugated with respect to the likelihood. This approach produces credibility bonus-malus premiums that satisfy appropriate transition rules. A practical example of its application is presented and the results obtained are compared with those derived from the traditional Poisson-Gamma model in which only the number of claims is taken into account.

GOUDENÈGE, JANE; MOLENT, ANDREA; ZANETTE, ANTONINO. *Pricing and hedging GLWB in the Heston and in the Black-Scholes with stochastic interest rate models*. 38–57. Valuing Guaranteed Lifelong Withdrawal Benefit (GLWB) has attracted significant attention from both the academic field and real world financial markets. As remarked by Forsyth and Vetzal (2014) [P Forsyth, K Vetzal (2014), An optimal stochastic control framework for determining the cost of hedging of variable annuities, Journal of Economics and Dynamic Control 44: 29–53] the Black and Scholes framework seems to be inappropriate for such a long maturity products. They propose to use a regime switching model. Alternatively, we propose here to use a stochastic volatility model (Heston model) and a Black-Scholes model with stochastic interest rate (Hull-White model). For this purpose we present four numerical methods for pricing GLWB variables annuities: a hybrid tree-finite difference method and a Hybrid Monte Carlo method, an ADI finite difference scheme, and a Standard Monte Carlo method. These methods are used to determine the no-arbitrage fee for the most popular versions of the GLWB contract, and to calculate the Greeks used in hedging. Both constant withdrawal and optimal withdrawal (including lapsation) strategies are considered. Numerical results are presented which demonstrate the sensitivity of the no-arbitrage fee to economic, contractual and longevity assumptions.

GUAN, GUOHUI; LIANG, ZONGXIA. *A stochastic Nash equilibrium portfolio game between two DC pension funds*. 237–244. In this paper, we study the stochastic Nash equilibrium portfolio game between two pension funds under inflation risks. The financial market consists of cash, bond and two stocks. It is assumed that the price index is derived through a generalized Fisher equation while the bond is related to the price index to hedge the risk of inflation. Besides, these two pension managers can invest in their familiar stocks. The goal of the pension managers is to maximize the utility of the weighted terminal wealth and relative wealth. Dynamic programming method is employed to derive the Nash equilibrium strategies. In the end, a numerical analysis is presented to reveal the economic behaviors of the two DC pension funds.

GUO, DONGMEI; HU, YI; WANG, SHOUYANG; ZHAO, LIN. *Comparing risks with reference points: a stochastic dominance approach*. 105–116. This paper develops a stochastic dominance rule for the reference-dependent utility theory proposed by Koszegi and Rabin (2007) [B Koszegi; M Rabin (2006), A model of reference-dependent preference, Quarterly Journal of Economics 121: 1133–1165]. The new ordering captures the effects of loss aversion and can be used as a semi-parametric approach in the comparison of risks with reference points. It is analytically amenable and possesses a variety of intuitively appealing properties, including the abilities to identify both "increase in risk" and "increase in downside risk", to resolve the Allais-type anomalies, to capture the violation of translational invariance and scaling invariance, and to accommodate the endowment effect for risk. The generalization to third-order dominance reveals that loss aversion can either reinforce or weaken prudence, depending on the location of the reference point. Potential applications of the new ordering in financial contexts are briefly discussed.

GUO, XU; LI, JINGYUAN; LIU, DONGRI; WANG, JIANLI. *Preserving the Rothschild-Stiglitz type of increasing risk with background risk*. 144–149. Background risk refers to a risk that is

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exogenous and is not subject to transformations by a decision-maker. In this paper, we extend the definition of the Rothschild-Stiglitz type of increasing risk to a background risk framework. We theoretically investigate a more general definition of increase in risk in the presence of background risk. The results suggest that an extended concept of expectation dependence plays a vital role.

HE, JUNNAN; TANG, QIHE; ZHANG, HUAN. *Risk reducers in convex order*. 80–88. Given a risk position X, a random addition Z is called a risk reducer for X if the new position $X+Z$ is less risky than $X+E[Z]$ in convex order. We utilize the concept of convex hull to give a structural description of risk reducers in the case of an atomless probability space. Then we study risk reducers that are fully dependent on X. Applications to multivariate stochastic ordering, index-linked hedging strategies, and optimal reinsurance are proposed.

HEJAZI, SEYED AMIR; JACKSON, KENNETH R. *A neural network approach to efficient valuation of large portfolios of variable annuities*. 169–181. Managing and hedging the risks associated with Variable Annuity (VA) products require intraday valuation of key risk metrics for these products. The complex structure of VA products and computational complexity of their accurate evaluation have compelled insurance companies to adopt Monte Carlo (MC) simulations to value their large portfolios of VA products. Because the MC simulations are computationally demanding, especially for intraday valuations, insurance companies need more efficient valuation techniques. Recently, a framework based on traditional spatial interpolation techniques has been proposed that can significantly decrease the computational complexity of MC simulation (Gan and Lin, 2015) [G Gan; X.S. Lin (2015), Valuation of large variable annuity portfolios under nested simulation: a functional data approach, Insurance: Mathematics and Economics 62: 138–150]. However, traditional interpolation techniques require the definition of a distance function that can significantly impact their accuracy. Moreover, none of the traditional spatial interpolation techniques provide all of the key properties of accuracy, efficiency, and granularity (Hejazi *et al.*, 2015) [S A Hejazi; K R Jackson; G Gan (2015), A spatial interpolation framework for efficient valuation of large portfolios of variable annuities]. In this paper, we present a neural network approach for the spatial interpolation framework that affords an efficient way to find an effective distance function. The proposed approach is accurate, efficient, and provides an accurate granular view of the input portfolio. Our numerical experiments illustrate the superiority of the performance of the proposed neural network approach compared to the traditional spatial interpolation schemes.

IGNATIEVA, KATJA; SONG, ANDREW; ZIVEYI, JONATHAN. *Pricing and hedging of guaranteed minimum benefits under regime-switching and stochastic mortality*. 286–300. This paper presents a novel framework for pricing and hedging of the Guaranteed Minimum Benefits (GMBs) embedded in variable annuity (VA) contracts whose underlying mutual fund dynamics evolve under the influence of the regime-switching model. Semi-closed form solutions for prices and Greeks (i.e. sensitivities of prices with respect to model parameters) of various GMBs under stochastic mortality are derived. Pricing and hedging is performed using an accurate, fast and efficient Fourier Space Time-stepping (FST) algorithm. The mortality component of the model is calibrated to the Australian male population. Sensitivity analysis is performed with respect to various parameters including guarantee levels, time to maturity, interest rates and volatilities. The hedge effectiveness is assessed by comparing profit-and-loss distributions for an unhedged, statically and semi-statically hedged portfolios. The results provide a comprehensive analysis on pricing and hedging the longevity risk, interest rate risk and equity risk for the GMBs embedded in VAs, and highlight the benefits to insurance providers who offer those products.

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KNISPEL, THOMAS; LAEVEN, ROGER J A; SVINDLAND, GREGOR. *Robust optimal risk sharing and risk premia in expanding pools*. 182–195. We consider the problem of optimal risk sharing in a pool of cooperative agents. We analyze the asymptotic behavior of the certainty equivalents and risk premia associated with the Pareto optimal risk sharing contract as the pool expands. We first study this problem under expected utility preferences with an objectively or subjectively given probabilistic model. Next, we develop a robust approach by explicitly taking uncertainty about the probabilistic model (ambiguity) into account. The resulting robust certainty equivalents and risk premia compound risk and ambiguity aversion. We provide explicit results on their limits and rates of convergence, induced by Pareto optimal risk sharing in expanding pools.

LANDSMAN, ZINOVIY M; MAKOV, UDI E; SHUSHI, TOMER. *Multivariate tail conditional expectation for elliptical distributions*. 216–223. In this paper we introduce a novel type of a multivariate tail conditional expectation (MTCE) risk measure and explore its properties. We derive an explicit closed-form expression for this risk measure for the elliptical family of distributions taking into account its variance-covariance dependency structure. As a special case we consider the normal, Student-t and Laplace distributions, important and popular in actuarial science and finance. The motivation behind taking the multivariate TCE for the elliptical family comes from the fact that unlike the traditional tail conditional expectation, the MTCE measure takes into account the covariation between dependent risks, which is the case when we are dealing with real data of losses. We illustrate our results using numerical examples in the case of normal and Student-t distributions.

LENG, XUAN; PENG, LIANG. *Inference pitfalls in Lee-Carter model for forecasting mortality*. 58–65. Forecasting mortality is of importance in managing longevity risks for insurance companies and pension funds. Some widely employed models are the so-called Lee-Carter model and its extensions, which involve a two-step estimation procedure. Empirical findings from using the Lee-Carter model and its extensions prefer an ARIMA (p, 1, q) model for modeling the dynamics of the logarithms of mortality rates, which is called mortality index and is a key element in forecasting mortality rates and managing longevity risks. In this paper we prove that the proposed two-step estimation procedure in Lee and Carter (1992) cannot detect the true dynamics of the mortality index in general, which means that future mortality projections based on the two step inference procedure for Lee-Carter model and its extensions are questionable.

LI, CHEN; LI, XIAOHU. *Sufficient conditions for ordering aggregate heterogeneous random claim amounts*. 406–413. This note has a revisit to stochastic comparison on aggregate claim amounts. We develop sufficient conditions for the usual stochastic order on aggregate claim amounts of independent claim sizes and with a common occurrence frequency vector. Besides, we obtain the usual stochastic order on aggregate claim amounts with a common WSAI claim size vector, and this also improves Theorem 4.6 of Zhang and Zhao (2015) [Y Zhang; P Zhao (2015), Comparisons on aggregate risks from two sets of heterogeneous portfolios, Insurance: Mathematics and Economics 65: 124–135]

LIANG, XIAOQING; TSAI, CARY CHI-LIANG. *Valuing guaranteed equity-linked contracts under piecewise constant forces of mortality*. 150–161. The work of this paper is motivated by the study in Gerber *et al.* (2012) [H U Gerber; E S W Shiu; H Yang (2012), Valuing equity-linked death benefits and other contingent options: a discounted density approach, Insurance: Mathematics and Economics 51: 73–92] and some following papers, in which equity-linked death benefits

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embedded in various variable annuity products are valuated for any time-until-death random variables whose density function can be approximated by a linear combination of densities of exponential random variables. Their analysis is made for the case where the time-until-death is exponentially distributed, i.e., under the assumption of a constant force of mortality. The main purpose of our study is to show that the discounted density approach can also be used to obtain similar explicit results on life-contingent options under the assumption of piecewise constant forces of mortality. Moreover, we study a term insurance product with the payoff at the time of death being equity-linked and inflation-indexed, and investigate two types of annuity-immediate products whose annual payments are equity-indexed with a minimum guaranteed amount. We also illustrate approximations and numerical calculations for some results obtained in this paper, and analyze parameter sensitivities.

LIU, YANXIN; LI, JOHNNY SIU-HANG. *It's all in the hidden states: a longevity hedging strategy with an explicit measure of population basis risk*. 301–319. In this paper, we propose the generalized state-space hedging method for use when the populations associated with the hedging instruments and the liability being hedged are different. In this method, the hedging strategy is derived by first reformulating the assumed multi-population stochastic mortality model in a state-space representation, and then considering the sensitivities of the hedge portfolio and the liability being hedged to all relevant hidden states. Inter alia, this method allows us to decompose the underlying longevity risk into components arising solely from the hidden states that are shared by all populations and components stemming exclusively from the hidden states that are population-specific. The latter components collectively represent an explicit measure of the population basis risk involved. Through this measure, we can infer that a portion of population basis risk depends on how the longevity hedge is constructed while another portion exists no matter what the notional amounts of the hedging instruments are. We present the proposed hedging method in both static and dynamic settings.

MILJKOVIC, TATJANA; GRÜN, BETTINA. *Modeling loss data using mixtures of distributions*. 387–396. In this paper, we propose an alternative approach for flexible modeling of heavy tailed, skewed insurance loss data exhibiting multimodality, such as the well-known data set on Danish Fire losses. Our approach is based on finite mixture models of univariate distributions where all K components of the mixture are assumed to be from the same parametric family. Six models are developed with components from parametric, non-Gaussian families of distributions previously used in actuarial modeling: Burr, Gamma, Inverse Burr, Inverse Gaussian, Log-normal, and Weibull. Some of these component distributions are already alone suitable to model data with heavy tails, but do not cover the case of multimodality. Estimation of the models with a fixed number of components K is proposed based on the EM algorithm using three different initialization strategies: distance-based, k-means, and random initialization. Model selection is possible using information criteria, and the fitted models can be used to estimate risk measures for the data, such as VaR and TVaR. The results of the mixture models are compared to the composite Weibull models considered in recent literature as the best models for modeling Danish Fire insurance losses. The results of this paper provide new valuable tools in the area of insurance loss modeling and risk evaluation.

PIRJOL, DAN; ZHU, LINGJIONG. *Discrete sums of geometric Brownian motions, annuities and Asian options*. 19–37. The discrete sum of geometric Brownian motions plays an important role in modeling stochastic annuities in insurance. It also plays a pivotal role in the pricing of Asian options in mathematical finance. In this paper, we study the probability distributions of the

infinite sum of geometric Brownian motions, the sum of geometric Brownian motions with geometric stopping time, and the finite sum of the geometric Brownian motions. These results are extended to the discrete sum of the exponential Lévy process. We derive tail asymptotics and compute numerically the asymptotic distribution function. We compare the results against the known results for the continuous time integral of the geometric Brownian motion up to an exponentially distributed time. The results are illustrated with numerical examples for life annuities with discrete payments, and Asian options.

PITSELIS, GEORGIOS. *Credible risk measures with applications in actuarial sciences and finance*. 373–386. In this paper, we introduce a general framework for obtaining a new type of risk measures, the so called credible risk measures, as a result of incorporating credibility methodology with some well known risk measures, such as the value at risk (VaR) and the conditional tail expectation (CTE). The resulting credible risk measures are more informative than the usual risk measures (i.e. VaR, CTE) in capturing the risk of individual insurer's contract (or returns of an individual asset) as well as the portfolio risk consisting of several similar but not identical contracts (or returns of a portfolio of similar assets), which are grouped together to share the risk. These credible risk measures are: the credible value at risk, the credible conditional tail expectation, the credible tail conditional median and the credible quantile tail expectation. Two examples of credible risks measures are presented, one with insurance loss data and the other with industry financial data. The advantages and disadvantages of these new credible measures are also discussed.

SORDO, MIGUEL A; CASTAÑO-MARTÍNEZ, ANTONIA; PIGUEIRAS, GEMA. *A family of premium principles based on mixtures of TVaRs*. 397–405. Risk-adjusted distributions are commonly used in actuarial science to define premium principles. In this paper, we claim that an appropriate risk-adjusted distribution, besides satisfying other desirable properties, should be well-behaved under conditioning with respect to the original risk distribution. Based on a sequence of such risk-adjusted distributions, we introduce a family of premium principles that gradually incorporate the degree of risk-aversion of the insurer in the risk loading. Members of this family are particular distortion premium principles that can be represented as mixtures of TVaRs, where the weights in the mixture reflect the attitude toward risk of the insurer. We make a systematic study of this family of premium principles.

WOO, JAE-KYUNG. *On multivariate discounted compound renewal sums with time-dependent claims in the presence of reporting/payment delays*. 354–363. In this paper, we consider an insurance portfolio containing several types of policies which may simultaneously face claims arising from the same catastrophe. A renewal counting process for the number of events causing claims and multivariate claim severities which are dependent on the occurrence time and/or the delay in reporting or payment are assumed. A unified model is proposed to study the time-dependent loss quantities such as the discounted aggregate reported/unreported claims and the number of the incurred but not reported (IBNR) claims. We then derive the joint moments of (i) different types of discounted aggregate claims until time tt; and (ii) different types of discounted aggregate reported/unreported claims (including the total numbers of IBNR as special case) until time tt. Finally, some numerical examples involving covariances and correlations of the aforementioned quantities are provided.

YOUNG, VIRGINIA R; ZHANG, YUCHONG. *Lifetime ruin under ambiguous hazard rate*. 125–134. We determine the optimal robust investment strategy of an individual who targets a

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given rate of consumption and who seeks to minimize the probability of lifetime ruin when her hazard rate of mortality is ambiguous. By using stochastic control, we characterize the value function as the unique classical solution of an associated Hamilton-Jacobi-Bellman equation, obtain feedback forms for the optimal strategies for investing in the risky asset and distorting the hazard rate, and determine their dependence on various model parameters. We also include numerical examples to illustrate our results, as well as perturbation analysis for small values of the parameter that measures one's level of ambiguity aversion.

ZHANG, MING-HENG; CHEN, PING. *Mean-variance asset-liability management under constant elasticity of variance process*. 11–18. This paper investigates a mean-variance asset-liability management (ALM) problem under the constant elasticity of variance (CEV) process. The company can invest in n + 1 assets: one risk-free bond and nn risky stocks. The uncontrollable liability process is modelled by a geometric Brownian motion. The feasibility is studied and potential optimal portfolio is proven to be admissible. We derive the efficient frontier and efficient feedback portfolio in terms of the solutions of two backward stochastic differential equations (BSDEs), which do not admit analytical solutions in general. The closed form solutions are obtained under some special cases. Applying the Monte Carlo simulation, we provide several numerical examples to demonstrate how the efficient frontier is influenced by the relevant parameters.

ZHANG, ZHENZHONG; TONG, JINYING; HU, LIANGJIAN. *Long-term behavior of stochastic interest rate models with Markov switching*. 320–326. In this paper, we consider the long time behavior of Cox–Ingersoll–Ross (CIR) interest rate model with Markov switching. Using the ergodic theory of switching diffusions, we show that CIR model with Markov switching has a unique stationary distribution. Furthermore, we prove that the sequence $\overline{X}_t := \frac{1}{t}\int_0^t X_s ds$ converges almost surely. As a by-product, we find that the marginal stationary distribution for CIR model with Markov switching can be determined uniquely by its moments.

ZHAO, QIAN; WANG, RONGMING; WEI, JIAQIN. *Exponential utility maximization for an insurer with time-inconsistent preferences*. 89–104. This paper studies the optimal consumption-investment-reinsurance problem for an insurer with a general discount function and exponential utility function in a non-Markovian model. The appreciation rate and volatility of the stock, the premium rate and volatility of the risk process of the insurer are assumed to be adapted stochastic processes, while the interest rate is assumed to be deterministic. The object is to maximize the utility of intertemporal consumption and terminal wealth. By the method of multi-person differential game, we show that the time-consistent equilibrium strategy and the corresponding equilibrium value function can be characterized by the unique solutions of a BSDE and an integral equation. Under appropriate conditions, we show that this integral equation admits a unique solution. Furthermore, we compare the time-consistent equilibrium strategies with the optimal strategy for exponential discount function, and with the strategies for naive insurers in two special cases.

ZHU, JINXIA; YANG, HAILIANG. *Optimal capital injection and dividend distribution for growth restricted diffusion models with bankruptcy*. 259–271. We consider the optimal capital injection and dividend control problem for a class of growth restricted diffusions with the possibility of bankruptcy. The surplus process of a company is modeled by a diffusion process with return and volatility being functions of the surplus process. The company can control the dividend payments and capital injections with the goal of maximizing the expectation of the total discounted dividends minus the total cost of capital injections up to the time of bankruptcy. We distinguish three cases and provide optimality results for each case.

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ASIMIT, ALEXANDRU V; LI, JINZHU. *Extremes for coherent risk measures*. 332–341. Various concepts appeared in the existing literature to evaluate the risk exposure of a financial or insurance firm/subsidiary/line of business due to the occurrence of some extreme scenarios. Many of those concepts, such as Marginal Expected Shortfall or Tail Conditional Expectation, are simply some conditional expectations that evaluate the risk in adverse scenarios and are useful for signaling to a decision-maker the poor performance of its risk portfolio or to identify which sub-portfolio is likely to exhibit a massive downside risk. We investigate the latter risk under the assumption that it is measured via a coherent risk measure, which obviously generalizes the idea of only taking the expectation of the downside risk. Multiple examples are given and our numerical illustrations show how the asymptotic approximations can be used in the capital allocation exercise. We have concluded that the expectation of the downside risk does not fairly take into account the individual risk contribution when allocating the VaR-based regulatory capital, and thus, more conservative risk measurements are recommended. Finally, we have found that more conservative risk measurements do not improve the fairness of the cost of capital allocation when the uncertainty with parameter estimation is present, even at a very high level.

AVANZI, BENJAMIN; WONG, BERNARD; YANG, XINDA. *A micro-level claim count model with overdispersion and reporting delays*. 1–14. The accurate estimation of outstanding liabilities of an insurance company is an essential task. This is to meet regulatory requirements, but also to achieve efficient internal capital management. Over the recent years, there has been increasing interest in the utilisation of insurance data at a more granular level, and to model claims using stochastic processes. So far, this so-called 'micro-level reserving' approach has mainly focused on the Poisson process. In this paper, we propose and apply a Cox process approach to model the arrival process and reporting pattern of insurance claims. This allows for over-dispersion and serial dependency in claim counts, which are typical features in real data. We explicitly consider risk exposure and reporting delays, and show how to use our model to predict the numbers of Incurred-But-Not-Reported (IBNR) claims. The model is calibrated and illustrated using real data from the AUSI data set.

AVANZI, BENJAMIN; TAYLOR, GREG C; VU, PHUONG ANH; WONG, BERNARD. *Stochastic loss reserving with dependence: a flexible multivariate Tweedie approach*. 63–78. Stochastic loss reserving with dependence has received increased attention in the last decade. A number of parametric multivariate approaches have been developed to capture dependence between lines of business within an insurer's portfolio. Motivated by the richness of the Tweedie family of distributions, we propose a multivariate Tweedie approach to capture cell-wise dependence in loss reserving. This approach provides a transparent introduction of dependence through a common shock structure. In addition, it also has a number of ideal properties, including marginal flexibility, transparency, and tractability including moments that can be obtained in closed form. Theoretical results are illustrated using both simulated data sets and a real data set from a property-casualty insurer in the US.

AVRAM, FLORIN; BADESCU, ALEXANDRU M; PISTORIUS, MARTIJN; RABEHASAINA, LANDY. *On a class of dependent Sparre Andersen risk models and a bailout application*. 27–39. In this paper a one-dimensional surplus process is considered with a certain Sparre Andersen type

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dependence structure under general interclaim times distribution and correlated phase-type claim sizes. The Laplace transform of the time to ruin under such a model is obtained as the solution of a fixed-point problem, under both the zero-delayed and the delayed cases. An efficient algorithm for solving the fixed-point problem is derived together with bounds that illustrate the quality of the approximation. A two-dimensional risk model is analyzed under a bailout type strategy with both fixed and variable costs and a dependence structure of the proposed type. Numerical examples and ideas for future research are presented at the end of the paper.

BARSOTTI, FLAVIA; MIHAUD, XAVIER; SALHI, YAHIA. *Lapse risk in life insurance: correlation and contagion effects among policyholders' behaviors*. 317–331. The present paper proposes a new methodology to model the lapse risk in life insurance by integrating the dynamic aspects of policyholders' behaviors and the dependency of the lapse intensity on macroeconomic conditions. Our approach, suitable to stable economic regimes as well as stress scenarios, introduces a mathematical framework where the lapse intensity follows a dynamic contagion process, see Dassios and Zhao (2011). This allows to capture both contagion and correlation potentially arising among insureds' behaviors. In this framework, an external market driven jump component drives the lapse intensity process depending on the interest rate trajectory: when the spread between the market interest rates and the contractual crediting rate crosses a given threshold, the insurer is likely to experience more surrenders. A log-normal dynamic for the forward rates is introduced to build trajectories of an observable market variable and mimic the effect of a macroeconomic triggering event based on interest rates on the lapse intensity. Contrary to previous works, our shot-noise intensity is not constant and the resulting intensity process is not Markovian. Closed-form expressions and analytic sensitivities for the moments of the lapse intensity are provided, showing how lapses can be affected by massive copycat behaviors. Further analyses are then conducted to illustrate how the mean risk varies depending on the model's parameters, while a simulation study compares our results with those obtained using standard practices. The numerical outputs highlight a potential misestimation of the expected number of lapses under extreme scenarios when using classical stress testing methodologies.

BAYERSTADLER, ANDREAS; VAN DIJK, LINDA; WINTER, FABIAN. *Bayesian multinomial latent variable modeling for fraud and abuse detection in health insurance*. 244–252. Healthcare fraud and abuse are a serious challenge to healthcare payers and to the entire society. This article presents a predictive model for fraud and abuse detection in health insurance based on a training dataset of manually reviewed claims. The goal of the analysis is to predict different fraud and abuse probabilities for new invoices. The prediction is based on a wide framework of fraud and abuse reports which examine the behavior of medical providers and insured members by measuring systematic deviation from usual patterns in medical claims data. We show that models which directly use the results of the reports as model covariates do not exploit the full potential in terms of predictive quality. Instead, we propose a multinomial Bayesian latent variable model which summarizes behavioral patterns in latent variables, and predicts different fraud and abuse probabilities. The estimation of model parameters is based on a Markov Chain Monte Carlo (MCMC) algorithm using Bayesian shrinkage techniques. The presented approach improves the identification of fraudulent and abusive claims compared to different benchmark approaches.

BIAGINI, FRANCESCA; ZHANG, YINGLIN. *Polynomial diffusion models for life insurance liabilities*. 114–129. In this paper we study the pricing and hedging problem of a portfolio of life insurance products under the benchmark approach, where the reference market is modelled as driven by a state variable following a polynomial diffusion on a compact state space. Such a

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model can be used to guarantee not only the positivity of the OIS short rate and the mortality intensity, but also the possibility of approximating both pricing formula and hedging strategy of a large class of life insurance products by explicit formulas.

CHEN, LV; QIAN, LINYI; SHEN, YANG; WANG, WEI. *Constrained investment-reinsurance optimization with regime switching under variance premium principle*. 253–267. This paper studies optimal investment and reinsurance problems for an insurer under regime-switching models. Two types of risk models are considered, the first being a Markov-modulated diffusion approximation risk model and the second being a Markov-modulated classical risk model. The insurer can invest in a risk-free bond and a risky asset, where the underlying models for investment assets are modulated by a continuous-time, finite-state, observable Markov chain. The insurer can also purchase proportional reinsurance to reduce the exposure to insurance risk. The variance principle is adopted to calculate the reinsurance premium, and Markov-modulated constraints on both investment and reinsurance strategies are considered. Explicit expressions for the optimal strategies and value functions are derived by solving the corresponding regime-switching Hamilton-Jacobi-Bellman equations. Numerical examples for optimal solutions in the Markov-modulated diffusion approximation model are provided to illustrate our results.

DE JONG, PIET; TICKLE, LEONIE; XU, JIANHUI. *Coherent modeling of male and female mortality using Lee-Carter in a complex number framework*. 130–137. Forecasts of female and male mortality that are conducted independently run the risk of projecting implausible sex differentials and fail to exploit correlations that are known to exist between the sexes. We present a new model for the simultaneous modeling of female and male mortality. The model casts mortality as a complex-valued process where the real and imaginary parts correspond to female and male mortalities, respectively. Calculations proceed similarly to the usual Lee-Carter model, via the singular value decomposition, albeit in complex form. Initial applications suggest that the complex Lee-Carter gives fits that are broadly comparable to independent real fits, while offering the advantage of explicit modeling of the relationship between the sexes. Furthermore, model parameters are informative and easily-interpretable.

DEELSTRA, GRISELDA; GRASSELLI, MARTINO; VAN WEVERBERG, CHRISTOPHER. *The role of the dependence between mortality and interest rates when pricing Guaranteed Annuity Options*. 205–219. In this paper we investigate the consequences on the pricing of insurance contingent claims when we relax the typical independence assumption made in the actuarial literature between mortality risk and interest rate risk. Starting from the Gaussian approach of Liu *et al.* (2014) [X. Liu, R. Mamon, H. Gao (2014), A generalized pricing framework addressing correlated mortality and interest risks: a change of probability measure approach, Stochastics 86(4): 594–608], we consider some multifactor models for the mortality and interest rates based on more general affine models which remain positive and we derive pricing formulas for insurance contracts like Guaranteed Annuity Options (GAOs). In a Wishart affine model, which allows for a non-trivial dependence between the mortality and the interest rates, we go far beyond the results found in the Gaussian case by Liu *et al.* (2014), where the value of these insurance contracts can be explained only in terms of the initial pairwise linear correlation.

DELONG, LUKASZ; CHEN, AN. *Asset allocation, sustainable withdrawal, longevity risk and non-exponential discounting*. 342–352. The present paper studies an optimal withdrawal and investment problem for a retiree who is interested in sustaining her retirement consumption above a pre-specified minimum consumption level. Apparently, the withdrawal and investment policy

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depends substantially on the retiree's health condition and her time preferences (subjective discount factor). We assume that the health of the retiree can worsen or improve in an unpredictable way over her lifetime and model the retiree's mortality intensity by a stochastic process. In order to make the decision about the consumption and investment policy more realistic, we assume that the retiree applies a non-exponential discount factor (an exponential discount factor with a small amount of hyperbolic discounting) to value her future income. In other words, we consider an optimization problem by combining four important aspects: asset allocation, sustainable withdrawal, longevity risk and non-exponential discounting. Due to the non-exponential discount factor, we have to solve a time-inconsistent optimization problem. We derive a non-local HJB equation which characterizes the equilibrium optimal investment and consumption strategy. We establish the first-order expansions of the equilibrium value function and the equilibrium strategies by applying expansion techniques. The expansion is performed on the parameter controlling the degree of discounting in the hyperbolic discounting that is added to the exponential discount factors. The first-order equilibrium investment and consumption strategies can be calculated in a feasible way by solving PDEs.

DENUIT, MICHEL M; TRUFIN, JULIEN. *From regulatory life tables to stochastic mortality projections: The exponential decline model*. 295–303. Often in actuarial practice, mortality projections are obtained by letting age-specific death rates decline exponentially at their own rate. Many life tables used for annuity pricing are built in this way. The present paper adopts this point of view and proposes a simple and powerful mortality projection model in line with this elementary approach, based on the recently studied mortality improvement rates. Two main applications are considered. First, as most reference life tables produced by regulators are deterministic by nature, they can be made stochastic by superposing random departures from the assumed age-specific trend, with a volatility calibrated on market or portfolio data. This allows the actuary to account for the systematic longevity risk in solvency calculations. Second, the model can be fitted to historical data and used to produce longevity forecasts. A number of conservative and tractable approximations are derived to provide the actuary with reasonably accurate approximations for various relevant quantities, available at limited computational cost. Besides applications to stochastic mortality projection models, we also derive useful properties involving supermodular, directionally convex and stop-loss orders.

ECKERT, JOHANNA; GATZERT, NADINE; MARTIN, MICHAEL. *Valuation and risk assessment of participating life insurance in the presence of credit risk*. 382–393. In participating life insurance, management decisions regarding the asset composition can substantially impact the value of a policy from the policyholders' perspective as well as the insurer's risk situation. Due to the long-term guarantees often embedded in these contracts, life insurers typically invest a considerable portion of their capital in long-term assets such as corporate and government bonds. Besides interest rate risk, the value of these bond investments is thus particularly influenced by credit risk. Thus, the aim of this paper is to examine the impact of market risk associated with the asset composition on fair valuation and risk assessment with focus on credit risk and its interaction with equity risk and interest rate risk. Our analysis emphasizes that the consideration of credit risk associated with bonds has a strong impact on the fair valuation and risk measurement in the context of participating life insurance contracts, even in case of higher grade bond exposures.

FLORYSZCZAK, ANTHONY; LE COURTOIS, OLIVIER; MAJRI, MOHAMED. *Inside the Solvency 2 black box: Net Asset Values and Solvency Capital Requirements with a least-squares Monte-Carlo approach*. 15–26. The calculation of Net Asset Values and Solvency Capital

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Requirements in a Solvency 2 context-and the derivation of sensitivity analyses with respect to the main financial and actuarial risk drivers – is a complex procedure at the level of a real company, where it is illusory to be able to rely on closed-form formulas. The most general approach to performing these computations is that of nested simulations. However, this method is also hardly realistic because of its huge computation resources demand. The least-squares Monte Carlo method has recently been suggested as a way to overcome these difficulties. The present paper confirms that using this method is indeed relevant for Solvency 2 computations at the level of a company.

GOMES-GONÇALVES, ERIKA; GZYL, HENRYK; MAYORAL, SILVIA. *Loss data analysis: analysis of the sample dependence in density reconstruction by maxentropic methods*. 145–153. The problem of determining probability densities of positive random variables from empirical data is important in many fields, in particular in insurance and risk analysis. The method of maximum entropy has proven to be a powerful tool to determine probability densities from a few values of its Laplace transform. This is so even when the amount of data to compute numerically the Laplace transform is small. But in this case, the variability of the reconstruction due to the sample variability in the available data can lead to quite different results. It is the purpose of this note to quantify as much as possible the variability of the densities reconstructed by means of two maxentropic methods: the standard maximum entropy method and its extension to incorporate data with errors. The issues that we consider are of special interest for the advanced measurement approach in operational risk, which is based on loss data analysis to determine regulatory capital, as well as to determine the loss distribution of risks that occur with low frequency.

HAINAUT, DONATIEN. *Impact of volatility clustering on equity indexed annuities*. 367–381. This study analyses the impact of volatility clustering in stock markets on the evaluation and risk management of equity indexed annuities (EIA). To introduce clustering in equity returns, the reference index is modelled by a diffusion combined with a bivariate self-excited jump process. We infer a semi-closed form or parametric expression of the moment generating functions in this framework for the equity return and the intensities of jumps. An econometric procedure is proposed to fit the model to a time series. Next, we develop a method, based on a normal inverse Gaussian approximation of the index return, to evaluate options embedded in simple variable annuities. To conclude, we compare prices, one-year value at risks, and tail value at risks of simple EIAs, computed with different models.

HUANG, HUAXIONG; MILEVSKY, MOSHE ARYE. *Longevity risk and retirement income tax efficiency: A location spending rate puzzle*. 50–62. In this paper we model and solve a retirement consumption problem with differentially taxed accounts, parameterized by longevity risk aversion. The work is motivated by some observations on how Canadians de-accumulate financial wealth during retirement – which seem rather puzzling. While the Modigliani lifecycle model can justify a variety of (pre-tax) de-accumulation or draw down rates depending on risk preferences, the existence of asymmetric taxes implies that certain financial accounts should be depleted faster than others. Our analysis of data from the Survey of Financial Security indicates that Canadian retirees maintain approximately two-thirds of their financial wealth in tax-sheltered accounts and a third in taxable accounts regardless of age. The ratio of taxable to tax-sheltered wealth increases slightly or remains relatively constant depending on household income which is not what one would expect from the lifecycle model. Indeed, using our model we cannot locate a plausible tax function that justifies a constant "account ratio" regardless of age. For example under flat rates taxable accounts should be depleted well before tax-sheltered accounts are ever touched.

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The account ratio should go to zero quite rapidly in the absence of government mandated withdrawals. We also demonstrate that under progressive income taxes withdrawals are made from both accounts but at different rates depending on account size, pension income and longevity risk preferences. Again, the "account ratio" should eventually decline. We postulate that this sort of behavior is likely due to irrational considerations linked to mental accounting, etc. It remains to be seen whether this will persist over time and under a more careful analysis of Canadian cohorts or if retirees in other countries exhibit the same behavior.

JIN, CAN; LI, SHUANMING; WU, XUEYUAN. *On the occupation times in a delayed Sparre Andersen risk model with exponential claims*. 304–316. In this paper, we study the joint Laplace transform of the occupation times in disjoint intervals until ruin in a delayed Sparre Andersen risk model with general inter-claim times and exponential claims. We extend the transformation method in the literature and apply the theoretical fluctuation techniques to derive an explicit expression of the joint Laplace transform under consideration. Further, with the presence of a constant dividend barrier, we derive explicit expressions for the Laplace transforms of the time of ruin and the non-dividend paying duration, namely the total length of non-dividend paying periods prior to ruin. This quantity is of practical interest but has not been studied in the literature to date. Within this paper, all of the Laplace transforms are expressed in terms of scale functions associated with the given spectrally negative Lévy process. Numerical examples are also provided at the end of this paper regarding the Laplace transform of the non-dividend paying duration to illustrate how the distribution of this occupation time behaves in response to varying parameters and the impact of delay on the occupation times comparing with an ordinary Sparre Andersen risk model.

JODRÁ, P; JIMÉNEZ-GAMERO, M D. *A note on the Log-Lindley distribution*. 189–194. The Log-Lindley distribution is a continuous probability model with useful applications in insurance and inventory management. In this note, it is proven that pseudo-random data from this model can be generated by computer via the Lambert WW function. A reparametrization suitable to get estimates of the parameters is proposed. Moreover, it is shown that this reparametrization is appropriate to perform a regression analysis with dependent variable taking values in the unit interval.

KWOK, KAI YIN; CHIU, MEI CHOI; WONG, HOI YING. *Demand for longevity securities under relative performance concerns: stochastic differential games with cointegration*. 353–366. This paper investigates the impact of relative performance concerns on the longevity risk transfer market. When an insurer concerns about the relative performance in a two-insurer economy, she maximizes the expected utility of her terminal wealth benchmarked against her competitor's. The problem formulation for a general utility, a general interest rate process and cointegrated mortality rates uses a nonzero sum stochastic differential game approach. Explicit solution of the Nash equilibrium is derived for constant relative risk adverse insurers under the Vasicek-type stochastic interest and mortality rates. Existence and uniqueness of the Nash equilibrium are established for the CIR-type models, which rule out negative interest and mortality rates. While previous studies based on the single-agent approaches have shown a high investment demand in longevity bonds, the launch of it was unsuccessful in reality. Ours supplements that the demand is much lower subject to the relative performance concerns.

LAGERÅS, ANDREAS NORDVALL; LINDHOLM, MATHIAS. *Issues with the Smith-Wilson method*. 93–101. We analyse various features of the Smith-Wilson method used for discounting

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under the EU regulation Solvency II, with special attention to hedging. In particular, we show that all key rate duration hedges of liabilities beyond the Last Liquid Point will be peculiar. Moreover, we show that there is a connection between the occurrence of negative discount factors and singularities in the convergence criterion used to calibrate the model. The main tool used for analysing hedges is a novel stochastic representation of the Smith-Wilson method.

LANDRIAULT, DAVID; LI, BIN; LI, DANPING; LI, DONGCHEN. *A pair of optimal reinsurance-investment strategies in the two-sided exit framework*. 284–294. In this paper, we derive and study a pair of optimal reinsurance-investment strategies under the two-sided exit framework which aims to (1) maximize the probability that the surplus reaches the target b before ruin occurs over the time horizon $[0, e_\lambda]$ (where e_λ is an independent exponentially distributed random time); (2) minimize the probability that ruin occurs before the surplus reaches the target b over the time horizon $[0, e_\lambda]$. We assume the insurer can purchase proportional reinsurance and invest its wealth in a financial market consisting of a risk-free asset and a risky asset, where the dynamics of the latter is assumed to be correlated with the insurance surplus. By solving the associated Hamilton-Jacobi-Bellman (HJB) equation via a dual argument, an explicit expression for the optimal reinsurance-investment strategy is obtained. We find that the optimal strategy of objective (1) (objective (2) resp.) is always more aggressive (conservative resp.) than the strategy of minimizing the infinite-time ruin probability of Promislow and Young (2005) [S.D. Promislow, V.R. Young, Minimizing the probability of ruin when claims follow Brownian motion with drift, North American Actuarial Journal (2005) 9(3): 110–128]. Due to the presence of the time factor e_λ, the optimal strategy under objective (1) or (2) may lead to more aggressive positions as the wealth level increases, a behavior which may be more consistent with industry practices.

LANDSMAN, ZINOVIY M; MADOV, UDI; SHUSHI, TOMER. *Tail conditional moments for elliptical and log-elliptical distributions*. 179–188. In this paper we provide the tail conditional moments for the class of elliptical distributions, which was introduced in Kelker (1970) [Kelker, D (1970), Distribution theory of spherical distributions and location-scale parameter generalization, Sankhya 32: 831–869] and was widely discussed in Gupta *et al.* (2013) [Gupta, A K, Varga, T, Bodnar, T (2013), Elliptically contoured models in statistics and portfolio theory, Springer] and for the class of log-elliptical distributions. These families of distributions include some important members such as the normal, Student-t, logistic, Laplace, and log-normal distributions. We give analytic formulae for the nth higher order unconditional moments of elliptical distributions, which has not been provided before. We also propose novel risk measures, the tail conditional skewness and the tail conditional kurtosis, for examining the skewness and the kurtosis of the tail of loss distributions, respectively.

LI, JINZHU. *Uniform asymptotics for a multi-dimensional time-dependent risk model with multivariate regularly varying claims and stochastic return*. 195–204. This paper is devoted to asymptotic analysis for a multi-dimensional risk model with a general dependence structure and stochastic return driven by a geometric Lévy process. We take into account both the dependence among the claim sizes from different lines of businesses and that between the claim sizes and their common claim-number process. Under certain mild technical conditions, we obtain for two types of ruin probabilities precise asymptotic expansions which hold uniformly for the whole time horizon.

LIANG, ZONGXIA; ZHAO, XIAOYANG. *Optimal mean-variance efficiency of a family with life insurance under inflation risk*. 179–188. We study an optimization problem of a family under mean-variance efficiency. The market consists of cash, a zero-coupon bond, an inflation-indexed

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zero-coupon bond, a stock, life insurance and income-replacement insurance. The instantaneous interest rate is modeled as the Cox-Ingersoll-Ross (CIR) model, and we use a generalized Black-Scholes model to characterize the stock and labor income. We also take into account the inflation risk and consider our problem in the real market. The goal of the family is to maximize the mean of the surplus wealth at the retirement or death of the breadwinner and minimize its variance by finding a portfolio selection. The efficient frontier and optimal strategies are derived through the dynamic programming method and the technique of solving associated nonlinear HJB equations. We also present a numerical illustration to explore the impact of economical parameters on the efficient frontier.

LIN, X SHELDON; WU, PEI-HSUAN; WANG, XIAO. *Move-based hedging of variable annuities: a semi-analytic approach*. 40–49. In this paper, we propose a semi-analytic algorithm for measuring the mean and variance of the cost associated with a two-sided move-based hedging of options written on an underlying asset whose price follows a geometric Brownian motion. Numerical examples are presented to illustrate the computational accuracy and efficiency of the algorithm. We then apply the technique to a structured product-based variable annuity with buffered protection and an annual ratchet variable annuity.

LING, CHENGXIU; PENG, ZUOXIANG. *Tail asymptotics of generalized deflated risks with insurance applications*. 220–231. Let X and $S \in (0, 1)$ be two independent risk variables. This paper investigates approximations of generalized deflated risks $\mathbb{E}\{X^k \mathbb{I}\{SX > x\}\}$ with a flexible constant $k \geq 0$ under extreme value theory framework. Our findings are illustrated by three applications concerning higher-order tail approximations of deflated risks as well as approximations of the Haezendonck-Goovaerts and expectile risk measures. Numerical analyses show that higher-order approximations obtained in this paper significantly improve lower-order approximations.

MANESH, SIROUS FATHI; KHALEDI, BAHA-ELDIN; DHAENE, JAN. *Optimal allocation of policy deductibles for exchangeable risks*. 87–92. Let $X_1,\ldots, X_n$ be a set of n continuous and non-negative random variables, with log-concave joint density function f, faced by a person who seeks for an optimal deductible coverage for these n risks. Let $\mathbf{d} = (d_1,\ldots d_n)$ and $\mathbf{d}^* = (d_1^*,\ldots d_n^*)$ be two vectors of deductibles such that $\mathbf{d}^*$ majorized by $\mathbf{d}$. It is shown that $\sum_{i=1}^n (X_i \wedge d_i^*)$ is larger than $\sum_{i=1}^n (X_i \wedge d_i)$ in stochastic dominance, provided f is exchangeable. As a result, the vector $\left(\sum_{i=1}^n d_i, 0, \ldots, 0\right)$ is an optimal allocation that maximizes the expected utility of the policyholder's wealth. It is proven that the same result remains to hold in some situations if we drop the assumption that f is log-concave.

MAURER, RAIMOND; MITCHELL, OLIVIA S; ROGALLA, RALPH; SIEGELIN, IVONNE. *Accounting and actuarial smoothing of retirement payouts in participating life annuities*. 268–283. Life insurers use accounting and actuarial techniques to smooth reporting of firm assets and liabilities, seeking to transfer surpluses in good years to cover benefit payouts in bad years. Yet these techniques have been criticized as they make it difficult to assess insurers' true financial status. We develop stylized and realistically-calibrated models of a participating life annuity, an insurance product that pays retirees guaranteed lifelong benefits along with variable non-guaranteed surplus. Our goal is to illustrate how accounting and actuarial techniques for this type of financial contract shape policyholder wellbeing, along with insurer profitability and stability. Smoothing adds value to both the annuitant and the insurer, so curtailing smoothing could undermine the market for long-term retirement payout products.

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PAZDERA, JAROSLAV; SCHUMACHER, JOHANNES M; WERKER, BAS J M. *Cooperative investment in incomplete markets under financial fairness*. 394–406. Groups of agents, such as participants in a collective pension fund, can decide to undertake a joint investment and to define, ex ante, a rule for the division of proceeds. The collective investment decision and the allocation rule together form a risk sharing scheme. Such a scheme defines a contingent claim for each participant. Given a proposed risk sharing scheme and an agreed-upon pricing functional, the values of these claims can be determined and can be compared to the values of the contributions made by the agents. A risk sharing scheme is said to be financially fair if, for each agent, the value of the agent's claim as defined by the scheme is equal to the value of the agent's contribution. The paper provides conditions under which there exists a unique risk sharing scheme that is both Pareto efficient (in the sense of expected utility) and financially fair. Furthermore, an iterative algorithm is presented by which this scheme can be computed. The theory is illustrated by a simple example which shows that, in an incomplete financial market, agents may benefit substantially from forming a collective.

SARABIA, JOSÉ MARÍA; GÓMEZ DÉNIZ, EMILIO; PRIETO, FAUSTINO; JORDÁ, VANESA. *Risk aggregation in multivariate dependent Pareto distributions*. 154–163. In this paper we obtain closed expressions for the probability distribution function of aggregated risks with multivariate dependent Pareto distributions. We work with the dependent multivariate Pareto type II proposed by Arnold (1983, 2015) [B.C. Arnold, Pareto distributions, Fairland, MD: International Cooperative Publishing House, 1st ed., 1983; 2nd ed., 2015), which is widely used in insurance and risk analysis. We begin with an individual risk model, where the probability density function corresponds to a second kind beta distribution, obtaining the VaR, TVaR and several other tail risk measures. Then, we consider a collective risk model based on dependence, where several general properties are studied. We study in detail some relevant collective models with Poisson, negative binomial and logarithmic distributions as primary distributions. In the collective Pareto-Poisson model, the probability density function is a function of the Kummer confluent hypergeometric function, and the density of the Pareto-negative binomial is a function of the Gauss hypergeometric function. Using data based on one-year vehicle insurance policies taken out in 2004-2005 (Jong and Heller, 2008) [P. Jong, G. Heller, Generalized linear models for insurance data, Cambridge University Press, 2008], we conclude that our collective dependent models outperform other collective models considered in the actuarial literature in terms of AIC and CAIC statistics.

SCHMIDLI, HANSPETER. *On capital injections and dividends with tax in a classical risk model*. 138–144. The paper considers the classical risk model with dividends and capital injections. In addition to the model considered by Kulenko and Schmidli (2008), tax has to be paid for dividends. Capital injections yield tax exemptions. We calculate the value function and derive the optimal dividend strategy.

WANG, XINGCHUN. *Catastrophe equity put options with target variance*. 79–86. In this study, we consider a new class of catastrophe equity put options, whose payoff depends on the ratio of the realized variance of the stock over the life of the option and the target variance, which represents the insurance company's expectation of the future realized variance. This kind of options could help insurance companies raise more equity capital when a large number of catastrophic events occur during the life of the option. We employ a compound doubly stochastic Poisson process with lognormal intensity to describe accumulated catastrophe losses and assume the volatility varies stochastically. Finally, numerical results are presented to investigate the values of this class of options.

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YAO, HAIXIANG; CHEN, PING; LI, XUN. *Multi-period defined contribution pension funds investment management with regime-switching and mortality risk*. 103–113. Using mean-variance criterion, we investigate a multi-period defined contribution pension fund investment problem in a Markovian regime-switching market. Both stochastic wage income and mortality risk are incorporated in our model. In a regime-switching market, the market mode changes among a finite number of regimes, and the market state process is modeled by a Markov chain. The key parameters, such as the bank interest rate, or expected returns and covariance matrix of stocks, will change according to the market state. By virtue of Lagrange duality technique, dynamic programming approach and matrix representation method, we derive expressions of efficient investment strategy and its efficient frontier in closed-form. Also, we study some special cases of our model. Finally, a numerical example based on real data from the American market sheds light on our theoretical results.

ZHANG, NAN; JIN, ZHUO; LI, SHUANMING; CHEN, PING. *Optimal reinsurance under dynamic VaR constraint*. 232–243. This paper deals with the optimal reinsurance strategy from an insurer's point of view. Our objective is to find the optimal policy that maximises the insurer's survival probability. To meet the requirement of regulators and provide a tool to risk management, we introduce the dynamic version of Value-at-Risk (VaR), Conditional Value-at-Risk (CVaR) and worst-case CVaR (wcCVaR) constraints in diffusion model and the risk measure limit is proportional to company's surplus in hand. In the dynamic setting, a CVaR/wcCVaR constraint is equivalent to a VaR constraint under a higher confidence level. Applying dynamic programming technique, we obtain closed form expressions of the optimal reinsurance strategies and corresponding survival probabilities under both proportional and excess-of-loss reinsurance. Several numerical examples are provided to illustrate the impact caused by dynamic VaR/CVaR/wcCVaR limit in both types of reinsurance policy.

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CHARUPAT, NARAT; KAMSTRA, MARK J; MILEVSKY, MOSHE ARYE. *The sluggish and asymmetric reaction of life annuity prices to changes in interest rates*. 519–555. Many assume that in the short run, annuity prices promptly and efficiently respond to changes in interest rates. Using a unique database of quotes, we show this is not the case. Prices are less sensitive to changes in rates than expected, and responses are asymmetric. Prices react more rapidly and with greater sensitivity to an increase than to a decrease in rates. The results are robust, but there is a small degree of heterogeneity in the responses of different insurance companies. When rates increase, larger firms are slightly quicker to improve prices. The opposite is true when rates decline. In sum, we show that the microstructure of annuity dynamics is more complicated than (simply) adding mortality credits to bond yields.

CHAVEZ-DEMOULIN, VALÉRIE; EMBRECHTS, PAUL; HOFERT, MARIUS. *An extreme value approach for modeling operational risk losses depending on covariates*. 735–776. A general methodology for modeling loss data depending on covariates is developed. The parameters of the frequency and severity distributions of the losses may depend on covariates. The loss frequency over time is modeled with a nonhomogeneous Poisson process with rate function depending on the covariates. This corresponds to a generalized additive model, which can be estimated with spline smoothing via penalized maximum likelihood estimation. The loss severity over time is modeled with a nonstationary generalized Pareto distribution (alternatively, a generalized extreme value distribution) depending on the covariates. Since spline smoothing cannot directly be applied in this case, an efficient algorithm based on orthogonal parameters is suggested. The methodology is applied both to simulated loss data and a database of operational risk losses collected from public media. Estimates, including confidence intervals, for risk measures such as Value-at-Risk as required by the Basel II/III framework are computed. Furthermore, an implementation of the statistical methodology in R is provided.

ELYASIANI, ELYAS; STAIKOURAS, SOTIRIS K; DONTIS-CHARITOS, PANAGIOTIS. *Cross-industry product diversification and contagion in risk and return: the case of bank-insurance and insurance-bank takeovers*. 681–718. We investigate the impact of domestic/international bancassurance deals on the risk-return profiles of announcing and nonannouncing banks and insurers within a GARCH model. Bank-insurance deals produce intra- and interindustry contagion in both risk and return, with larger deals producing greater contagion. Bidder banks and peers experience positive abnormal returns, with the effects on insurer peers being stronger than those on bank peers. Insurance-bank deals produce insignificant excess returns for bidder and peer insurers and positive valuations for peer banks. Following the deal, the bank bidders' idiosyncratic (systematic) risk falls (increases), while insurance bidders exhibit a lower systematic risk and maintain their idiosyncratic risk.

ERGASHEV, BAKHODIR; PAVLIKOV, KONSTANTIN; URYASEV, STAN; SEKERIS, EVANGELOS. *Estimation of truncated data samples in operational risk modeling*. 613–640. This article addresses challenges of estimating operational risk regulatory capital when a loss sample is truncated from below at a data collection threshold. Recent operational risk literature reports that the attempts to estimate loss distributions by the maximum likelihood method are not always successful under the truncation approach that accounts for the existence of censored losses–the likelihood surface is sometimes ascending with no global solution. The literature offers an alternative called the shifting approach, which estimates the loss distribution without taking into account censored losses. We present a necessary and sufficient condition for the existence of the global solution to the likelihood maximization problem under the truncation approach when the true loss distribution is lognormal, and derive a practically explicit expression for the global solution. We show by a simulation study that, as the sample size increases, the capital bias by the truncation approach declines while the bias by the shifting approach does not.

GATZERT, NADINE; SCHMIT, JOAN T; KOLB, ANDREAS. *Assessing the risks of insuring reputation risk*. 641–679. Reputation risk is becoming increasingly important, especially with the rapidly growing influence of social media, heightened scrutiny on reputation risk by banking and insurance regulators, and reputation's impact on organizational value. Insurers have responded to this development only recently by offering new reputation risk insurance solutions. The aim of this article is to present the first detailed academic analysis of these new insurance policies, including examination of the risks insurers face in offering such coverage. We also offer

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a conceptualization of reputation risk in an insurance and risk management context with focus on exposures, perils, and hazards. Our analysis indicates that loss identification and measurement generate the greatest challenges to insurers in providing reputation risk coverage. Lack of experience as well as the complexity of the chain of reputation risk events related to reputation insurance coverage present insurers with significant challenges in making this a viable line of business.

GÜRTLER, MARC; HIBBELN, MARTIN; WINKELVOS, CHRISTINE. *The impact of the financial crisis and natural catastrophes on CAT bonds*. 579–612. This article employs secondary market data to examine how natural catastrophes or financial crises affect CAT bond premiums. We find evidence that both the financial crisis and Hurricane Katrina significantly affected CAT bond premiums. The premium increase resulting from natural catastrophes can primarily be attributed to an increased coefficient of expected loss calculated by catastrophe modeling companies. Furthermore, our results indicate a positive relationship between corporate spreads and CAT bond premiums. Thus, CAT bonds should not be regarded as "zero-beta" securities. Moreover, our results indicate that deal complexity, ratings, and the reinsurance cycle are significant drivers of CAT bond premiums.

HOFMANN, ANNETTE; PETER, RICHARD. *Self-insurance, self-protection, and saving: on consumption smoothing and risk management*. 719–734. This article studies the effect of risk preferences on self-insurance and self-protection in a two-period expected utility framework. Here the investment to reduce risk precedes its effect. In contrast to single-period models, self-insurance and self-protection react similarly when the agent's utility function becomes more concave. Effort is increased if and only if current consumption is sufficiently large. However, if we introduce endogenous saving, an agent with more concave utility always selects more self-insurance, but will select more self-protection if and only if the probability of loss is small enough. These latter results concur with those in standard monoperiodic models with no saving.

SHI, PENG; ZHANG, WEI. *A test of asymmetric learning in competitive insurance with partial information sharing*. 557–578. This article examines whether an insurer could gain advantageous information on repeat customers over its rivals in the Singapore automobile insurance market, which is featured by partial information sharing among insurers. We find that the insurer does update and accumulate more information regarding its policyholders' riskiness through repeated observations and thus make higher profits with repeat customers especially those of lower risk. We also show that the higher profit is driven by the fact that low risks tend to stay longer with the insurer, and in the meanwhile, they are charged a premium higher than their actuarial risk level.

YANG, SHANG-YIN; WANG, CHOU-WEN; HUANG, HONG-CHIH. *The valuation of lifetime health insurance policies with limited coverage*. 777–800. In adopting a traditional actuarial view, insurance companies often use expected values to determine the premiums for lifetime health insurance policies with limited coverage, which can lead to serious overpricing problems when the coverage limit is not very low or very high. To address this overpricing problem, this article provides analytical solutions for fair premiums of lifetime health insurance policies with limited coverage. Using internal data provided by insurance companies, this article describes the relationship between the level of limited coverage and excess premiums. The premium difference between a practical pricing method and a proposed pricing model creates a humped curve; the maximum excess premium ratio reaches nearly 20 percent for limited coverage for younger insured people.

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BIGNOZZI, VALERIA; TSANAKAS, ANDREAS. *Parameter uncertainty and residual estimation risk*. 949–978. The notion of residual estimation risk is introduced to quantify the impact of parameter uncertainty on capital adequacy, for a given risk measure and capital estimation procedure. Residual risk equals the risk measure applied to the difference between a random loss and the corresponding capital estimator. Modified estimation procedures are proposed, based on parametric bootstrapping and predictive distributions, which compensate the impact of parameter uncertainty and lead to higher capital requirements. In the particular case of location-scale families, the analysis simplifies and a capital estimator can always be found that leads to a residual risk of exactly zero.

BRAUN, ALEXANDER. *Pricing in the primary market for cat bonds: new empirical evidence*. 811–847. We present empirical evidence from the primary market for cat bonds, which provides new insights concerning the prevailing pricing practice of these instruments. For this purpose, transactional information from a multitude of sources has been collected and cross-checked in order to compile a data set comprising virtually all cat bond tranches that were launched between June 1997 and December 2012. In order to identify the main determinants of the cat bond spread at issuance, a series of OLS regressions with heteroskedasticity- and autocorrelation-consistent standard errors is run. Our results confirm the expected loss as the most important factor. Apart from that, covered territory, sponsor, reinsurance cycle, and the spreads on comparably rated corporate bonds exhibit a major impact. Based on these findings, we then propose an econometric cat bond pricing model that is applicable for all territories, perils, and trigger types. It exhibits a robust fit across different calibration subsamples and achieves a higher in-sample and out-of-sample accuracy than several competing specifications that have been introduced in earlier work.

CHOI, CHANGHUI; JANG, BONG-GYU; KIM, CHANGKI; ROH, SANG-YOUN. *Net contribution, liquidity, and optimal pension management*. 913–948. This article presents an optimal portfolio balancing strategy for a pension fund manager in the presence of fixed and proportional transaction costs with respect to stock trades and changes in net contribution. An analytic solution to the one-period problem is presented and a heuristic method for a multiperiod problem is developed. For reasonably calibrated parameters, we find that our numerical results explain the actual asset allocation schemes of some internationally renowned pension funds. Moreover, we show that net contribution and liquidity have significant impacts on the optimal asset allocation of a pension fund.

ITO, HARUYOSHI; AI, JING; OZAWA, AKIHIKO. *Managing weather risks: the case of J. League soccer teams in Japan*. 877–912. Weather-related risks present significant concerns for businesses worldwide. This article studies the impact weather conditions have on the financial performance of sports teams and proposes a hedging mechanism to manage the exposure. We analyze a unique game attendance data set supplied by the Japanese premier soccer association, J. League. Our analysis shows that precipitation has a significantly adverse impact on game attendance and team profits. We then design a hedging mechanism for this risk exposure and examine its contribution to the corporate value of the teams. In particular, we use the Wang transform model to incorporate the decision makers' risk preferences in the evaluation of the weather derivatives,

where the risk aversion parameters are obtained from a survey of J. League managers. We find that the proposed weather derivatives contribute significantly to team value. Our analysis and results provide insights for weather risk management for sports teams in the international markets.

KNOLLER, CHRISTIAN; KRAUT, GUNTHER; SCHOENMAEKERS, PASCAL. *On the propensity to surrender a variable annuity contract: an empirical analysis of dynamic policyholder behavior*. 979–1006. We empirically analyze surrender behavior for variable annuity contracts using Japanese individual policy data. For traditional life insurance products, surrender behavior is typically explained by the interest rate and the emergency fund hypotheses. For variable annuities, the interest rate hypothesis is not directly applicable. For these products, we expect the value of the financial options and guarantees provided to the policyholder to drive surrender behavior. We define this expectation as the "moneyness hypothesis." The statistical analysis confirms our moneyness hypothesis: the value of the embedded financial options and guarantees has the largest explanatory power for the surrender rate. The extent to which this finding holds depends on the single premium paid, which we consider a proxy for the policyholder's financial literacy. Moreover, our data set weakly supports the emergency fund hypothesis for the case of variable annuities.

MANKAÏ, SELIM; BELGACEM, AYMEN. *Interactions between risk taking, capital, and reinsurance for property-liability insurance firms*. 1007–1043. Financial theory has long recognized the structural relationship between capital and risk. This article posits reinsurance usage as a new endogenous decision variable and analyzes its effect on this decision mix from a sample of U.S. property-liability insurance firms. Empirical results obtained from a simultaneous equation model confirm the mutual interactions among capital, reinsurance and risk taking. Risk taking is positively related to capital, which highlights the effectiveness of regulatory mechanisms and the relevance of the capital buffer hypothesis. Reinsurance is negatively associated with capital, for which it displays a substitutive effect. These results seem to vary with the insurers' level of capitalization, affiliation with a group, size, and organizational form. Unlike other decision variables, the capital ratio is adjusted to its target level.

RAGIN, MARC A; HALEK, MARTIN. *Market expectations following catastrophes: an examination of insurance broker returns*. 849–876. We investigate the effect major catastrophes are expected to have on equilibrium price and quantity in the insurance market. In particular, we examine whether investors expect total industry revenue to increase following a disaster's shock to insurers' financial capital. Rather than examine insurers directly, we study insurance brokers, who earn commissions on premium revenue but do not pay losses following a disaster. We conduct an event study on insurance broker stock returns surrounding the 43 largest insured-loss catastrophes since 1970. We find that brokers earn positive abnormal returns on the day of the event, and that these returns are sustained following the top 20 largest events. We then investigate factors influencing these returns and find that returns are positively related to the size of the loss and negatively related to existing insurer capital. From this, we conclude that catastrophe shocks are expected to increase net industry revenue, benefiting brokers most immediately. This investor response is consistent with economic theories of a negative relationship between capital and insurance prices and price-inelastic demand for commercial insurance.

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AMIN, ZEINAB. *Quantification of operational risk: a scenario-based approach*. 286–297. In this article, I identify challenges to the loss distribution approach in modeling operational risk. I propose a scenario-based methodology for operational risk assessment, which recognizes that each risk can occur under a number of wide-ranging scenarios and that association between risks may behave differently for different scenarios. The model that is developed internally in the company provides a practical quantitative assessment of risk exposure that reflects a deep understanding of the company and its environment, making the risk calculation more responsive to the actual state, ensuring that the company is attending to its key operational risks. In this model qualitative and quantitative approaches are combined to build a loss distribution for individual and aggregate operational risk exposure. The model helps to portray the company's internal control systems and aspects of business environment. These features can help the company increase its operational efficiency, reduce loss from undesirable incidents, and maintain the integrity of internal control.

CANUDAS-ROMO, VLADIMIR; DUGOFF, EVA; WU, ALBERT W; AHMED, SAIFUDDIN; ANDERSON, GERARD. *Life expectancy in 2040: what do clinical experts expect?* 276–285. We use expert clinical and public health opinion to estimate likely changes in the prevention and treatment of important disease conditions and how they will affect future life expectancy. Focus groups were held including clinical and public health faculty with expertise in the six leading causes of death in the United States. Mortality rates and life tables for 2040 were derived by sex and age. Life expectancy at age 20 and 65 was compared to figures published by the Social Security Administration and to estimates from the Lee-Carter method. There was agreement among all three approaches that life expectancy at age 20 will increase by approximately one year per decade for females and males between now and 2040. According to the clinical experts, 70% of the improvement in life expectancy will occur in cardiovascular disease and cancer, while in the last 30 years most of the improvement has occurred in cardiovascular disease. Expert opinion suggests that most of the increase in life expectancy will be attributable to the already achieved reduction in smoking rates, especially for women.

GOLDEN, LINDA L; BROCKETT, PATRICK L; AI, JING; KELLISON, BRUCE. *Empirical evidence on the use of credit scoring for predicting insurance losses with psycho-social and biochemical explanations*. 233–251. An important development in personal lines of insurance in the United States is the use of credit history data for insurance risk classification to predict losses. This research presents the results of collaboration with industry conducted by a university at the request of its state legislature. The purpose was to see the viability and validity of the use of credit scoring to predict insurance losses given its controversial nature and criticism as redundant of other predictive variables currently used. Working with industry and government, this study analyzed more than 175,000 policyholders' information for the relationship between credit score

and claims. Credit scores were significantly related to incurred losses, evidencing both statistical and practical significance. We investigate whether the revealed relationship between credit score and incurred losses was explainable by overlap with existing underwriting variables or whether the credit score adds new information about losses not contained in existing underwriting variables. The results show that credit scores contain significant information not already incorporated into other traditional rating variables (e.g., age, sex, driving history). We discuss how sensation seeking and self-control theory provide a partial explanation of why credit scoring works (the psycho-social perspective). This article also presents an overview of biological and chemical correlates of risk taking that helps explain why knowing risk-taking behavior in one realm (e.g., risky financial behavior and poor credit history) transits to predicting risk-taking behavior in other realms (e.g., automobile insurance incurred losses). Additional research is needed to advance new nontraditional loss prediction variables from social media consumer information to using information provided by technological advances. The evolving and dynamic nature of the insurance marketplace makes it imperative that professionals continue to evolve predictive variables and for academics to assist with understanding the whys of the relationships through theory development.

MILIDONIS, ANDREAS. *An empirical investigation of CDS spreads using a regime-switching default risk model*. 252–275. Default risk in equity returns can be measured by structural models of default. In this article we propose a credit warning signal (CWS) based on the Merton Default Risk (MDR) model and a Regime-Switching Default Risk (RSDR) model. The RSDR model is a generalization of the MDR model, comprises regime-switching asset distribution dynamics, and thus produces more realistic default probability estimates in cases of deteriorating credit quality. Alternatively, it reduces to the MDR model. Using a dataset of U.S. credit default swap (CDS) contracts around the 2007–8 crisis we construct rating-based indices to investigate the MDR and RSDR implied probabilities of default in relation to the market-observed CDS spreads. The proposed CWS measure indicates an increase in implied default probabilities several months ahead of notable increases in CDS spreads.

POWERS, MICHAEL R; QIU, JOSEPH; SHEN, APRIL; SHEN, ZHAN. *Effects of competition on insurance contract formation*. 298–312. For an insurance transaction between a single risk-averse buyer and single risk-neutral seller with positive transaction costs, it is well known that the buyer will prefer a policy contract with an ordinary deductible. More detailed results demonstrate the Pareto optimality of an insurance contract characterized by a deductible (followed by coinsurance) for a single risk-averse buyer and single risk-averse seller. In the present work, we employ a market-game model to solve for the equilibrium insurance contract. This formulation, which approximates the behavior of excess property insurance and property catastrophe reinsurance markets, reveals that the equilibrium policy is described by full insurance up to a given policy limit, with no deductible or coinsurance. Our analysis shows further that this solution persists regardless of the numbers of buyers and sellers in the market, and in particular that the market-game equilibrium does not converge to a Pareto-optimal result because of boundary constraints on the number of sellers. Finally, we test our price-formation mechanism against an important generalization, and find that the policy-limit contract persists.

YASHIN, ANATOLIY I; ARBEEV, KONSTANTIN G; WU, DEQING; ARBEEVA, LIUBOV; KULMINSKI, ALEXANDER; KULMINSKAYA, IRINA; AKUSHEVICH, IGOR; UKRAINTSEVA, SVETLANA V. *How genes modulate patterns of aging-related changes on the way to 100: biodemographic models and methods in genetic analyses of longitudinal data*. 201–232. In this

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article we clarify mechanisms of genetic regulation of human aging and longevity traits. The objective of this article is to address the issues in previous research of not reaching a genome-wide level of statistical significance and lack of replication in the studies of independent populations. We performed GWAS of human life span using different subsets of data from the original Framingham Heart Study cohort corresponding to different quality control procedures, and we used one subset of selected genetic variants for further analyses. We used a simulation study to show that this approach to combining data improves the quality of GWAS with FHS longitudinal data to compare average age trajectories of physiological variables in carriers and noncarriers of selected genetic variants. We used a stochastic process model of human mortality and aging to investigate genetic influence on hidden biomarkers of aging and on dynamic interaction between aging and longevity. We investigated properties of genes related to selected variants and their roles in signaling and metabolic pathways and showed that the use of different quality control procedures results in different sets of genetic variants associated with life span. We selected 24 genetic variants negatively associated with life span and showed that the joint analyses of genetic data at the time of biospecimen collection and follow-up data substantially improved significance of associations of 24 selected SNPs with life span. We also showed that aging-related changes in physiological variables and in hidden biomarkers of aging differ for the groups of carriers and noncarriers of selected variants. The results of these analyses demonstrated benefits of using biodemographic models and methods in genetic association studies of these traits. Our findings showed that the absence of a large number of genetic variants with deleterious effects may make substantial contribution to exceptional longevity. These effects are dynamically mediated by a number of physiological variables and hidden biomarkers of aging. The results of these research demonstrated benefits of using integrative statistical models of mortality risks in genetic studies of human aging and longevity.

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DUNCAN, IAN G; GUERRIER, STÉPHANE. *Member plan choice and migration in response to changes in member premiums after Massachusetts health insurance reform.* 404–419. In 2006 Massachusetts implemented a substantial reform of its health insurance market that included a new program for uninsured individuals with income between 100% of Federal Poverty (the upper limit for state Medicaid benefits) and 300% of Federal Poverty. Enrollment was compulsory for all citizens because of a mandate. Consumers who enrolled in this program, which offered generous benefits with low copays, received graduated subsidies depending on their income. Five insurers were contracted to underwrite the program, and consumers were able to choose their insurer. Insurers bid annually, and the member contribution was set according to an affordability schedule for the lowest-bidding insurer. Consumers could choose from the range of insurers, but if they chose a plan other than the lowest cost, their contributions reflected the difference. Premiums were changed annually at July 1, and members were eligible to move to a different plan at this date; a number of members migrated each year. This study aims to quantify the effect of this premium-induced switching behavior. Prior studies of member switching behavior have looked at employer plans and estimated the elasticity of response to changes in member contributions. The Massachusetts environment is unique in that there is a mandate (so being uninsured is not an option) and members may choose insurer but not benefit plan. Thus a study of migration in Massachusetts is uniquely able to quantify the effect of price (contribution rates) on

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member switching behavior. We find elasticity averaging –0.21 for 2013 (the last year of the study) to be somewhat lower (in absolute value) than previous studies of employer populations. Elasticity has also been significantly increasing with time and appeared to have at least doubled over the studied period (i.e., 2008–2013). Prior studies have estimated higher elasticities in the range -0.3 to -0.6. We found that the data contained many outliers in terms of both changes in contributions and percentage of members switching plans. The effect of outliers was moderated by the choice of robust regression models, leading us to question whether other studies may have been affected by outliers, leading to overestimates of the elasticities.

ECKLES, DAVID L; MCCARTHY, DAVID G; ZENG, XUDONG. *The theory of optimal stochastic control as applied to insurance underwriting cycles*. 327–340. We use the theories of optimal stochastic control and engineering process control to analyze the well-known phenomenon of insurance underwriting cycles in continuous time. We show in a continuous time framework that underwriting cycles can be explained with a model where premiums are set rationally, but where there are various reporting and regulatory lags. We find that the observed cycle length depends on the length of these underlying lags. Our result can be seen as consistent with previous empirical work showing underwriting cycles varying across countries and lines of insurance. In the event that no lags exist, our result is also consistent with more recent literature suggesting that insurance cycles may not exist.

GUTTERMAN, SAM. *Obesity, mortality, and the Obesity Paradox*. 355–403. The percentage of the population who are obese has grown dramatically on a worldwide basis over the last several decades, although the growth in the prevalence of obesity has slowed recently at a high level in the United States. Although there have been numerous studies of the effect of this trend on mortality, the findings have been inconsistent and controversial, in part because of methodological differences and the complexity of the relationships between obesity and mortality. The objective of this article is to discuss the issues surrounding these relationships and to shed light on the likely effects of the obesity epidemic on mortality. Of particular interest is the so-called obesity-mortality paradox, where mortality experience is lower for overweight and in some cases obese individuals than for those of normal weight. Although more recent studies of the relationship between mortality and obesity seem to indicate those who are obese have experienced a reduced percentage of additional mortality, this may in part be due to the shorter average time those currently obese have been exposed to their condition, the heterogeneity of the normal and obese populations, measurement issues including treatment of smokers and those who are ill, and study design limitations. An increased number of premature deaths may arise as more individuals who are obese are exposed for a longer period to excess adiposity. Although public policy issues surrounding obesity are being addressed with a great deal of activity and publicity, they have and will continue to prove quite challenging for both individuals and society to manage and overcome. The prevalence of obesity has had and will continue to have a significant effect on the mortality experience in most areas of actuarial practice. As a result, it is important for actuaries to enhance their understanding of these effects.

LANDSMAN, ZINOVIY M; VALDEZ, EMILIANO A. *The Tail Stein's identity with applications to risk measures*. 313–326. In this article, we examine a generalized version of an identity made famous by Stein, who constructed the so-called Stein's Lemma in the special case of a normal distribution. Other works followed to extend the lemma to the larger class of elliptical distributions. The lemma has had many applications in statistics, finance, insurance, and actuarial science. In an attempt to broaden the application of this generalized identity, we consider the

version in the case where we investigate only the tail portion of the distribution of a random variable. Understanding the tails of a distribution is very important in actuarial science and insurance. Our article therefore introduces the concept of the "tail Stein's identity" to the case of any random variable defined on an appropriate probability space with a Lebesgue density function satisfying certain regularity conditions. We also examine this "tail Stein's identity" to the class of discrete distributions. This extended identity allows us to develop recursive formulas for generating tail conditional moments. As examples and illustrations, we consider several classes of distributions including the exponential family, and we apply this result to demonstrate how to generate tail conditional moments. This holds a large promise for applications in risk management.

NEVES, CÉSAR; DE MELO, EDUARDO FRAGA L. *Evaluating the technical provisions for traditional Brazilian annuity plans: continuous-time stochastic approach based on solvency principles*. 420–436. This article presents an approach for evaluating the liabilities of traditional Brazilian annuity plans, using a continuous-time stochastic approach based on modern solvency principles. The technical provisions are obtained by means of conditional expectation, under a real-world measure and considering the peculiar characteristics of each plan and the financial guarantees and profit participations (bonus and dividend plans) embedded in the annuity plans. We assume that policyholder behavior is not optimal, but we also illustrate a calculation of provision assuming optimal policyholder behavior to show the differences between both assumptions. In this article all explicit provisions formulas are derived, and several relevant conclusions about the values of these provisions are discussed.

STALLARD, ERIC. *Compression of morbidity and mortality: new perspectives*. 341–354. Compression of morbidity is a reduction over time in the total lifetime days of chronic disability, reflecting a balance between (1) morbidity incidence rates and (2) case-continuance rates, generated by case-fatality and case-recovery rates. Chronic disability includes limitations in activities of daily living and cognitive impairment, which can be covered by long-term-care insurance. Morbidity improvement can lead to a compression of morbidity if the reductions in age-specific prevalence rates are sufficiently large to overcome the increases in lifetime disability due to concurrent mortality improvements and progressively higher disability prevalence rates with increasing age. Compression of mortality is a reduction over time in the variance of age at death. Such reductions are generally accompanied by increases in the mean age at death; otherwise, for the variances to decrease, the death rates above the mean age at death would need to increase, and this has rarely been the case. Mortality improvement is a reduction over time in the age-specific death rates and a corresponding increase in the cumulative survival probabilities and age-specific residual life expectancies. Mortality improvement does not necessarily imply concurrent compression of mortality. This article reviews these concepts, describes how they are related, shows how they apply to changes in mortality over the past century and to changes in morbidity over the past 30 years, and discusses their implications for future changes in the United States. The major findings of the empirical analyses are the substantial slowdowns in the degree of mortality compression over the past half century and the unexpectedly large degree of morbidity compression that occurred over the morbidity/disability study period 1984–2004; evidence from other published sources suggests that morbidity compression may be continuing.

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Scandinavian Actuarial Journal

9, 2016

CALDERÍN-OJEDA, ENRIQUE; KWOK, CHUN FUNG. *Modeling claims data with composite Stoppa models*. 817–836. In this paper, a new class of composite model is proposed for modeling actuarial claims data of mixed sizes. The model is developed using the Stoppa distribution and a mode-matching procedure. The use of the Stoppa distribution allows for more flexibility over the thickness of the tail, and the mode-matching procedure gives a simple derivation of the model compositing with a variety of distributions. In particular, the Weibull-Stoppa and the Lognormal-Stoppa distributions are investigated. Their performance is compared with existing composite models in the context of the well-known Danish fire insurance data-set. The results suggest the composite Weibull-Stoppa model outperforms the existing composite models in all seven goodness-of-fit measures considered.

CHRISTIANSEN, MARCUS C; FAHRENWALDT, MATTHIAS A. *Dynamics of solvency risk in life insurance liabilities*. 763–792. We describe the time dynamics of the solvency level of life insurance contracts by representing the solvency level and the underlying risk sources as the solution of a forward-backward system. This leads to an additive decomposition of the total solvency level with respect to time and different risk sources. The decomposition turns out to be an intuitive tool to study risk sensitivities. We study the forward-backward system and discuss two methods to obtain explicit representations: via linear partial differential equations and via a Monte Carlo method based on Malliavin calculus.

JØRGENSEN, PETER LØCHTE; SLIPSAGER, SØREN KÆRGAARD. *An analysis of a three-factor model proposed by the Danish Society of Actuaries for forecasting and risk analysis*. 837–857. This paper provides the explicit solution to the three-factor diffusion model recently proposed by the Danish Society of Actuaries to the Danish industry of life insurance and pensions. The solution is obtained by use of the known general solution to multidimensional linear stochastic differential equation systems. With offset in the explicit solution, we establish the conditional distribution of the future state variables which allows for exact simulation. Using exact simulation, we illustrate how simulation of the system can be improved compared to a standard Euler scheme. In order to analyze the effect of choosing the exact simulation scheme over the traditional Euler approximation scheme frequently applied by practitioners, we carry out a simulation study. We show that due to its recursive nature, the Euler scheme becomes computationally expensive as it requires a small step size in order to minimize discretization errors. Using our exact simulation scheme, one is able to cut these computational costs significantly and obtain even better forecasts. As probability density tail behavior is key to expected investment portfolio performance, we further conduct a risk analysis in which we compare well-known risk measures under both schemes. Finally, we conduct a sensitivity analysis and find that the relative performance of the two schemes depends on the chosen model parameter estimates.

ZENG, XUDONG; CARSON, JAMES M; CHEN, R; WANG, YULING. *Optimal life insurance with no-borrowing constraints: duality approach and example*. 793–816. We solve an optimal

portfolio choice problem under a no-borrowing assumption. A duality approach is applied to study a family's optimal consumption, optimal portfolio choice, and optimal life insurance purchase when the family receives labor income that may be terminated due to the wage earner's premature death or retirement. We establish the existence of an optimal solution to the optimization problem theoretically by the duality approach and we provide an explicitly solved example with numerical illustration. Our results illustrate that the no-borrowing constraints do not always impact the family's optimal decisions on consumption, portfolio choice, and life insurance. When the constraints are binding, there must exist a wealth depletion time (WDT) prior to the retirement date, and the constraints indeed reduce the optimal consumption and the life insurance purchase at the beginning of time. However, the optimal consumption under the constraints will become larger than that without the constraints at some time later than the WDT.

Scandinavian Actuarial Journal

10, 2016

ALM, JONAS. *Signs of dependence and heavy tails in non-life insurance data*. 859–875. In this paper, we study data from the yearly reports the four major Swedish non-life insurers have sent to the Swedish Financial Supervisory Authority (FSA). We aim at finding marginal distributions of, and dependence between, losses on the five largest lines of business (LoBs) in order to create models for solvency capital requirement (SCR) calculation. We try to use data in an optimal way by sensibly defining an accounting year loss in terms of actuarial liability predictions and by pooling observations from several companies when possible to decrease the uncertainty about the underlying distributions and their parameters. We find that dependence between LoBs is weaker in our data than what is assumed in the Solvency II standard formula. We also find dependence between companies that may affect financial stability and must be taken into account when estimating loss distribution parameters. Moreover, we discuss under what circumstances an insurer is better (or worse) off using an internal model for SCR calculation, instead of the standard formula.

LUO, SHANGZHEN; WANG, MINGMING. *Barrier present value maximization for a diffusion model of insurance surplus*. 905–931. In this paper, we study a barrier present value (BPV) maximization problem for an insurance entity whose surplus process follows an arithmetic Brownian motion. The BPV is defined as the expected discounted value of a payment made at the time when the surplus process reaches a high barrier level. The insurance entity buys proportional reinsurance and invests in a Black-Scholes market to maximize the BPV. We show that the maximal BPV function is a classical solution to the corresponding Hamilton-Jacobi-Bellman equation and is three times continuously differentiable using a novel operator. Its associated optimal reinsurance-investment control policy is determined by verification techniques.

MITRIC, ILIE-RADU; TRUFIN, JULIEN. *On a risk measure inspired from the ruin probability and the expected deficit at ruin*. 932–951. In this paper, we study a risk measure derived from ruin theory defined as the amount of capital needed to cope in expectation with the first occurrence of a ruin event. Specifically, within the compound Poisson model, we investigate some properties of this risk measure with respect to the stochastic ordering of claim severities. Particular situations where combining risks yield diversification benefits are identified. Closed form expressions and upper bounds are also provided for certain claim severities.

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TÅGHOLT GAD, KAMILLE SOFIE; WOETMANN NIELSEN, JEPPE. *Reserves and cash flows under stochastic retirement*. 905–931. Uncertain time of retirement and uncertain structure of retirement benefits are risk factors for life insurance companies. Nevertheless, classical life insurance models assume these are deterministic. In this paper, we include the risk from stochastic time of retirement and stochastic benefit structure in a classical finite-state Markov model for a life insurance contract. We include discontinuities in the distribution of the retirement time. First, we derive formulas for appropriate scaling of the benefits according to the time of retirement and discuss the link between the scaling and the guarantees provided. Stochastic retirement creates a need to rethink the construction of disability products for high ages and ways to handle this are discussed. We show how to calculate market reserves and how to use modified transition probabilities to calculate expected cash flows without significantly more complexity than in the traditional model. At last, we demonstrate the impact of stochastic retirement on market reserves and expected cash flow in numerical examples.

South African Actuarial Journal

16, 2016

AGOSTINHO, PJF; CHERRY, C J. *The significance of claims fraud in microinsurance and a statistical method to channel limited fraud identification resources*. 143–181. In the past decade, the topic of microinsurance has received much attention from researchers around the world as the drive to alleviate persistent global poverty intensifies. Although microinsurance is a powerful tool that can be used to assist in the fight against poverty by acting as a safety net for policyholders, the problem of claims fraud is a serious threat to its long-term sustainability. Analysis of the existing literature reveals a severe shortage of research into the problem of microinsurance claims fraud, even though we have found that it poses a greater threat in microinsurance than regular insurance. In this paper we highlight the problem of claims fraud in low-income markets and we explain how fraud has the potential to make microinsurance initiatives unsustainable. After establishing that action is needed to combat fraud in microinsurance, we briefly present a number of fraud mitigation techniques that have been successful in conventional insurance. However, certain characteristics that differentiate microinsurance from regular insurance reveal that most of these fraud combating approaches are not appropriate to microinsurance; the proportionately higher costs of identifying claims fraud relative to policy size, the lack of data and the lack of resources experienced by microinsurers render these methods impractical and unaffordable in the context of microinsurance. We proceed to demonstrate the workings of a statistical method known as Principle Component Analysis of Ridit Scores (the Pridit method), initially developed by Brockett *et al.* (2002) [Brockett, PL, Derrig, RA, Golden, LL, Levine, A & Alpert, M (2002). Fraud classification using principle component analysis of Ridits. Journal of Risk & Insurance 69(3): 341–371] which has been shown to effectively identify fraudulent claims without the need for a training sample. The method can thus easily be applied by microinsurers to assist in the detection of claims fraud. While this method of fraud detection is not without limitations, it may provide a pragmatic and cost-effective way for microinsurers to begin tackling claims fraud. In this paper, the method is clearly explained by means of a worked example to help microinsurers implement the method at low cost.

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LOWTHER, MICHAEL W; MORT, J W T. *Towards best practice in the actuarial assessment of claims for maintenance against deceased estates*. 127–141. This paper begins to record best practice in the actuarial assessment of claims for maintenance against deceased estates in South Africa. Although this is a small field of actuarial practice, it is in the public interest that generally accepted standards be agreed upon. The paper applies an actuarial quality framework to identify aspects of the field, and then populates each aspect from the actuarial and legal experience respectively of the authors, and their interactions with other practitioners.

RANCHOD, S; CHILDS, B; ABRAHAM, M; TAYLOR, R. *International benchmarking of hospital utilisation: how does the South African private sector compare?* 69–90. We benchmark the hospital-inpatient admission rates and average length of stay of the South African medical scheme population against a set of international comparators. Such a comparison is useful in developing reasonable expectations of the utilisation achievable in the private-hospital sector in South Africa, and as a means of identifying unusual characteristics of the South African environment. Such comparisons should be done on a like-for-like basis, and explicitly adjusted for differences in data definitions, patient demographics and clinical case mix. Structural differences between countries must be considered in interpreting results. We use an economic basis for determining the comparator set rather than a health-systems basis. Detailed case-mix data by country is not available so demographic and broad disease-grouping categories are used as proxies. A further limitation is that day cases are excluded. Considering two separate data sources, South Africa appears to have relatively high admission rates with low average lengths of stay. On a combined basis, the bed days used per 1 000 medical scheme beneficiaries for South Africa appears near the lower end of the spectrum, which suggests that the South African private sector is making relatively efficient use of its hospital resources.

SMITH, M L; BEYERS, F J C; DE VILLIERS, J P. *A method of parameterising a feed forward multi-layered perceptron artificial neural network, with reference to South African financial markets*. 35–67. Abstract: No analytic procedures currently exist for determining optimal artificial neural network structures and parameters for any given application. Traditionally, when artificial neural networks have been applied to financial modelling problems, structure and parameter choices are often made a priori without sufficient consideration of the effect of such choices. A key aim of this study is to develop a general method that could be used to construct artificial neural networks by exploring the model structure and parameter space so that informed decisions could be made relating to the model design. In this study, a formal approach is followed to determine suitable structures and parameters for a Feed Forward Multi-layered Perceptron artificial neural network with a Resilient Propagation learning algorithm with a single hidden layer. This approach is demonstrated through the modelling of four South African economic variables, namely the average monthly returns on the money, bond and equity markets as well as monthly inflation. Artificial neural networks can be constructed on the aforementioned variables in isolation or, jointly, in an integrated model. The performance of a range of more traditional time series models is compared with that of the artificial neural network models. The results suggest that, on a statistical level, artificial neural networks perform as well as time series models at forecasting the returns for financial markets. Hybrid models, combining artificial neural networks with the time series models, are constructed, trained and tested for the money market and for the rate of inflation. They appear to add value to the time series models when forecasting inflation, but not for the money market.

STRYDOM, M; CORUBOLO, D; NEL, C. *Changes in mortality of people living with HIV in South Africa and their potential implications for life assurers*. 1–33. This research investigates the

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impact of improved (and improving) mortality experience in South Africa as a result of the increased (and increasing) access to antiretroviral treatment on South African life assurers, the entry-level insurance market and the wider South African economy. The research focuses on various potential impacts on the entry-level insurance market, including new business profitability, product development and pricing, market penetration and the potential for increased savings. This research has been done with the assistance of four of the main South African life offices and also draws on the new THEMBISA AIDS model on which a working paper has been produced. The research is based on the THEMBISA model in order to investigate the potential impact of alternative mortality scenarios on typical entry-level products within the industry where the scenarios have been based on actual current and proposed antiretroviral roll-out strategies by the Department of Health. Potential improvements to profitability, premium reductions, benefit enhancements and cashback benefits are quantified using a profit test model for entry-level market products.

VAN ZYL, N; VAN ZYL, D D J. *The impact of behavioural economics and finance on retirement provision*. 91–125. The significant shift from defined benefit to defined contribution retirement funds in South Africa has led to many fund members bearing responsibility for a range of risks. Many of these risks, such as those related to investment, longevity and cognitive deterioration are unavoidable. Another category of risk is that related to the choices made by government, employers, trustees, advisors and/or individuals at either national, scheme or individual level. These choices may also pose a threat to a member's financial wellbeing in retirement. Behavioural economics and finance helps to explain the choices made by these stakeholders in the retirement industry. The authors explain this concept in the context of industry stakeholders and the unique South African economic and demographic landscape, focusing on defined contribution retirement funds. Key behavioural insights applicable to the retirement industry are explored and, where practical, illustrated by stakeholder behaviour. Possible ways to harness these insights in order to improve retirement wellbeing are then discussed.

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Variance

9(1), 2015

ADLER, AVRAHAM. *Estimating the parameter risk of a loss ratio distribution – revisited*. 114–139. When building statistical models to help estimate future results, actuaries need to be aware that not only is there uncertainty inherent in random events (process risk), there is also uncertainty inherent in using a finite sample to parameterize the models (parameter risk). This paper revisits Van Kampen (2003) in replicating its bootstrap method and compares it with measures of parameter uncertainty developed using maximum likelihood estimation and Bayesian MCMC analysis.

ADLER, AVRAHAM. *A survey of approaches to a changepoint problem in an actuarial context*. 64–100. A representative data set is used to provide an example comparing classical and Bayesian approaches to making inferences about the point in a sequence of random variables at which the underlying distribution may shift. Inferences about the underlying distributions themselves are also made. Most of the underlying 'R' code used in the analysis is shown in the appendix.

EVANS, JONATHAN PALMER. *The recent review and changes to the National Council on Compensation Insurance's individual risk experience rating plan.* 36–53. NCCI recently completed an extended review of its Experience Rating (ER) Plan. Although no major changes had been made for many years, testing indicated that ER Plan performance was still generally good. The primary cause of deteriorating performance was the use of a fixed split point between primary and excess losses while average claim severity increased dramatically. The review process uncovered many interesting facets of actuarial methodology related to experience rating, but the changes coming out of the review did not fundamentally change the structure of the plan. NCCI has implemented an increase in the split point from $5,000 to $15,000+ inflation (over three years), and subsequent procedures to periodically increase the split point in the future corresponding to an index of claim severity. Along with the split point increase, the maximum cap on modification factors was changed. As part of the review, NCCI also made changes to several components of the calculation of primary and excess experience period expected losses to conform to changes in NCCI's class ratemaking procedures. A well-constructed experience rating plan can perform very well for a very long time with appropriate indexation applied to components. Simplicity, consistency, transparency, and an automatic indexation are particularly important for industry-wide bureau plans such as the NCCI Experience Rating Plan.

HONG, LIANG. *Discussion paper: "The mathematics of excess losses"* 11–19. My congratulations to Mr. Leigh J. Halliwell on his paper (2013) [Halliwell, L. J. (2013), The mathematics of excess losses, Variance 6: 32–47] that clearly presents the mathematics of excess losses with an interesting example. I agree with him that the mathematics of excess losses is beautiful and powerful. However, the mathematics of excess losses also contains several subtle points that are not mentioned in the paper. This discussion note complements the article by clarifying some of these points. To be clear, it is not my intention to be critical of Mr. Halliwell. The purpose of this note is two-fold: 1. To clarify some important hidden points in the mathematics of excess losses; 2. To give references to some uncredited results. For those ambitious actuaries who want to dig deeper for a full understanding of the rigorous mathematics of excess losses, this note also provides some directions for further studies. For the convenience of readers, we will adopt the notations in Halliwell (2013). Throughout this note, X will denote a nonnegative random variable. F and G will denote the cumulative distribution function (CDF) and survival function of X, respectively.

LI, Z MING; FERRARA, PAUL GREGORY. *Advances in common shock modeling.* 20–35. In this paper we rigorously investigate the common shock, or contagion, model, for correlating insurance losses. In addition, we develop additional theory which describes how the common shock model can be incorporated within a larger set of distributions. We also address the issue of calibrating contagion models to empirical data. To this end, we propose several procedures for calibrating contagion models using real-world industry data. Finally, we demonstrate the efficacy, and efficiency, of these calibration procedures by calibrating aggregate loss models, which incorporate contagion. Further, the case study illustrates the power of contagion modeling by demonstrating how the introduction of contagion can correct for the short-comings of traditional collective risk modeling.

LO, JOSEPH; PATEL, NITA B; CALDER, ALAN. *Judgmental topics in P&C companies: findings from a prediction survey.* 101–113. Interaction with actuarial models by both actuaries and non-actuaries is inevitable and requires careful study so that these models may better serve their purpose. Yet empirical and scientific investigations into how experts make their judgments are rarely reported in actuarial science literature. This paper discusses findings from a prediction

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survey, whose 120 respondents in a global Property and Casualty ("P&C") company were nearly evenly split between underwriters and analysts (e.g., actuaries, risk managers, and finance). The hypothesis that underwriters and analysts tend to give different quantitative judgments under similar levels of information and incentivization was tested. Of the four one-step prediction problems, none gave evidence to support this hypothesis.

TZOUGAS, GEORGE; VRONTOS, SPYRIDON D; FRANGOS, NICHOLAS E. *Risk classification for claim counts and losses using regression models for location, scale and shape*. 140–157. This paper presents and compares different risk classification models for the frequency and severity of claims employing regression models for location, scale and shape. The differences between these models are analyzed through the mean and the variance of the annual number of claims and the costs of claims of the insureds, who belong to different risk classes and interesting results about claiming behavior are obtained. Furthermore, the resulting a priori premiums rates are calculated via the expected value and standard deviation principles with independence between the claim frequency and severity components assumed.

VENTER, GARY G; SAHASRABUDDHE, RAJESH V. *A note on parameter risk*. 54–63. Consideration of parameter risk is particularly important for actuarial models of uncertainty. That is because – unlike process risk – parameter risk does not diversify when modeling a large volume of independent exposures. Without consideration of parameter risk, decision makers may be tempted to underwrite higher volumes as a result of the apparent high degree of predictability in the mean outcome. However, the financial impact of parameter error is magnified by volume and doing so could have significant consequences for the firm. In this paper, we present an inventory of uncertainty models associated with various approaches that actuaries use in estimating model parameters.

Variance

9(2), 2015

BOOR, JOSEPH A. *The credibility of the overall rate indication: making the theory work*. 167–186. Actuaries have used the so-called "square root rule" for the credibility for many years, even though the "F" value can take any value, and its assumption that the data receiving the complement of credibility is stable is often violated. Best estimate credibility requires fewer or no assumptions, but often requires certain key constants. This paper provides a variety of methods for estimating the key constants needed to implement best estimate credibility formulas, especially those arising from the Gerber-Jones formula. As such, this paper provides the tools needed to implement key theoretical formulas in practical actuarial work.

ERHARDT, ROBERT J. *Incorporating spatial dependence and climate change trends for measuring long-term temperature derivative risk*. 213–226. In this paper we explore a method to model the financial risks of holding portfolios of long-term temperature derivatives for any subset of the 30 North American cities whose derivatives are actively traded on the Chicago Mercantile Exchange (CME). Long-term derivatives are those whose period of accrual for degree days is substantially longer than the temporal auto correlation of daily temperature data, and therefore accruals can be modeled with a multivariate normal distribution. One commonly traded temperature derivative on the CME has a 6-month index period, which satisfies this long-term condition. The method presented incorporates spatial dependence among the cities, and allows for possible trends in degree days due to climate change. Though limited to long-term contracts,

the method is mathematically and computationally quite simple and applicable to some of the most commonly traded temperature derivatives. Possible implications for the insurance industry are discussed.

EVANS, JONATHAN PALMER. *A continuous version of Sherman's inverse power curve model with simple cumulative development factor formulas*. 187–195. A continuous version of Sherman's discrete inverse power curve model for loss development is defined. This continuous version, apparently unlike its discrete counterpart, has simple formulas for cumulative development factors, including tail factors. The continuous version has the same tail convergence conditions and basic analytical properties as the discrete version. Parameter fitting and numerical comparisons between the discrete and continuous model versions are explored.

EVANS, JONATHAN PALMER. *Tail factor convergence in Sherman's inverse power curve loss development factor model*. 227–233. The infinite product of the age-to-age development factors in Sherman's inverse power curve model is proven to converge to a finite number when the power parameter is less than?1, and alternatively to diverge to infinity when the power parameter is?1 or greater. For the convergent parameter values, a simple formula is derived, in terms of any finite product of age-to-age factors, for the endpoints of an interval containing the limit of the infinite product. These endpoints converge to the limit as the finite time cutoff point increases. For any finite time cutoff, the product of age-to-age factors lies below the interval, and thus the lower endpoint of the interval is always a better estimate of the limit than the finite product itself. Several numerical examples are included for illustration. The convergence condition and the interval formula are applicable to the selection of a finite cutoff age, review of the reasonability of the convergence rate, and actual numerical calculations of the tail factor.

FERRARA, PAUL GREGORY; PARSA, RAHUL A; WEAVER, BRYCE A. *A linear approximation to copula regression*. 256–269. Recently, Parsa and Klugman (2011) [Parsa, R and Klugman, S A (2011), Copula regression, Variance 5: 45–54] proposed a generalization of ordinary least squares regression, which they called copula regression. Though theoretically appealing, implementation, especially calibration, of copula regression is generally more involved than for generalized linear models. In this paper a linear approximation to copula regression, for which implementation is similar to that for least squares regression, will be introduced. We proceed by investigating the connection between the proposed approximation to copula regression, and copula regression itself. In particular, we develop a set of criteria which ensure a predictable bias in the estimates from the linear approximation to copula regression.

MOEHRING, MARQUIS JACOB. *PEBELS: Policy exposure based excess loss smoothing*. 234–255. PEBELS is a method for estimating the expected loss cost for each loss layer of an individual property risk regardless of size. By providing maximum resolution in estimating layer loss costs, PEBELS facilitates increased accuracy and sophistication in many actuarial pricing applications such as ratemaking, predictive modeling, catastrophe modeling, and reinsurance pricing. The existing actuarial literature provides methods for estimating high layer loss cost for credible property portfolios in aggregate, but does not provide a method to produce similar provisions for smaller non-credible risks. PEBELS generalizes existing reinsurance pricing theory, and leverages increasingly available exposure data to fill that void.

WANG, SHAUN S; CHEN, HAN. *Actuarial values of housing markets*. 196–212. This paper discusses a methodology of calculating actuarial housing values, with the goal of helping

mortgage lenders to gauge departures of housing market values from the fundamentals, and assisting policymakers with tools for implementing counter-cyclical policies. The methodology calculates actuarial values by employing a control mechanism on the metro level housing price index so that it doesn't deviate too high or too low from the fundamentals. The control mechanism is achieved by incorporating macro, micro, and metro-specific data on the economic and demographic factors that affect supply and demand.

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