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Geneva Papers on Risk and Insurance

36 (2), 2011

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

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

CHUNG-FERN, R.; WEN-HSIN, H. *Value relevance of embedded value and IFRS 4 insurance contracts.* 283-303. In light of the recent exodus of foreign insurers from Taiwan and the local insurers' outcries against the International Financial Reporting Standard (IFRS) 4 Insurance Contracts, we examine the value relevance of financial statements for life insurance firms, with particular interests to the embedded value (EV) disclosure. We find that the EV of equity has an incremental information role for book value of equity, which indicates that the accounting

mismatching problem in the insurance industry creates a demand for fair value accounting. The fair value of liabilities under IFRS 4 Phase 2 has been disputed globally by accountants, actuaries, academia and regulators. The EV model is a concept approaching the fair value model. The research findings provide important empirical evidences supporting the fair value concept of IFRS 4.

FLOREANI, AO. *Risk margin estimation through the cost of capital approach: some conceptual issues*. 226-253. The Solvency II directive requires that insurance liabilities are valued using a best estimate plus a risk margin. The risk margin should be estimated using the cost of capital approach, that is the cost of the solvency capital requirement—which is computed through a value at risk measure—needed to support the insurance obligation until settlement. The unitary cost of capital applied to the future capital requirement should be fixed. This paper deals with conceptual issues relating to the risk margin estimate through the cost of capital approach. It shows that the Solvency II specification of the methodology is consistent with financial economics. However, the theoretical framework required (a frictionless and normally distributed world) is too far-fetched to be acceptable. Even if these conditions were satisfied, a variable unitary cost of capital must be used.

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

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

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

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36 (3), 2011

ALTUNTAS, M.; BERRY-STÖLZLE, T. R.; HOYT, R. E. *Implementation of enterprise risk management: evidence from the German property-liability insurance industry*. 414-439. Implementing a properly functioning enterprise risk management (ERM) programme has become increasingly important for insurance companies. Unlike traditional risk management where individual risks are managed in separate silos, ERM is based on the concept of managing all relevant risks in an integrated, holistic fashion. ERM has also been growing in importance as a result of increased attention on risk management in the context of corporate governance. A recent report by The Geneva Association identified strengthening “risk management practices” as one of three key measures that “aim to strengthen financial stability”. Despite the heightened interest in ERM by insurance managers and actuaries, there is only limited empirical evidence on how insurance companies actually implement the ERM approach. The goal of our research is to examine the implementation of the ERM components by insurers. Therefore, we surveyed all German property-liability insurance companies with premiums written in excess of 40 million euros. There are 113 such insurers and 95 of them participated in our survey, leading to a response rate of 84 per cent. The questionnaire covers a comprehensive set of dimensions of an ERM system. In addition to detailed questions about specific ERM activities, the questionnaire assesses when these ERM activities were initiated. The results document significant increases in the extent to which ERM is being implemented by these firms and details the sequence of implementation of this evolving risk management process.

ASHBY, S. *Risk management and the global banking crisis: lessons for insurance solvency regulation*. 330-347. This paper investigates the causes of the banking crisis and the resulting lessons that need to be learned for insurance regulation. The paper argues that the banking crisis was predominantly caused by weaknesses in the management and regulation of banks, weaknesses that lead to problems such as flawed compensation schemes, poor risk management communication and an over-reliance on mathematical risk models. On the basis of these findings, doubts are expressed about the direction of certain insurance regulatory reforms—such as the focus on capital requirements and quantitative risk assessment (the so-called “Pillar I” of most reforms). It is also recommended that a more balanced approach to insurance regulation should be implemented, which places much greater emphasis on enhancing risk management guidance and supervisory tools (Pillar II) and improving disclosure rules (Pillar III).

BARANOFF, E. G.; SAGER, T. W. *The interplay between insurers’ financial and asset risks during the crisis of 2007-2009*. 348-379. In this study we compare the interplay between capital and asset risks before and during the 2007–2009 financial crisis for the U.S. life and health insurance industries partitioned into segments by product specialisation, size and governance. The results show substantial intra-industry variation in the partial elasticity of capital with respect to asset risk, as well as significant impact of the crisis. Segment variation was driven by product focus. Most notable is the greater impact of the crisis on the U.S. insurers specialising in annuities (least risky product) than on specialists in health lines (riskiest product). During the crisis, the elasticity between asset risk and capital declined for all segments indicating that insurers’ operation may have shifted from offsetting risk to seeking risk.

EL MEKKAOUI DE FREITAS, N.; DUC, C.; BRIARD, K.; MAGE, S.; LEGENDRE, B. *Career interruptions: how do they impact pension rights?* 440-457. The aim of this article is to analyse the question of career interruptions and to evaluate their impact on pension retirement for French private

sector workers. Using the last French survey on households' wealth (2003–2004), we first study the career set-backs for individuals born between 1937 and 1949. We highlight the new trends in professional paths. The risk of unemployment and job flexibility has sharply risen. As a consequence, some cohorts appear to be more exposed to career interruptions. Second, we determine how pension rights for French employees are affected by different career accidents. We consider unemployment, part-time employment and inactivity periods. Our results show how, by compensating for some career accidents, the French legislation allows individuals to receive, in some cases, the same level of social security pension that they would have received with a smooth professional path.

HANEWALD, K.; POST, T.; GRÜNDL, H. *Stochastic mortality, macroeconomic risks and life insurer solvency*. 458-475. Motivated by a recent demographic study establishing a link between macroeconomic fluctuations and the mortality index 'kt' in the Lee–Carter model, we develop a dynamic asset-liability model to assess the impact of macroeconomic fluctuations on the solvency of a life insurance company. Liabilities in this stochastic simulation framework are driven by a GDP-linked variant of the Lee–Carter mortality model. Furthermore, interest rates and stock prices react to changes in GDP, which itself is modelled as a stochastic process. Our simulation results show that insolvency probabilities are significantly higher when the reaction of mortality rates to changes in GDP is incorporated.

HÖRING, D.; GRÜNDL, H. *Investigating risk disclosure practices in the European insurance industry*. 380-413. In light of the upcoming Solvency II Pillar 3 disclosure regulation for the insurance industry, this paper explores the risk disclosure practices in annual reports of European primary insurers in the Dow Jones Stoxx 600 Insurance Index between 2005 and 2009. On the basis of a self-constructed risk disclosure index, the study examines the relation between the extent of risk disclosure and insurance companies' characteristics such as size, risk, profitability, ownership dispersion, cross-listing, home country and type of insurance sold, to draw inferences regarding motives for enhanced risk disclosure based on positive accounting theory.

LIEDTKE, P. M. *Editorial: Rules of engagement: global regulatory reforms and the insurance industry*. 325-329.

OUTREVILLE, J.-F. *The Geneva Risk and Insurance Review 2010: we have learned much since Willett and Knight*. 476-487. The purpose of this paper is to review and summarise the papers published in The Geneva Risk and Insurance Review in 2010. Historical reference to Willett and Knight is emphasised to illustrate the importance of risk and uncertainty in our modern economies and how it is still the starting point of economic research not only in public finance as proposed by Agnar Sandmo [Uncertainty in the theory of public finance, Geneva Risk and Insurance Review (2010) 35(1):1-18] but also in other papers published in this volume. Many issues touch upon anomalies like adverse selection, asymmetric information, moral hazard and rating restrictions that can influence the performance of insurance markets. These issues are of particular relevance for insurers and the proper functioning of insurance markets.

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BLAKE, D.; COURBAGE, C.; MACMINN, R.; SHERRIS, M. *Editorial: Longevity risk and capital markets: the 2010-2011 update*. 489-500.

- GAILLE, S.; SHERRIS, M. *Modelling mortality with common stochastic long-run trends*. 595-621. Modelling mortality and longevity risk is critical to assessing risk for insurers issuing longevity risk products. It has challenged practitioners and academics alike because of first the existence of common stochastic trends and second the unpredictability of an eventual mortality improvement in some age groups. When considering cause-of-death mortality rates, both aforementioned trends are additionally affected by the cause of death. Longevity trends are usually forecasted using a Lee-Carter model with a single stochastic time series for period improvements, or using an age-based parametric model with univariate time series for the parameters. We assess a multivariate time series model for the parameters of the Heligman-Pollard function, through Vector Error Correction Models which include the common stochastic long-run trends. The model is applied to circulatory disease deaths in U.S. over a 50-year period and is shown to be an improvement over both the Lee-Carter model and the stochastic parameter ARIMA Heligman-Pollard model.
- HUANG, H.-C.; WANG, C.-W.; MIAO, Y.-C. *Securitisation of crossover risk in reverse mortgages*. 622-647. When the outstanding balance exceeds the housing value before the loan is settled, the insurer suffers an exposure to crossover risk induced by three risk factors: interest rates, house prices and mortality rates. With consideration of housing price risk, interest rate risk and longevity risk, we provide a three-dimensional lattice method that simultaneously captures the evolution of housing prices and short-term interest rates to calculate the fair valuation of reverse mortgages numerically. For a reverse mortgage insurer, the premium structure of reverse mortgage insurance is determined by setting the present value of the total expected claim losses equal to the present value of the premium charges. However, when the actual loss is higher than the expected loss, the insurer will incur an unexpected loss. To offset the potential loss, we also design two types of crossover bonds to transfer the unexpected loss to bond investors. Therefore, through the crossover bonds, reverse mortgage insurers can partially transfer crossover risk onto bond holders.
- LANE, M. *Longevity risk from the perspective of the ILS markets*. 501-515. This paper compares and contrasts the evolution of the longevity risk transfer market with the development of the Catastrophe Bond Market, more formally known as the Insurance Linked Securities (ILS) Market. The ILS market is small; the longevity market is potentially enormous. The ILS market has been around for some 15 years; the Longevity market less than 5 years. The ILS market has had a heterogeneous approach to loss measures; the longevity market has striven for homogeneity. The ILS market has used security, i.e. bond, structures; the longevity market uses derivative, i.e. swap, structures. Nearly all ILS transactions cover “event” risk; nearly all longevity structures are “aggregate”. The paper reflects on these and other differences and speculates on the nature of the two approaches.
- MAZONAS, P. M.; STALLARD, P. J. E.; GRAHAM, L. *Longevity risk in fair valuing level 3 assets in securitised portfolios*. 516-543. Fair value accounting aims to establish a three-level hierarchy that distinguishes (1) readily observable measurement inputs from (2) less readily observable measurement inputs and (3) unobservable measurement inputs. Level 3 longevity valued assets will pose unique valuation risks once securitised pools of these alternative asset classes come to market as investment vehicles for pension plans and individual retirement accounts. No uniform framework is available to assure consistent fair market valuation and transparency for investor decision-making. Applying existing international auditing standards and analytical procedures (IFRS 13) will offer a platform upon which fund managers, their auditors and actuaries can

agree upon uniform valuation and presentation guidelines. Application of these quasi-governmental standards will bring future liquidity to otherwise illiquid capital market instruments. This paper presents a valuation methodology consistent with fair value accounting and auditing standards. The methodology incorporates the longevity predictive modelling of Stallard in a form that is compatible with Bayes Factor weighted average valuation techniques based on the study by Kass and Raftery. The methodology is applicable to fair valuation of life settlement portfolios where the combination of too few large death benefit policies and large variances in individual life expectancy estimates currently challenge accurate valuation and periodic re-valuation.

WANG, C.-W.; HUANG, H.-C.; LIU, I.-C. *A quantitative comparison of the Lee-Carter Model under different types of non-Gaussian innovations*. 675-696. In the classical Lee-Carter model, the mortality indices that are assumed to be a random walk model with drift are normally distributed. However, for the long-term mortality data, the error terms of the Lee-Carter model and the mortality indices have tails thicker than those of a normal distribution and appear to be skewed. This study therefore adopts five non-Gaussian distributions – Student's t-distribution and its skew extension (i.e., generalised hyperbolic skew Student's t-distribution), one finite-activity Lévy model (jump diffusion distribution), and two infinite-activity or pure jump models (variance gamma and normal inverse Gaussian)—to model the error terms of the Lee-Carter model. With mortality data from six countries over the period 1900–2007, both in-sample model selection criteria (e.g., Bayesian information criterion, Kolmogorov–Smirnov test, Anderson–Darling test, Cramér–von-Mises test) and out-of-sample projection errors indicate a preference for modelling the Lee-Carter model with non-Gaussian innovations.

WANG, J. L.; HSIEH, M.-H.; CHIU, Y.-F. *Using reverse mortgages to hedge longevity and financial risks for life insurers: a generalised immunisation approach*. 697-717. The launch of new innovative longevity-linked products, such as reverse mortgages, increases the complexity and challenges faced by insurers in implementing an asset-liability management strategy. With the house price dynamic and a large final payment received at the end of the policy year, a reverse mortgage provides a different liability duration pattern from an annuity. In this paper, we propose a generalised immunisation approach to obtain an optimal product portfolio for hedging the longevity and financial risks of life insurance companies. The proposed approach does not rely on specific assumptions regarding mortality models or interest rate models. As long as the scenarios generated by the adopted models are highly correlated, the proposed approach should be effective. By using stochastic mortality and interest rate models and the Monte Carlo simulation approach, we show that the proposed generalised immunisation approach can serve as an effective vehicle to control the aggregate risk of life insurance companies. The numerical results further demonstrate that adding the reverse mortgage to the insurers' product portfolio creates a better hedging effect and effectively reduces the total risk associated with the surplus of the life insurers.

YANG, S. S. *Securitisation and tranching longevity and house price risk for reverse mortgage products*. 648-674. Reverse mortgage (RM) products are growing increasingly popular in many developed countries. This article designs a tranching security to deal with longevity and house price risks for RM products. The securitisation structure for RM products, the collateralised reverse mortgage obligation (CRMO), is similar to that for the collateralised debt obligation (CDO). However, unlike the CDO, the CRMO takes into account the dynamics of future mortality rates and house price returns instead of the default rate. To capture longevity risk for RM borrowers, this study employs the CBD model to project future mortality rates, as well as

compares these results with those from the Lee-Carter model and static mortality table. The house price return dynamics is modelled using an ARMA-GARCH process. The calculation of fair spreads of CRMO in different tranches is illustrated under the risk-neutral valuation framework. On the basis of mortality experience and the programme of Home Equity Conversion Mortgage in the United States, this research demonstrates the problems of using static mortality tables and models risk for pricing fair spreads for CRMO numerically.

YUE, C.-S. J.; HUANG, H.-C. *A study of incidence experience for Taiwan life insurance*. 718-733.

Mortality improvement has become a major issue in ratemaking for insurance companies, and ratemaking is especially difficult in Taiwan. There are two reasons for this difficulty: population size and rapid improvement in mortality. Because the history of life insurance in Taiwan is relatively short, all life insurance products are typically offered based on the same experience life table, which is constructed based on the population purchasing all types of life insurance products in Taiwan. In this study, we used experience data from Taiwan life insurance companies to explore whether there are risk factors related to mortality rates. The experience data will also be used to evaluate whether the customers of life insurance companies possess mortality patterns similar to that of the overall population in Taiwan.

ZHOU, R.; LI, J. S.-H.; TAN, K. S. *Economic pricing of mortality-linked securities in the presence of population basis risk*. 544-566.

Standardised mortality-linked securities are easier to analyse and more conducive to the development of liquidity. However, when a pension plan relies on standardised instruments to hedge its longevity risk exposure, it is inevitably subject to various forms of basis risk. In this paper, we use an economic pricing method to study the impact of population basis risk, that is, the risk due to the mismatch in the populations of the exposure and the hedge, on prices of mortality-linked securities. The pricing method we consider is highly transparent, allowing us to understand how population basis risk affects the demand and supply of a mortality-linked security. We apply the method to a hypothetical longevity bond, using real mortality data from different populations. Our illustrations show that, interestingly, population basis risk can affect the price of a mortality-linked security in different directions, depending on the properties of the populations involved.

ZHU, N.; BAUER, D. *Applications of forward mortality factor models in life insurance practice*. 567-594.

Two of the most important challenges for the application of stochastic mortality models in life insurance practice are their complexity and their apparent incompatibility with classical life contingencies theory, which provides the backbone of insurers' Electronic Data Processing systems. Forward Mortality Factor Models comprise one model class that overcomes these challenges. Relying on a simple model version that originates from a semi-parametric estimation based on British population mortality data, this paper demonstrates the merits of this model class by discussing several practically important example applications. In particular, we calculate the Economic Capital for a stylised life insurer, we present a closed-form solution for the value of a Guaranteed Annuity Option, and we derive the fair option fee for a Guaranteed Minimum Income Benefit within a Variable Annuity contract. Our numerical results illustrate the economic significance of systematic mortality risk.

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

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

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

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

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Insurance: Mathematics & Economics

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BEIRLANT, J.; DIERCKX, G.; GUILLOU, A. *Bias-reduced estimators for bivariate tail modelling*. 18-26. Ledford and Tawn (1997) introduced a flexible bivariate tail model based on the coefficient of tail dependence and on the dependence of the extreme values of the random variables. In this paper, we extend the concept by specifying the slowly varying part of the model as done by Hall (1982) with the univariate case. Based on Beirlant et al. (2009), we propose a bias-reduced estimator for the coefficient of tail dependence and for the estimation of small tail probabilities. We discuss the properties of these estimators via simulations and a real-life example. Furthermore, we discuss some theoretical asymptotic aspects of this approach.

BJÖRKWALL, S.; HÖSSJER, O.; OHLSSON, E.; VERRALL, R. *A generalized linear model with smoothing effects for claims reserving*. 27-37. In this paper, we continue the development of the ideas introduced in England and Verrall (2001) by suggesting the use of a reparameterized version of the generalized linear model (GLM) which is frequently used in stochastic claims reserving. This model enables us to smooth the origin, development and calendar year parameters in a similar way as is often done in practice, but still keep the GLM structure. Specifically, we use this model structure in order to obtain reserve estimates and to systemize the model selection procedure that arises in the smoothing process. Moreover, we provide a bootstrap procedure to achieve a full predictive distribution.

BROEDERS, D.; CHEN, A.; KOOS, B. *A utility-based comparison of pension funds and life insurance companies under regulatory constraints*. 1-10. This paper compares two different types of annuity providers, i.e. defined benefit pension funds and life insurance companies. One of the key differences is that the residual risk in pension funds is collectively borne by the beneficiaries and the sponsor's shareholders while in the case of life insurers it is borne by the external shareholders. First, this paper employs a contingent claim approach to evaluate the risk return tradeoff for annuitants. For that, we take into account the differences in contract specifications and in regulatory regimes. Second, a welfare analysis is conducted to examine whether a consumer with power utility experiences utility gains if she chooses a defined benefit plan or a life annuity contract over a defined contribution plan. We demonstrate that regulation can be designed to support a level playing field amongst different financial institutions.

DIKO, P.; USÁBEL, M. *A numerical method for the expected penalty-reward function in a Markov-modulated jump-diffusion process*. 126-131. A generalization of the Cramér-Lundberg risk model perturbed by a diffusion is proposed. Aggregate claims of an insurer follow a compound Poisson process and premiums are collected at a constant rate with additional random fluctuation. The insurer is allowed to invest the surplus into a risky asset with volatility dependent on the level of the investment, which permits the incorporation of rational investment strategies as proposed by Berk and Green (2004). The return on investment is modulated by a Markov process which generalizes previously studied settings for the evolution of the interest rate in time. The Gerber-Shiu expected penalty-reward function is studied in this context, including ruin probabilities (a first-passage

problem) as a special case. The second order integro-differential system of equations that characterizes the function of interest is obtained. As a closed-form solution does not exist, a numerical procedure based on the Chebyshev polynomial approximation through a collocation method is proposed. Finally, some examples illustrating the procedure are presented.

GATZERT, N.; KELLNER, R. *The influence of non-linear dependencies on the basis risk of industry loss warranties*. 132-144. Index-linked catastrophic loss instruments represent an alternative to traditional reinsurance to hedge against catastrophic losses. The use of these instruments comes with benefits, such as a reduction of moral hazard and higher transparency. However, at the same time, it introduces basis risk as a crucial key risk factor, since the index and the company's losses are usually not fully dependent. The aim of this paper is to examine the impact of basis risk on an insurer's solvency situation when an industry loss warranty contract is used for hedging. Since previous literature has consistently stressed the importance of a high degree of dependence between the company's losses and the industry index, we extend previous studies by allowing for non-linear dependencies between relevant processes (high-risk and low-risk assets, insurance company's loss and industry index). The analysis shows that both the type and degree of dependence play a considerable role with regard to basis risk and solvency capital requirements and that other factors, such as relevant contract parameters of index-linked catastrophic loss instruments, should not be neglected to obtain a comprehensive and holistic view of their effect upon risk reduction.

GRAF, S.; KLING, A.; RUß, J. *Risk analysis and valuation of life insurance contracts: combining actuarial and financial approaches*. 115-125. In this paper, we analyze traditional (i.e. not unit-linked) participating life insurance contracts with a guaranteed interest rate and surplus participation. We consider three different surplus distribution models and an asset allocation that consists of money market, bonds with different maturities, and stocks. In this setting, we combine actuarial and financial approaches by selecting a risk minimizing asset allocation (under the real world measure P) and distributing terminal surplus such that the contract value (under the pricing measure Q) is fair. We prove that this strategy is always possible unless the insurance contracts introduce arbitrage opportunities in the market. We then analyze differences between the different surplus distribution models and investigate the impact of the selected risk measure on the risk minimizing portfolio.

LEUNG, A. P. *Reactive investment strategies*. 89-99. Asset liability management is a key aspect of the operation of all financial institutions. In this endeavor, asset allocation is considered the most important element of investment management. Asset allocation strategies may be static, and as such are usually assessed under asset models of various degrees of complexity and sophistication. In recent years attention has turned to dynamic strategies, which promise to control risk more effectively. In this paper we present a new class of dynamic asset strategy, which respond to actual events. Hence they are referred to as 'reactive' strategies. They cannot be characterized as a series of specific asset allocations over time, but comprise rules for determining such allocations as the world evolves. Though they depend on how asset returns and other financial variables are modeled, they are otherwise objective in nature. The resulting strategies are optimal, in the sense that they can be shown to outperform all other strategies of their type when no asset allocation constraints are imposed. Where such constraints are imposed, the strategies may be demonstrated to be almost optimal, and dramatically more effective than static strategies.

LI, J. S.-H.; CHAN, W.-S. *Time-simultaneous prediction bands: a new look at the uncertainty involved in forecasting mortality*. 81-88. Conventionally, isolated (point-wise) prediction

intervals are used to quantify the uncertainty in future mortality rates and other demographic quantities such as life expectancy. A pointwise interval reflects uncertainty in a variable at a single time point, but it does not account for any dynamic property of the time-series. As a result, in situations when the path or trajectory of future mortality rates is important, a band of pointwise intervals might lead to an invalid inference. To improve the communication of uncertainty, a simultaneous prediction band can be used. The primary objective of this paper is to demonstrate how simultaneous prediction bands can be created for prevalent stochastic models, including the Cairns–Blake–Dowd and Lee–Carter models. The illustrations in this paper are based on mortality data from the general population of England and Wales.

LI, X.; LIN, J. *Stochastic orders in time transformed exponential models with applications*. 47-52.

This paper studies expectations of a supermodular function of bivariate random risks following [Time Transformed Exponential] TTE models. Comparison of such expectations are conducted based on some stochastic orders of the involved univariate survival functions in the models, and also the upper orthant-convex order between two bivariate random risks in TTE models is built. This corrects Theorem 2.3 of Mulero et al. (2010) and invalidates some results there. Some applications in actuarial science are presented as well.

MA, Q.-P. *On “optimal pension management in a stochastic framework” with exponential utility*.

61-69. This paper reconsiders the optimal asset allocation problem in a stochastic framework for defined-contribution pension plans with exponential utility, which has been investigated by Battocchio and Menoncin [Battocchio, P., Menoncin, F., 2004. Optimal pension management in a stochastic framework. *Insurance: Mathematics and Economics*. 34, 79–95]. When there are three types of asset, cash, bond and stock, and a non-hedgeable wage risk, the optimal pension portfolio composition is horizon dependent for pension plan members whose terminal utility is an exponential function of real wealth (nominal wealth-to-price index ratio). With market parameters usually assumed, wealth invested in bond and stock increases as retirement approaches, and wealth invested in cash asset decreases. The present study also shows that there are errors in the formulation of the wealth process and control variables in solving the optimization problem in the study of Battocchio and Menoncin, which render their solution erroneous and lead to wrong results in their numerical simulation.

NGAI, A.; SHERRIS, M. *Longevity risk management for life and variable annuities: the effectiveness of static hedging using longevity bonds and derivatives*. 100-114.

For many years, the longevity risk of individuals has been underestimated, as survival probabilities have improved across the developed world. The uncertainty and volatility of future longevity has posed significant risk issues for both individuals and product providers of annuities and pensions. This paper investigates the effectiveness of static hedging strategies for longevity risk management using longevity bonds and derivatives (q-forwards) for the retail products: life annuity, deferred life annuity, indexed life annuity, and variable annuity with guaranteed lifetime benefits. Improved market and mortality models are developed for the underlying risks in annuities. The market model is a regime-switching vector error correction model for GDP, inflation, interest rates, and share prices. The mortality model is a discrete-time logit model for mortality rates with age dependence. Models were estimated using Australian data. The basis risk between annuitant portfolios and population mortality was based on UK experience. Results show that static hedging using q-forwards or longevity bonds reduces the longevity risk substantially for life annuities, but significantly less for deferred annuities. For inflation-indexed annuities, static hedging of longevity is less effective because of the inflation risk. Variable annuities provide

limited longevity protection compared to life annuities and indexed annuities, and as a result longevity risk hedging adds little value for these products.

RUSSO, V.; GIACOMETTI, R.; ORTOBELLI, S.; RACHEV, S.; FABOZZI, F. J. *Calibrating affine stochastic mortality models using term assurance premiums*. 53-60. In this paper, we focus on the calibration of affine stochastic mortality models using term assurance premiums. We view term assurance contracts as a “swap” in which policyholders exchange cash flows (premiums vs. benefits) with an insurer analogous to a generic interest rate swap or credit default swap. Using a simple bootstrapping procedure, we derive the term structure of mortality rates from a stream of contract quotes with different maturities. This term structure is used to calibrate the parameters of affine stochastic mortality models where the survival probability is expressed in closed form. The Vasicek, Cox–Ingersoll–Ross, and jump-extended Vasicek models are considered for fitting the survival probabilities term structure. An evaluation of the performance of these models is provided with respect to premiums of three Italian insurance companies.

SORDO, M. A.; SUAREZ-LLORENS, A. *Stochastic comparisons of distorted variability measures*. 11-17. In this paper, the authors consider the dispersive order and the excess wealth order to compare the variability of distorted distributions. We know from Sordo (2009a) that the excess wealth order can be characterized in terms of a class of variability measures associated to the tail conditional distribution which includes, as a particular measure, the tail variance. Given that the tail conditional distribution is a particular distorted distribution, a natural question is whether this result can be extended to include other classes of variability measures associated to general distorted distributions. As the authors show in this paper, the answer is yes, by focusing on distorted distributions associated to concave distortion functions. For distorted distributions associated to more general distortions, the characterizations are stated in terms of the stronger dispersive order.

TSAI, C. C.-L.; JIANG, L. *Actuarial applications of the linear hazard transform in life contingencies*. 70-80. In this paper, we study the linear hazard transform and its applications in life contingencies. Under the linear hazard transform, the survival function of a risk is distorted, which provides a safety margin for pricing insurance products. Combining the assumption of a-power approximation with the linear hazard transform, the net single premium of a continuous life insurance policy can be approximated in terms of the net single premiums of discrete ones. Moreover, Macaulay duration, modified duration and dollar duration, all measuring the sensitivity of the price of a life insurance policy to force of mortality movements under the linear hazard transform, are defined and investigated. Some examples are given for illustration.

ZENG, Y.; LI, Z. *Optimal time-consistent investment and reinsurance policies for mean-variance insurers*. 145-154. This paper investigates the optimal time-consistent policies of an investment-reinsurance problem and an investment-only problem under the mean-variance criterion for an insurer whose surplus process is approximated by a Brownian motion with drift. The financial market considered by the insurer consists of one risk-free asset and multiple risky assets whose price processes follow geometric Brownian motions. A general verification theorem is developed, and explicit closed-form expressions of the optimal policies and the optimal value functions are derived for the two problems. Economic implications and numerical sensitivity analysis are presented for our results. Our main findings are: (i) the optimal time-consistent policies of both problems are independent of their corresponding wealth processes; (ii) the two problems have the

same optimal investment policies; (iii) the parameters of the risky assets (the insurance market) have no impact on the optimal reinsurance (investment) policy; (iv) the premium return rate of the insurer does not affect the optimal policies but affects the optimal value functions; (v) reinsurance can increase the mean-variance utility.

ZHU, W. *Ambiguity aversion and an intertemporal equilibrium model of catastrophe-linked securities pricing*. 38-46. To explain several stylized facts concerning catastrophe-linked securities premium spread, the author proposes an intertemporal equilibrium model by allowing agents to act in a robust control framework against model misspecification with respect to rare events. The author has presented closed-form pricing formulas in some special cases and tested the model using empirical data and simulation.

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BAYRAKTAR, E.; HU, X.; YOUNG, V. R. *Minimizing the probability of lifetime ruin under stochastic volatility*. 194-206. The authors assume that an individual invests in a financial market with one riskless and one risky asset, with the latter's price following a diffusion with stochastic volatility. Given the rate of consumption, we find the optimal investment strategy for the individual who wishes to minimize the probability of going bankrupt. To solve this minimization problem, the authors use techniques from stochastic optimal control.

BO, L. *Exponential change of measure applied to term structures of interest rates and exchange rates*. 216-225. In this paper, we study the term structures of interest rates and foreign exchange rates through establishing a state-price deflator. The state-price deflator considered here can be viewed as an extension to the potential representation of the state-price density in [Rogers, L.C.G., 1997. The potential approach to the term structure of interest rates and foreign exchange rates. *Mathematical Finance* 7(2), 157-164]. We identify a risk-neutral probability measure from the state-price deflator by a technique of exponential change of measure for Markov processes proposed by [Palmowski, Z., Rolski, T., 2002. A technique for exponential change of measure for Markov processes. *Bernoulli* 8(6), 767-785] and present examples of several classes of diffusion processes (jump-diffusions and diffusions with regime-switching) to illustrate the proposed theory. A comparison between the exponential change of measure and the Esscher transform for identifying risk-neutral measures is also presented. Finally, we consider the exchange rate dynamics by virtue of the ratio of the current state-price deflators between two economies and then discuss the pricing of currency options.

HATZOPOULOS, P.; HABERMAN, S. *A dynamic parameterization modeling for the age-period-cohort mortality*. 155-174. An extended version of dynamic parametric model is proposed for analyzing mortality structures, incorporating the cohort effect. A one-factor parameterized exponential polynomial in age effects within the generalized linear models (GLM) framework is used. Sparse principal component analysis (SPCA) is then applied to time-dependent GLM parameter estimates and provides (marginal) estimates for a two-factor principal component (PC) approach structure. Modeling the two-factor residuals in the same way, in age-cohort effects, provides estimates for the (conditional) three-factor age-period-cohort model. The age-time and cohort related components are extrapolated using dynamic linear regression (DLR) models. An application is presented for England & Wales males (1841-2006).

LIANG, Z.; YUEN, K. C.; GUO, J. *Optimal proportional reinsurance and investment in a stock market with Ornstein–Uhlenbeck process*. 207-215. In this paper, the authors study the optimal investment and proportional reinsurance strategy when an insurance company wishes to maximize the expected exponential utility of the terminal wealth. It is assumed that the instantaneous rate of investment return follows an Ornstein–Uhlenbeck process. Using stochastic control theory and Hamilton–Jacobi–Bellman equations, explicit expressions for the optimal strategy and value function are derived not only for the compound Poisson risk model but also for the Brownian motion risk model. Further, we investigate the partially observable optimization problem, and also obtain explicit expressions for the optimal results.

SHANG, Z.; GOOVAERTS, M.; DHAENE, J. *A recursive approach to mortality-linked derivative pricing*. 240-248. In this paper, we develop a recursive method to derive an exact numerical and nearly analytical representation of the Laplace transform of the transition density function with respect to the time variable for time-homogeneous diffusion processes. We further apply this recursion algorithm to the pricing of mortality-linked derivatives. Given an arbitrary stochastic future lifetime T , the probability distribution function of the present value of a cash flow depending on T can be approximated by a mixture of exponentials, based on Jacobi polynomial expansions. In case of mortality-linked derivative pricing, the required Laplace inversion can be avoided by introducing this mixture of exponentials as an approximation of the distribution of the survival time T in the recursion scheme. This approximation significantly improves the efficiency of the algorithm.

SHI, P.; VALDEZ, E. A. *A copula approach to test asymmetric information with applications to predictive modeling*. 226-239. In this article, we present a copula regression model for testing asymmetric information as well as for predictive modeling applications in automobile insurance market. We use the Frank copula to jointly model the type of coverage and the number of accidents, with the dependence parameter providing for evidence of the relationship between the choice of coverage and the frequency of accidents. This dependence therefore provides an indication of the presence (or absence) of asymmetric information. The type of coverage is in some sense ordered so that coverage with higher ordinals indicate the most comprehensive coverage. Henceforth, a positive relationship would indicate that more coverage is chosen by high risk policyholders, and vice versa. This presence of asymmetric information could be due to either adverse selection or moral hazard, a distinction often made in the economics or insurance literature, or both. We calibrated our copula model using a one-year cross-sectional observation of claims arising from a major automobile insurer in Singapore. Our estimation results indicate a significant positive coverage–risk relationship. However, when we correct for the bias resulting from possible underreporting of accidents, we find that the positive association vanishes. We further used our estimated model for other possible actuarial applications. In particular, we are able to demonstrate the effect of coverage choice on the incidence of accidents, and based on which, the pure premium is derived. In general, a positive margin is observed when compared with the gross premium available in our empirical database.

TAN, K. S.; WENG, C.; ZHANG, Y. *Optimality of general reinsurance contracts under CTE risk measure*. 175-187. By formulating a constrained optimization model, we address the problem of optimal reinsurance design using the criterion of minimizing the conditional tail expectation (CTE) risk measure of the insurer’s total risk. For completeness, we analyze the optimal reinsurance model under both binding and unbinding reinsurance premium constraints. By resorting to the Lagrangian approach based on the concept of directional derivative, explicit and

analytical optimal solutions are obtained in each case under some mild conditions. We show that pure stop-loss ceded loss function is always optimal. More interestingly, we demonstrate that ceded loss functions, that are not always non-decreasing, could be optimal. We also show that, in some cases, it is optimal to exhaust the entire reinsurance premium budget to determine the optimal reinsurance, while in other cases, it is rational to spend less than the prescribed reinsurance premium budget.

VERDONCK, T.; VAN WOUWE, M. *Detection and correction of outliers in the bivariate chain-ladder method*. 188-193. The expected profit or loss of a non-life insurance company is determined for the whole of its multiple business lines. This implies the study of the claims reserving problem for a portfolio consisting of several correlated run-off triangles. A popular technique to deal with such a portfolio is the multivariate chain-ladder method of. However, it is well known that the chain-ladder method is very sensitive to outlying data. For the univariate case, we have already developed a robust version of the chain-ladder method. In this article we propose two techniques to detect and correct outlying values in a bivariate situation. The methodologies are illustrated and compared on real examples from practice.

YANG, X.; FREES, E. W.; ZHANG, Z. *A generalized beta copula with applications in modeling multivariate long-tailed data*. 265-284. This work proposes a new copula class that the authors call the MGB2 copula. The new copula originates from extracting the dependence function of the multivariate GB2 distribution (MGB2) whose marginals follow the univariate generalized beta distribution of the second kind (GB2). The MGB2 copula can capture non-elliptical and asymmetric dependencies among marginal coordinates and provides a simple formulation for multi-dimensional applications. This new class features positive tail dependence in the upper tail and tail independence in the lower tail. Furthermore, it includes some well-known copula classes, such as the Gaussian copula, as special or limiting cases.

To illustrate the usefulness of the MGB2 copula, the authors build a trivariate MGB2 copula model of bodily injury liability closed claims. Extended GB2 distributions are chosen to accommodate the right-skewness and the long-tailedness of the outcome variables. For the regression component, location parameters with continuous predictors are introduced using a nonlinear additive function. For comparison purposes, we also consider the Gumbel and t copulas, alternatives that capture the upper tail dependence. The paper introduces a conditional plot graphical tool for assessing the validation of the MGB2 copula. Quantitative and graphical assessment of the goodness of fit demonstrate the advantages of the MGB2 copula over the other copulas.

ZEMP, A. *Risk comparison of different bonus distribution approaches in participating life insurance*. 249-264. The fair pricing of explicit and implicit options in life insurance products has received broad attention in the academic literature over the past years. Participating life insurance (PLI) contracts have been the focus especially. These policies are typically characterized by a term life insurance, a minimum interest rate guarantee, and bonus participation rules with regard to the insurer's asset returns or reserve situation. Researchers replicate these bonus policies quite differently. We categorize and formally present the most common PLI bonus distribution mechanisms. These bonus models closely mirror the Danish, German, British, and Italian regulatory framework. Subsequently, we perform a comparative analysis of the different bonus models with regard to risk valuation. We calibrate contract parameters so that the compared contracts have a net present value of zero and the same safety level as the initial position, using

risk-neutral valuation. Subsequently, we analyze the effect of changes in the asset volatility and in the initial reserve amount (per contract) on the value of the default put option (DPO), while keeping all other parameters constant. Our results show that DPO values obtained with the PLI bonus distribution model of Bacinello (2001), which replicates the Italian regulatory framework, are most sensitive to changes in volatility and initial reserves.

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ASIMIT, A. V.; FURMAN, E.; TANG, Q.; VERNIC, R. *Asymptotics for risk capital allocations based on Conditional Tail Expectation*. 310-324. An investigation of the limiting behavior of a risk capital allocation rule based on the Conditional Tail Expectation (CTE) risk measure is carried out. More specifically, with the help of general notions of Extreme Value Theory (EVT), the aforementioned risk capital allocation is shown to be asymptotically proportional to the corresponding Value-at-Risk (VaR) risk measure. The existing methodology acquired for VaR can therefore be applied to a somewhat less well-studied CTE. In the context of interest, the EVT approach is seemingly well-motivated by modern regulations, which openly strive for the excessive prudence in determining risk capitals.

BACINELLO, A. R.; MILLOSOVICH, P.; OLIVIERI, A.; PITACCO, E. *Variable annuities: a unifying valuation approach*. 285-297. Life annuities and pension products usually involve a number of guarantees, such as minimum accumulation rates, minimum annual payments or a minimum total payout. Packaging different types of guarantees is the feature of so-called variable annuities. Basically, these products are unit-linked investment policies providing a post-retirement income. The guarantees, commonly referred to as GMxBs (namely, Guaranteed Minimum Benefits of type 'x'), include minimum benefits both in the case of death and survival. In this paper we propose a unifying framework for the valuation of variable annuities under quite general model assumptions. We compute and compare contract values and fair fee rates under 'static' and 'mixed' valuation approaches, via ordinary and least squares Monte Carlo methods, respectively.

BRAHIMI, B.; MERAGHNI, D.; NECIR, A.; ZITIKIS, R. *Estimating the distortion parameter of the proportional-hazard premium for heavy-tailed losses*. 325-334. The distortion parameter reflects the amount of loading in insurance premiums. A specific value of a given premium determines a value of the distortion parameter, which depends on the underlying loss distribution. Estimating the parameter, therefore, becomes a statistical inferential problem, which has been initiated by Jones and Zitikis [Jones, B.L., Zitikis, R., 2007. Risk measures, distortion parameters, and their empirical estimation. *Insurance: Mathematics and Economics*, 41, 279–297] in the case of the distortion premium and tackled within the framework of the central limit theorem. Heavy-tailed losses do not fall into this framework as they rely on the extreme-value theory. In this paper, we concentrate on a special but important distortion premium, called the proportional-hazard premium, and propose an estimator for its distortion parameter in the case of heavy-tailed losses. We derive an asymptotic distribution of the estimator, construct a practically implementable confidence interval for the distortion parameter, and illustrate the performance of the interval in a simulation study.

BRAUN, A. *Pricing catastrophe swaps: a contingent claims approach*. 520-536. In this paper, we comprehensively analyze the catastrophe (cat) swap, a financial instrument which has attracted little scholarly attention to date. We begin with a discussion of the typical contract design, the

current state of the market, as well as major areas of application. Subsequently, a two-stage contingent claims pricing approach is proposed, which distinguishes between the main risk drivers ex-ante as well as during the loss reestimation phase and additionally incorporates counterparty default risk. Catastrophe occurrence is modeled as a doubly stochastic Poisson process (Cox process) with mean-reverting Ornstein–Uhlenbeck intensity. In addition, we fit various parametric distributions to normalized historical loss data for hurricanes and earthquakes in the US and find the heavy-tailed Burr distribution to be the most adequate representation for loss severities. Applying our pricing model to market quotes for hurricane and earthquake contracts, we derive implied Poisson intensities which are subsequently condensed into a common factor for each peril by means of exploratory factor analysis. Further examining the resulting factor scores, we show that a first order autoregressive process provides a good fit. Hence, its continuous-time limit, the Ornstein–Uhlenbeck process should be well suited to represent the dynamics of the Poisson intensity in a cat swap pricing model.

BRILL, P. H.; YU, K. *Analysis of risk models using a level crossing technique*. 298-309. This paper analyzes ruin-like risk models in Insurance, which are variants of the Cramer–Lundberg (C–L) model with a barrier or a threshold. We consider three model variants, which have different portfolio strategies when the risk reserve reaches the barrier or exceeds the threshold. In these models we construct a time-extended risk process defined on cycles of a specific renewal process. The time until ruin is equal to one cycle of the specific renewal process. We also consider a fourth model, which is a variant of a model proposed by. The analysis of each model employs a level crossing method (LC) to derive the steady-state probability distribution of the time-extended risk process. From the derived distribution we compute the expected time until ruin, the probability distribution of the deficit at ruin, and related quantities of interest.

CAIRNS, A. J. G. *Modelling and management of longevity risk: approximations to survivor functions and dynamic hedging*. 438-453. This paper looks at the development of dynamic hedging strategies for typical pension plan liabilities using longevity-linked hedging instruments. Progress in this area has been hindered by the lack of closed-form formulae for the valuation of mortality-linked liabilities and assets, and the consequent requirement for simulations within simulations. We propose the use of the probit function along with a Taylor expansion to approximate longevity-contingent values. This makes it possible to develop and implement computationally efficient, discrete-time delta hedging strategies using -forwards as hedging instruments. The methods are tested using the model proposed by (CBD). We find that the probit approximations are generally very accurate, and that the discrete-time hedging strategy is very effective at reducing risk.

CHEN, A. *A risk-based model for the valuation of pension insurance*. 401-409. In the US, defined benefit plans are insured by the Pension Benefit Guaranty Corporation (PBGC). Taking account of the fact that the PBGC covers only the residual deficits of the pension fund the sponsoring company is unable to cover and that the plans can be prematurely terminated, we consider a model that accounts for the joint dynamics of the pension fund's and sponsoring firm's assets in order to effectively determine the risk-based pension premium for the insurance provided by the PBGC. We obtain a closed-form pricing formula for this risk-based premium. Its magnitude depends highly on the investment portfolio of the pension fund and of the sponsoring company as well as the correlation between these two portfolios.

CONSTANTINESCU, C.; HASHORVA, E.; JI, L. *Archimedean copulas in finite and infinite dimensions—with application to ruin problems*. 487-495. In this paper the authors discuss the

link between Archimedean copulas and Dirichlet distributions for both finite and infinite dimensions. With motivation from the recent papers and the authors apply their results to certain ruin problems.

DE FRANCO, C.; TANKOV, P. *Portfolio insurance under a risk-measure constraint*. 361-370. The authors study the problem of portfolio insurance from the point of view of a fund manager, who guarantees to the investor that the portfolio value at maturity will be above a fixed threshold. If, at maturity, the portfolio value is below the guaranteed level, a third party will refund the investor up to the guarantee. In exchange for this protection, the third party imposes a limit on the risk exposure of the fund manager, in the form of a convex monetary risk measure. The fund manager therefore tries to maximize the investor's utility function subject to the risk-measure constraint. The authors give a full solution to this non-convex optimization problem in the complete market setting and show in particular that the choice of the risk measure is crucial for the optimal portfolio to exist. Explicit results are provided for the entropic risk measure (for which the optimal portfolio always exists) and for the class of spectral risk measures (for which the optimal portfolio may fail to exist in some cases).

ERYILMAZ, S.; GEBIZLIOGLU, O. L.; TANK, F. *Modeling of claim exceedances over random thresholds for related insurance portfolios*. 496-500. Large claims in an actuarial risk process are of special importance for the actuarial decision making about several issues like pricing of risks, determination of retention treaties and capital requirements for solvency. This paper presents a model about claim occurrences in an insurance portfolio that exceed the largest claim of another portfolio providing the same sort of insurance coverages. Two cases are taken into consideration: independent and identically distributed claims and exchangeable dependent claims in each of the portfolios. Copulas are used to model the dependence situations. Several theorems and examples are presented for the distributional properties and expected values of the critical quantities under concern.

FERNÁNDEZ-PONCE, J. M.; PELLEREY, F.; RODRÍGUEZ-GRÍÑOLO, M. R. *A characterization of the multivariate excess wealth ordering*. 410-417. In this paper, some new properties of the upper-corrected orthant of a random vector are proved. The univariate right-spread or excess wealth function, introduced by Fernández-Ponce et al. (1996), is extended to multivariate random vectors, and some properties of this multivariate function are studied. Later, this function was used to define the excess wealth ordering by Shaked and Shanthikumar (1998) and Fernández-Ponce et al. (1998). The multivariate excess wealth function enable us to define a new stochastic comparison which is weaker than the multivariate dispersion orderings. Also, some properties relating the multivariate excess wealth order with stochastic dependence are described.

GAO, F.; WANG, S. *Asymptotic behavior of the empirical conditional value-at-risk*. 345-352. The authors study asymptotic behavior of the empirical conditional value-at-risk (CVaR). In particular, the Berry–Essen bound, the law of iterated logarithm, the moderate deviation principle and the large deviation principle for the empirical CVaR are obtained. The authors also give some numerical examples.

GOOVAERTS, M. J.; KAAS, R.; LAEVEN, R. J. A. *Worst case risk measurement: Back to the future?* 380-392. This paper studies the problem of finding best-possible upper bounds on a rich class of risk measures, expressible as integrals with respect to measures, under incomplete probabilistic information. Both univariate and multivariate risk measurement problems are

considered. The extremal probability distributions, generating the worst case scenarios, are also identified. The problem of worst case risk measurement has been studied extensively by Etienne De Vijlder and his co-authors, within the framework of finite-dimensional convex analysis. This paper revisits and extends some of their results.

GUILLÉN, M.; PRIETO, F.; SARABIA, J. M. *Modelling losses and locating the tail with the Pareto Positive Stable distribution*. 454-461. This paper focuses on modelling the severity distribution. We directly model the small, moderate and large losses with the Pareto Positive Stable (PPS) distribution and thus it is not necessary to fix a threshold for the tail behaviour. Estimation with the method of moments is straightforward. Properties, graphical tests and expressions for value-at-risk and tail value-at-risk are presented. Furthermore, we show that the PPS distribution can be used to construct a statistical test for the Pareto distribution and to determine the threshold for the Pareto shape if required. An application to loss data is presented. We conclude that the PPS distribution can perform better than commonly used distributions when modelling a single loss distribution for moderate and large losses. This approach avoids the pitfalls of cut-off selection and it is very simple to implement for quantitative risk analysis.

HARTMAN, B. M.; HEATON, M. J. *Accounting for regime and parameter uncertainty in regime-switching models*. 429-437. As investment guarantees become increasingly complex, realistic simulation of the price becomes more critical. Currently, regime-switching models are commonly used to simulate asset returns. Under a regime switching model, simulating random asset streams involves three steps: (i) estimate the model parameters given the number of regimes using maximum likelihood, (ii) choose the number of regimes using a model selection criteria, and (iii) simulate the streams using the optimal number of regimes and parameter values. This method, however, does not properly incorporate regime or parameter uncertainty into the generated asset streams and therefore into the price of the guarantee. To remedy this, this article adopts a Bayesian approach to properly account for those two sources of uncertainty and improve pricing.

HUA, L.; JOE, H. *Second order regular variation and conditional tail expectation of multiple risks*. 537-546. For the purpose of risk management, the study of tail behavior of multiple risks is more relevant than the study of their overall distributions. Asymptotic study assuming that each marginal risk goes to infinity is more mathematically tractable and has also uncovered some interesting performance of risk measures and relationships between risk measures by their first order approximations. However, the first order approximation is only a crude way to understand tail behavior of multiple risks, and especially for sub-extremal risks. In this paper, we conduct asymptotic analysis on conditional tail expectation (CTE) under the condition of second order regular variation (2RV). First, the closed-form second order approximation of CTE is obtained for the univariate case. Then CTE of the form, as, is studied, where is a loss aggregating function and with independent of and the survivor function of satisfying the condition of 2RV. Closed-form second order approximations of CTE for this multivariate form have been derived in terms of corresponding value at risk. For both the univariate and multivariate cases, we find that the first order approximation is affected by only the regular variation index of marginal survivor functions, while the second order approximation is influenced by both the parameters for first and second order regular variation, and the rate of convergence to the first order approximation is dominated by the second order parameter only. We have also shown that the 2RV condition and the assumptions for the multivariate form are satisfied by many parametric distribution families, and thus the closed-form approximations would be useful for applications. Those closed-form results extend the study of.

KRÄTSCHMER, V.; ZÄHLE, H. *Sensitivity of risk measures with respect to the normal approximation of total claim distributions*. 335-344. A simple and commonly used method to approximate the total claim distribution of a (possibly weakly dependent) insurance collective is the normal approximation. In this article, we investigate the error made when the normal approximation is plugged in a fairly general distribution-invariant risk measure. We focus on the rate of convergence of the error relative to the number of clients, we specify the relative error's asymptotic distribution, and we illustrate our results by means of a numerical example. Regarding the risk measure, we take into account distortion risk measures as well as distribution-invariant coherent risk measures.

LANDRIAULT, D.; SHI, T.; WILLMOT, G. E. *Joint densities involving the time to ruin in the Sparre Andersen risk model under exponential assumptions*. 371-379. Recent research into the nature of the distribution of the time of ruin in some Sparre Andersen risk models has resulted in series expansions for the associated density function. Examples include in the classical Poisson model with exponential interclaim times, and, who used a duality argument in the case with exponential claim amounts. The aim of this paper is not only to unify previous methodology through the use of Lagrange's expansion theorem, but also to provide insight into the nature of the series expansions by identifying the probabilistic contribution of each term in the expansion through analysis involving the distribution of the number of claims until ruin. The (defective) distribution of the number of claims until ruin is then further examined. Interestingly, a connection to the well-known extended truncated negative binomial (ETNB) distribution is also established. Finally, a closed-form expression for the joint density of the time to ruin, the surplus prior to ruin, and the number of claims until ruin is derived. In the last section, the formula of for the density of the time to ruin in the classical risk model is re-examined to identify its individual contributions based on the number of claims until ruin.

LEFÈVRE, C.; PICARD, P. *A new look at the homogeneous risk model*. 512-519. The present paper aims to revisit the homogeneous risk model investigated by, first, a claim arrival process is defined on a fixed time interval by assuming that the arrival times satisfy an order statistic property. Then, the variability and the covariance of an aggregate claim amount process is discussed. The distribution of the aggregate discounted claims is also examined. Finally, a closed-form expression for the non-ruin probability is derived in terms of a family of Appell polynomials. This formula holds for all claim distributions, even dependent. It generalizes several results obtained so far.

LI, J.; SZIMAYER, A. *The uncertain mortality intensity framework: pricing and hedging unit-linked life insurance contracts*. 471-486. We study the valuation and hedging of unit-linked life insurance contracts in a setting where mortality intensity is governed by a stochastic process. We focus on model risk arising from different specifications for the mortality intensity. To do so we assume that the mortality intensity is almost surely bounded under the statistical measure. Further, we restrict the equivalent martingale measures and apply the same bounds to the mortality intensity under these measures. For this setting we derive upper and lower price bounds for unit-linked life insurance contracts using stochastic control techniques. We also show that the induced hedging strategies indeed produce a dynamic superhedge and subhedge under the statistical measure in the limit when the number of contracts increases. This justifies the bounds for the mortality intensity under the pricing measures. We provide numerical examples investigating fixed-term, endowment insurance contracts and their combinations including various guarantee features. The pricing partial differential equation for the upper and lower price bounds is solved by finite difference methods. For our contracts and choice of parameters the

pricing and hedging is fairly robust with respect to misspecification of the mortality intensity. The model risk resulting from the uncertain mortality intensity is of minor importance.

LIANG, Z.; HUANG, J. *Optimal dividend and investing control of an insurance company with higher solvency constraints*. 501-511. This paper considers the optimal control problem of a large insurance company under a fixed insolvency probability. The company controls proportional reinsurance rate, dividend pay-outs and investing process to maximize the expected present value of the dividend pay-outs until the time of bankruptcy. This paper aims at describing the optimal return function as well as the optimal policy. As a by-product, the paper theoretically sets a risk-based capital standard to ensure the capital requirement that can cover the total risk.

NG, A. C.-Y.; LI, J. S.-H. *Valuing variable annuity guarantees with the multivariate Esscher transform*. 393-400. Variable annuities are usually sold with a range of guarantees that protect annuity holders from some downside market risk. Although it is common to see variable annuity guarantees written on multiple funds, existing pricing methods are, by and large, based on stochastic processes for one single asset only. In this article, we fill this gap by developing a multivariate valuation framework. First, we consider a multivariate regime-switching model for modeling returns on various assets at the same time. We then identify a risk-neutral probability measure for use with the model under consideration. This is accomplished by a multivariate extension of the regime-switching conditional Esscher transform. We further extend our results to the situation when the guarantee being valued is linked to equity indexes measured in foreign currencies. In particular, we derive a probability measure that is risk-neutral from the perspective of domestic investors. Finally, we illustrate our results with a hypothetical variable annuity guarantee.

NIELSEN, J. A.; SANDMANN, K.; SCHLÖGL, E. *Equity-linked pension schemes with guarantees*. 547-564. This paper analyses the relationship between the level of a return guarantee in an equity-linked pension scheme and the proportion of an investor's contribution needed to finance this guarantee. Three types of schemes are considered: investment guarantee, contribution guarantee and surplus participation. The evaluation of each scheme involves pricing an Asian option, for which relatively tight upper and lower bounds can be calculated in a numerically efficient manner. The authors find a negative (and for two contract specifications also concave) relationship between the participation in the surplus return of the investment strategy and the guarantee level in terms of a minimum rate of return. Furthermore, the introduction of the possibility of early termination of the contract (e.g. due to the death of the investor) has no qualitative and very little quantitative impact on this relationship.

PETERS, G. W.; SHEVCHENKO, P. V.; YOUNG, M.; YIP, W. *Analytic loss distributional approach models for operational risk from the α -stable doubly stochastic compound processes and implications for capital allocation*. 565-579. Under the Basel II standards, the Operational Risk (OpRisk) advanced measurement approach is not prescriptive regarding the class of statistical model utilized to undertake capital estimation. It has however become well accepted to utilize a Loss Distributional Approach (LDA) paradigm to model the individual OpRisk loss processes corresponding to the Basel II Business line/event type. In this paper we derive a novel class of doubly stochastic α -stable family LDA models. These models provide the ability to capture the heavy tailed loss processes typical of OpRisk, whilst also providing analytic expressions for the compound processes annual loss density and distributions, as well as the aggregated compound processes' annual loss models. In particular we develop models of the annual loss processes in two scenarios. The first scenario considers the loss processes with a stochastic intensity parameter,

resulting in inhomogeneous compound Poisson processes annually. The resulting arrival processes of losses under such a model will have independent counts over increments within the year. The second scenario considers discretization of the annual loss processes into monthly increments with dependent time increments as captured by a Binomial processes with a stochastic probability of success changing annually. Each of these models will be coupled under an LDA framework with heavy-tailed severity models comprised of α -stable severities for the loss amounts per loss event. In this paper we will derive analytic results for the annual loss distribution density and distribution under each of these models and study their properties.

PLAT, R. *One-year Value-at-Risk for longevity and mortality*. 462-470. Upcoming new regulation on regulatory required solvency capital for insurers will be predominantly based on a one-year Value-at-Risk measure. This measure aims at covering the risk of the variation in the projection year as well as the risk of changes in the best estimate projection for future years. This paper addresses the issue how to determine this Value-at-Risk for longevity and mortality risk. Naturally, this requires stochastic mortality rates. In the past decennium, a vast literature on stochastic mortality models has been developed. However, very few of them are suitable for determining the one-year Value-at-Risk. This requires a model for mortality trends instead of mortality rates. Therefore, we will introduce a stochastic mortality trend model that fits this purpose. The model is transparent, easy to interpret and based on well known concepts in stochastic mortality modeling. Additionally, we introduce an approximation method based on duration and convexity concepts to apply the stochastic mortality rates to specific insurance portfolios.

SCHMEISER, H.; WAGNER, J. *A joint valuation of premium payment and surrender options in participating life insurance contracts*. 580-596. In addition to an interest rate guarantee and annual surplus participation, life insurance contracts typically embed the right to stop premium payments during the term of the contract (paid-up option), to resume payments later (resumption option), or to terminate the contract early (surrender option). Terminal guarantees are on benefits payable upon death, survival and surrender. The latter are adapted after exercising the options. A model framework including these features and an algorithm to jointly value the premium payment and surrender options is presented. In a first step, the standard principles of risk-neutral evaluation are applied and the policyholder is assumed to use an economically rational exercise strategy. In a second step, option value sensitivity on different contract parameters, benefit adaptation mechanisms, and exercise behavior is analyzed numerically. The two latter are the main drivers for the option value.

SUNG, K. C.; YAM, S. C. P.; YUNG, S. P.; ZHOU, J. H. *Behavioral optimal insurance*. 418-428. The present work studies the optimal insurance policy offered by an insurer adopting a proportional premium principle to an insured whose decision-making behavior is modeled by Kahneman and Tversky's Cumulative Prospect Theory with convex probability distortions. We show that, under a fixed premium rate, the optimal insurance policy is a generalized insurance layer (that is, either an insurance layer or a stop-loss insurance). This optimal insurance decision problem is resolved by first converting it into three different sub-problems similar to those in; however, as we now demand a more regular optimal solution, a completely different approach has been developed to tackle them. When the premium is regarded as a decision variable and there is no risk loading, the optimal indemnity schedule in this form has no deductibles but a cap; further results also suggests that the deductible amount will be reduced if the risk loading is decreased. As a whole, our paper provides a theoretical explanation for the popularity of limited coverage insurance policies in the market as observed by many socio-economists, which serves as a mathematical bridge between behavioral finance and actuarial science.

ZHANG, W.-G.; ZHANG, X.-L.; CHEN, Y. *Portfolio adjusting optimization with added assets and transaction costs based on credibility measures*. 353-360. In response to changeful financial markets and investor's capital, we discuss a portfolio adjusting problem with additional risk assets and a riskless asset based on credibility theory. We propose two credibilistic mean-variance portfolio adjusting models with general fuzzy returns, which take lending, borrowing, transaction cost, additional risk assets and capital into consideration in portfolio adjusting process. We present crisp forms of the models when the returns of risk assets are some deterministic fuzzy variables such as trapezoidal, triangular and interval types. We also employ a quadratic programming solution algorithm for obtaining optimal adjusting strategy. The comparisons of numeral results from different models illustrate the efficiency of the proposed models and the algorithm.

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DAWSON, P.; DOWD, K.; CAIRNS, A. J. G.; BLAKE, D. *Survivor derivatives: a consistent pricing framework*. 579-596. Survivorship risk is a significant factor in the provision of retirement income. Survivor derivatives are in their early stages and offer potentially significant welfare benefits to society. This article applies the approach developed by Dowd et al. (2006), Olivier and Jeffery (2004), Smith (2005), and Cairns (2007) to derive a consistent framework for pricing a wide range of linear survivor derivatives, such as forwards, basis swaps, forward swaps, and futures. It then shows how a recent option pricing model set out by Dawson et al. (2009) can be used to price nonlinear survivor derivatives, such as survivor swaptions, caps, floors, and combined option products. It concludes by considering applications of these products to a pension fund that wishes to hedge its survivorship risks.

ECKARDT, M.; RATHKE-DÖPPNER, S. *The quality of insurance intermediary services—empirical evidence for Germany*. 667-701. Competing insurance intermediaries provide heterogeneous services that are difficult for incompletely informed consumers to assess. Transaction cost economics, search theory, and principal-agent theory provide arguments on product quality differences between exclusive agents and independent intermediaries. This article uses a sample of 927 insurance intermediaries in Germany. By performing OLS estimations, we test the impact of the different distribution channels and other factors on intermediaries' service quality. Depending on the proxies used for service quality, we find mixed evidence for the product quality hypothesis. Service quality depends to a large extent on the information-gathering and processing activities of the individual intermediaries, independent of the respective distribution channel.

HARDLE, W. K.; CABRERA, B. L. *Calibrating cat bonds for Mexican earthquakes*. 625-650. This article examines the calibration of a real parametric catastrophe bond (CAT bond) for earthquakes sponsored by the Mexican government, which is of a high interest as it delivers several policy-relevant findings. The results demonstrate that a combination of reinsurance and CAT bond is optimal in the sense that it provides coverage for a lower cost and lower exposure at default than reinsurance itself. A hybrid CAT bond for earthquakes is also priced in order

to reduce the basis and moral risk borne by the sponsor and to reflect the value of the loss by several variables.

HARRINGTON, S. E. *U.S. Health-care reform: The Patient Protection and Affordable Care Act*. 703-708. This short article provides an overview of the Patient Protection and Affordable Care Act, which was approved by the U.S. Congress and signed by President Barack Obama in March 2010, with an emphasis on provisions related to the expansion of health insurance. It highlights key provisions concerning coverage expansion, insurance market reforms, and the projected costs and financing of the legislation.

IBRAGIMOV, R.; JAFFEE, D.; WALDEN, J. *Pricing and capital allocation for multiline insurance firms*. 551-578. We study multiline insurance companies with limited liability. Insurance premiums are determined by no-arbitrage principles. The results are developed under the realistic assumption that the losses created by insurer default are allocated among policyholders following an ex post, pro rata, sharing rule. In general, the ratio of default costs to expected claims, and thus the ratio of premiums to expected claims, vary across insurance lines. Moreover, capital and related costs are allocated across lines in proportion to each line's share of a digital default option on the insurer. Our results expand and generalize those derived elsewhere in the literature.

LIEBENBERG, A. P.; CARSON, J. M.; HOYT, R. E. *The demand for life insurance policy loans*. 651-666. Previous research has examined the demand for life insurance policy loans using aggregate policy loan data. In contrast, we use a detailed household survey data set containing life insurance and policy loan information to alternatively, and in some cases more directly, examine the four hypotheses traditionally associated with policy loan demand. Our research provides the first U.S. evidence (in the post-World War II period) in support of the policy loan emergency fund hypothesis. In particular, we find that the more detailed emergency fund proxies used here reveal a significantly positive relation between loan demand and recent expense or income shocks.

WEISS, M. A.; TENNYSON, S.; REGAN, L. *The effects of regulated premium subsidies on insurance costs: An empirical analysis of automobile insurance*. 597-624. State regulation of rates is sometimes used as a means to make automobile insurance more affordable to consumers by restricting insurer profits and pricing practices. Incentive distortions arising from this type of rate regulation might lead to higher accident rates and higher insurance loss costs. Annual state-level panel data for the time period 1980–1998 are used to investigate these effects, using empirical methods that recognize the endogenous determination of states' regulatory choices. Results suggest that rate regulation that systematically suppresses (some or all) drivers' insurance premiums is associated with significantly higher average loss costs and higher insurance claim frequency.

ZANJANI, G. *An economic approach to capital allocation*. 523-549. This article starts with primitive assumptions on preferences and risk. It then derives prices consistent with a social optimum within an insurance company and the consumer-level capital allocation implied therein. The allocation “adds up” to the total capital of the firm (a result echoing findings in the congestion pricing literature—where optimal tolls exactly cover the rental cost of the highway). The allocation follows each consumer's share of recoveries in states of insurer default, weighted by the severity of the default in terms of welfare impact. However, the article argues that an economic approach technically restricts only the capital allocated to marginal units of coverage: inframarginal units could in principle receive different allocations.

BERNIER, G.; MAHFOUDHI, R. M. *On the economics of post-assessments in insurance guaranty funds: a stakeholders' perspective.* 857-892. This article proposes a model that suggests there are contagion effects among members of an insurance guaranty fund when post-assessments are charged to all other insurers upon the failure of a member company. Indeed, these extraordinary payments are shown to increase the default rate of other firms in the industry, ultimately lowering the value of corporate claims as well as government tax claims. The model is also used to examine the efficiency of different recoupment mechanisms (both existing and new) used by regulators and insurers to potentially reduce these contagion effects. Analysis allows us to stipulate the conditions under which a "tax carryforward" provision could be more efficient than the usual recoupment mechanisms known as "premium rate surcharge" and "premium tax credit."

BROEDERS, D. *Valuation of contingent pension liabilities and guarantees under sponsor default risk.* 911-934. This article analyzes the relationship between a pension fund with contingently indexed defined benefit liabilities and its sponsor, using contingent claims analysis. As pension funds generally choose to run a mismatch risk, future surpluses and deficits will occur. Surpluses are divided between beneficiaries and sponsor through contingent indexation of the benefits and refunding. Covering a deficit at the pension fund level is a function of the sponsor's financial ability to do so. This article suggests that this system creates an asymmetric allocation of the residual risk between sponsor and beneficiaries. The optimal investment policy for the pension fund in this context can be found by reverse engineering option valuation formulas. The main conclusion is that sponsor default risk negatively impacts the optimum risk profile and thereby the market value of contingent pension liabilities.

CONSIGLIO, A.; DE GIOVANNI, D. *Pricing the option to surrender in incomplete markets.* 935-957. New international accounting standards require insurers to reflect the value of embedded options and guarantees in their products. Pricing techniques based on the Black and Scholes paradigm are often used; however, the hypotheses underneath this model are rarely met. We propose a framework that encompasses the most known sources of incompleteness. We show that the surrender option, joined with a wide range of claims embedded in insurance contracts, can be priced through our tool, and deliver hedging portfolios to mitigate the risk arising from their positions. We provide extensive empirical analysis to highlight the effect of incompleteness on the fair value of the option.

DEELSTRA, G.; VANMAELE, M.; VYNCKE, D. *Minimizing the risk of a financial product using a put option.* 767-800. In this article, we elaborate a method for determining the optimal strike price for a put option, used to hedge a position in a financial product such as a basket of shares and a bond. This strike price is optimal in the sense that it minimizes, for a given budget, a class of risk measures satisfying certain properties. Formulas are derived for one single underlying as well as for a weighted sum of underlyings. For the latter we will consider two cases depending on the dependence structure of the components in this weighted sum. Applications and numerical results are presented.

HALEK, M.; ECKLES, D. *Effects of analysts' ratings on insurer stock returns: evidence of asymmetric responses.* 801-827. We examine the information value contained in insurer rating changes. Using a contemporary event study approach, we document an asymmetric reaction of stock prices to rating changes: downgrades cut share prices by approximately 7 percent but

upgrades have little significant effect. This result varies across agencies as share prices react more strongly to A.M. Best and Standard & Poor's downgrades than to Moody's. We observe a similar asymmetric reaction to rating changes subject to a common rating benchmark. Finally, we find that prices fall most dramatically when a rating downgrade from one rating agency follows a downgrade from another agency.

LI, J. *Fear of loss and happiness of win: properties and applications*. 749-766. This article proposes two coefficients, "fear of loss" (FL) and "happiness of win" (HW), to capture the variation of risk attitude with respect to wealth. Several properties of interpersonal comparisons of FL and HW are achieved. We present three applications in the default risk bargaining problem (Tibiletti, 2006) to demonstrate that these properties can deliver more shortcut bargaining conditions and unambiguous comparative static results in situations involving interpersonal risk exchanges. We show that FL and HW coefficients are instrumental in explaining the comparative diffidence between an insurer and an insured.

LUDKOVSKI, M.; YOUNG, V. R. *Ex post moral hazard and bayesian learning in insurance*. 829-856. We study a dynamic insurance market with asymmetric information and ex post moral hazard. In our model, the insurance buyer's risk type is unknown to the insurer; moreover, the buyer has the option of not reporting losses. The insurer sets premia according to the buyer's experience rating, computed via Bayesian estimation based on buyer's history of reported claims. Accordingly, the buyer has strategic incentive to withhold information about losses. We construct an insurance market information equilibrium model and show that a variety of reporting strategies are possible. The results are illustrated with explicit computations in a two-period risk-neutral case study.

MILEVSKY, M. A.; SONG, K. *Do markets like frozen defined benefit pensions? An event study*. 893-909. An increasing number of North American companies are freezing or terminating their traditional defined benefit (DB) pension plans. In this article we document a positive announcement effect when a publicly traded company discloses that it has partially or fully frozen its DB plan and replaced it with—or enhanced—the 401(k) defined contribution (DC) plan. This positive risk-adjusted return is greater for firms with higher beta and/or lower return on equity (ROE) prior to the freeze. In other words the positive impact is more pronounced for firms that are likely to face financial distress if they maintain their traditional pension plan and the associated long-term promises.

ZHOU-RICHTER, T.; BROWNE, M. J.; GRÜNDL, H. *Don't they care? Or, are they just unaware?: Risk perception and the demand for long-term care insurance*. 715-747. The potential need for long-term care (LTC) is one of the greatest financial risks faced not only by the elderly but also by their adult children, who often provide care or financial assistance. We investigate adult children's role in the demand for LTC insurance. Similar to flood insurance, we find that demand for LTC insurance is low due to low risk perception. The more aware adult children are of the risk, the more likely LTC insurance is to be purchased, either by the children themselves on behalf of their parents or by the parents under the influence of their children.

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BIENER, C.; ELING, M. *The performance of micro-insurance programs: a data envelopment analysis*. 83-115. The purpose of this research is to measure the performance of micro-insurance

programs using data envelopment analysis and to derive implications for the viable provision of micro-insurance products. This is a worthwhile exercise given the significant limitations of the existing performance measures used in the micro-insurance industry. A single and simple to interpret performance measure can overcome these limitations and provide a sophisticated tool for performance measurement within a multidimensional framework. Moreover, this technique can incorporate the important social function that micro-insurers fulfill and provide powerful managerial implications. We illustrate the capabilities of data envelopment analysis using a sample of 20 micro-insurance programs and recent innovations from the efficiency literature, such as the bootstrapping of efficiency scores and a truncated regression analysis of efficiency determinants.

BIKKER, J. A.; GORTER, J. *Restructuring of the Dutch non-life insurance industry: consolidation, organizational form, and focus*. 163-184. Since the deregulation of the European insurance market in 1994, Dutch nonlife insurance firms have sized up and increased their focus. Concurrently, the stock organizational form has become increasingly dominant. This article investigates these 1995–2005 trends from a cost-efficiency perspective. We observe substantial economies of scale that are even larger for smaller firms. In line with the efficient structure hypothesis, both stocks and mutuals are found to have comparative cost advantages. Supporting the strategic focus hypothesis, we find that more specialized insurers have lower costs. Thick frontier efficiency estimates point to large cost X-inefficiencies that have moderately decreased over time.

BORN, P.; BOYER, M. M. *Claims-made and reported policies and insurer profitability in medical malpractice*. 139-162. The liability crisis of the 1970s led to the introduction of a new type of insurance policy designed to reduce the undiversifiable uncertainty associated with writing long-tail liability lines. These new claims-made and reported policies gained favor in place of the traditional occurrence coverage in the early 1980s not only in medical malpractice but also in the general liability arena. The main question we want to address in this article is why two types of contracts that cover the same risk exposure exist in the medical malpractice insurance industry whereas only one exists primarily in other insurance lines.

CHURCHILL, C.; PHILLIPS, R. D.; REINHARD, D. *Introduction to the 2011 symposium issue of JRI on Micro-insurance*. 1-5. The articles in this symposium challenge academic researchers with interests from the fields of risk management and insurance, development economics, experimental economics, and others to come together to address the difficulties of designing products targeted to the poor in developing countries.

GAILLARDETZ, P.; LAKHMIRI, J. Y. *A new premium principle for equity-indexed annuities*. 245-265. In this article, we introduce a premium principle for equity-indexed annuities (EIAs). Traditional actuarial loadings that protect insurance companies against risks cannot be extended to the valuation of EIAs since these products are embedded with various financial guarantees. We proposed a loaded premium that protects the issuers against the financial and mortality risks. We first obtain the fair premium based on a fair value of the equity-linked contract using arbitrage-free theory. Assuming a specific risk level for hedging errors, we obtain a new participation rate based on a security loading. A detailed numerical analysis is performed for a point-to-point EIA.

GIESBERT, L.; STEINER, S.; BENDIG, M. *Participation in micro life insurance and the use of other financial services in Ghana*. 7-35. This article investigates households' decisions to take up micro life insurance and to use other financial services. It estimates a multivariate probit model based on Ghanaian household survey data. The results suggest a mutually reinforcing relationship

between the use of insurance and the use of other formal financial services. Risk-averse households and households who consider themselves more exposed to risk than others are found to be less likely to participate in insurance. This suggests that insurance is considered to be risky. There is indicative evidence for adverse selection and a life-cycle effect in the uptake of insurance.

HAMID, S. A.; ROBERTS, J.; MOSLEY, P. *Can Micro Health Insurance Reduce Poverty? Evidence From Bangladesh*. 57-82. This article examines the impact of micro health insurance on poverty reduction in rural areas of Bangladesh. The research is based on household-level primary data collected from the operating areas of the Grameen Bank during 2006. A number of outcome measures are considered; these include household income, stability of household income via food sufficiency and ownership of nonland assets, and the probability of being above or below the poverty line. The results show that micro health insurance has a positive association with all of these indicators, and this is statistically significant and quantitatively important for food sufficiency.

KARLAN, D.; KUTSOATI, E.; MCMILLAN, M.; UDRY, C. *Crop price indemnified loans for farmers: a pilot experiment in rural Ghana*. 37-55. Farmers face a particular set of risks that complicate the decision to borrow. We use a randomized experiment to investigate (1) the role of crop-price risk in reducing demand for credit among farmers and (2) how risk mitigation changes farmers' investment decisions. In Ghana, we offer farmers loans with an indemnity component that forgives 50 percent of the loan if crop prices drop below a threshold price. A control group is offered a standard loan product at the same interest rate. Loan uptake is high among all farmers and the indemnity component has little impact on uptake or other outcomes of interest.

MURRAY, J. E. *Asymmetric information and countermeasures in early twentieth-century American short-term disability micro-insurance*. 117-138. American workers and employers a century ago formed micro-insurance funds to provide sick pay to temporarily disabled workers. This article analyzes a 1908 survey of several hundred such micro-insurers. Theoretically, a single cross-section may yield evidence of asymmetric information, but cannot enable the separation of moral hazard and adverse selection effects. However, micro-insurance fund managers and outside observers believed they did see separate such effects and so micro-insurers created separate countermeasures to mitigate these problems. This article finds prima facie evidence of asymmetric information and suggestive evidence of the separability of informational asymmetries and the effectiveness of such countermeasures.

PAGACH, D.; WARR, R. *The characteristics of firms that hire Chief Risk Officers*. 185-211. We examine the characteristics of firms that adopt enterprise risk management (ERM) and find support for the hypothesis that firms adopt ERM for direct economic benefit rather than to merely comply with regulatory pressure. Using chief risk officer (CRO) hires as a proxy for ERM adoption we find that firms that are larger, more volatile, and have greater institutional ownership are more likely to adopt ERM. In addition, when the CEO has incentives to take risk, the firm is also more likely to hire a CRO. Finally, banks with lower levels of Tier 1 capital are also more likely to hire a CRO.

SCOTT, J. S.; WATSON, J. G.; HU, W.-Y. *What makes a better annuity?* 213-244. Given costly and limited annuity products, we investigate how annuity market innovation could improve participation and increase individual welfare. We find that participation gains are most likely with new annuity products that concentrate on late-life payouts. Our welfare analysis suggests

that annuity innovation should focus on adding survival contingencies to assets commonly held by individuals. Finally, in a complete market setting, we find demand only for those annuity contracts with a significant time gap between purchase and payout (a rarity in current contracts). Overall, our analysis indicates ample opportunity for innovation to spur annuity demand and improve individual welfare.

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ANDERSEN, T. M.; SVARER, M. *State dependent unemployment benefits*. 325-344. Optimal design of unemployment insurance is considered in a search setting where the state of nature (business cycle) affects the unemployment risk and thus the return to search. The incentive effects or distortions of individual job search arising due to the unemployment insurance scheme are crucial for optimal policies, so is the scope for risk diversification that depends critically on whether the balanced budget requirement applies to each state of nature or across states of nature. In the former case a basic budget effect tends to cause optimal benefits to be procyclical. If risk diversification across states of nature is possible, the fact that incentives are more distorted in good than bad states of nature tends to make both benefits and contribution rates countercyclical. It is shown that countercyclical benefits exacerbate employment fluctuations but increase average employment by aligning benefits more with states of nature where the incentive costs are small.

CHANG, C.-C.; LIN, S.-K.; YU, M.-T. *Valuation of catastrophe equity puts with markov-modulated poisson processes*. 447-473. We derive the pricing formula for catastrophe equity put options (CatEPuts) by assuming catastrophic events follow a Markov Modulated Poisson process (MMPP) whose intensity varies according to the change of the Atlantic Multidecadal Oscillation (AMO) signal. U.S. hurricanes events from 1960 to 2007 show that the CatEPuts pricing errors under the MMPP(2) are smaller than the PP by 30 percent to 66 percent. The scenario analysis indicates that the MMPP outperforms the exponential growth pattern (EG) if the hurricane intensity is the AMO signal, whereas the EG may outperform the MMPP if the future climate is warming rapidly.

CROCKER, K. J.; SNOW, A. *Multidimensional screening in insurance markets with adverse selection*. 287-307. Bundled coverage of different losses and distinct perils, along with differential deductibles and policy limits, are common features of insurance contracts. We show that, through these practices, insurers can implement multidimensional screening of insurance applicants who possess hidden knowledge of their risks, and thereby reduce the externality cost of adverse selection. Competitive forces drive insurers to exploit multidimensional screening, enhancing the efficiency of insurance contracting. Moreover, multidimensional screening allows competitive insurance markets to attain pure strategy Nash equilibria over a wider range of applicant pools, resolving completely the Rothschild–Stiglitz nonexistence puzzle in markets where the perils space is sufficiently divisible.

HONG, S. K.; LEW, K. O.; MACMINN, R.; BROCKETT, P. *Mossin's theorem given random initial wealth*. 309-324. Bundled coverage of different losses and distinct perils, along with differential deductibles and policy limits, are common features of insurance contracts. We show that, through these practices, insurers can implement multidimensional screening of insurance applicants who possess hidden knowledge of their risks, and thereby reduce the externality cost of adverse

selection. Competitive forces drive insurers to exploit multidimensional screening, enhancing the efficiency of insurance contracting. Moreover, multidimensional screening allows competitive insurance markets to attain pure strategy Nash equilibria over a wider range of applicant pools, resolving completely the Rothschild–Stiglitz nonexistence puzzle in markets where the perils space is sufficiently divisible.

KOÇ, C. *Disease-specific moral hazard and optimal health insurance design for physician services.* 413-446. This article analyzes disease-specific moral hazard effects in the demand for physician office visits and explores whether optimal insurance for physician services should be designed to have disease-specific cost sharing. Generalized method of moments is implemented to address the endogeneity of private health insurance, and the nonnegativity and the discreteness of physician services use. The results indicate that the moral hazard effect varies considerably across disease-specific specialist care. The strongest moral hazard (for no-condition related specialist visits) is almost twice the moral hazard effect of the weakest (for chronic condition related specialist visits). Although the findings indicate some variation in the moral hazard effect across disease-specific general practitioner visits, the variation is less considerable. The main policy implication is that optimal insurance for physician services should be designed to have differential cost sharing based on disease status rather than to have uniform cost sharing.

KUANG, D.; NIELSEN, B.; NIELSEN, J. P. *Forecasting in an extended chain-ladder-type model.* 345-359. Reserving in general insurance is often done using chain-ladder-type methods. We propose a method aimed at situations where there is a sudden change in the economic environment affecting the policies for all accident years in the reserving triangle. It is shown that methods for forecasting nonstationary time series are helpful. We illustrate the method using data published in Barnett and Zehnwrith (2000, pp. 245–321). These data illustrate features we also found in data from the general insurer RSA during the recent credit crunch.

LANDRY, C.; JAHAN-PARVAR, M. R. *Flood insurance coverage in the coastal zone.* 361-388. We explore determinants of flood insurance demand in the coastal zone using micro-data for nine South Eastern counties. Overall estimates indicate price inelastic demand, though subsidized policyholders have greater coverage and are more price sensitive. Mortgage borrowers exhibit no greater coverage; only 12 percent in 100-year flood zone indicate flood insurance was required by their lender. Flood insurance demand is increasing in the levels of flood and erosion risk. We find a positive correlation between household income and coverage, but the effect is not monotonic. Community-level erosion hazard mitigation projects influence flood insurance coverage, with beach replenishment acting as a complement.

PARENTE, S. T.; FELDMAN, R.; ABRAHAM, J.; XU, Y. *Consumer response to a national marketplace for individual health insurance.* 389-411. The objective of this analysis is to simulate the difference between national and state-specific individual insurance markets on take-up of individual health insurance. This simulation analysis was completed in three steps. First, we reviewed the literature to characterize the state-specific individual insurance markets with respect to state regulations and to identify the effect of those regulations on health insurance premiums. Second, we used empirical data to develop premium estimates for the simulation that reflect case-mix as well as state-specific differences in health care markets. Third, we used a revised version of the 2005 Medical Expenditure Panel Survey (MEPS) to complete a set of simulations to identify the impact of three different scenarios for national market development. (National market estimates are based on the simulation model with competition among all 50 states and moderate

impact assumptions.) We find evidence of a significant opportunity to reduce the number of uninsured under a proposal to allow the purchase of health insurance across state lines. The best scenario to reduce the uninsured, numerically, is competition among all 50 states with one clear winner. The most pragmatic scenario, with a good impact, is one winner in each regional market.

ROTHSCHILD, C. G. *The efficiency of categorical discrimination in insurance markets.* 267-285. Crocker and Snow (1986) show that banning categorization based on risk-related characteristics such as gender or race in pricing insurance policies is inefficient whenever categorization is costless. Their analysis, by contrast, suggests ambiguous welfare effects of banning costly categorization. I show that this latter conclusion is incorrect: categorical pricing bans are inefficient even when categorization is costly. Whenever the ban-imposing government can instead provide breakeven partial social insurance, it can remove its ban in such a way that the insurance market will choose to employ the categorizing technology only when doing so is Pareto improving.

SHIU, Y.-M. *Reinsurance and capital structure: evidence from the United Kingdom non-life insurance industry.* 475-494. Using a data set consisting of statutory returns of U.K. non-life insurers from 1985 to 2002, I find that insurers with higher leverage tend to purchase more reinsurance, and insurers with higher reinsurance dependence tend to have a higher level of debt. My results are consistent with the expected bankruptcy costs argument, agency costs theory, risk-bearing hypothesis, and renting capital hypothesis. I also find that the impact of leverage on reinsurance will be weaker for insurers that use more derivatives than those that use less. Moreover, high levels of derivative use increase the leverage gains attributable to reinsurance.

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ADAMS, M.; LIN, C.; ZOU, H. *Chief Executive officer incentives, monitoring, and corporate risk management: Evidence from insurance use.* 551-582. Corporate governance and risk management issues have received prominent publicity in recent years following several major company failures such as Bear Stearns and Lehman Brothers. While prior studies have examined this issue within the context of derivatives' trading, little is known regarding the linkage between corporate governance and alternative corporate risk management activities such as insurance. Using a detailed firm survey conducted by the World Bank (2004), we examine the impacts of various governance monitoring mechanisms and chief executive officer (CEO) characteristics on the corporate insurance decision. Overall, our results suggest that both monitoring mechanisms and managerial incentives induce the corporate purchase of property insurance. However, the purchase of property insurance for managerial self-interest is only prevalent in firms subject to lax monitoring, and the determinants of insurance purchases are more in line with the prediction of the economic theory in firms with strong monitoring. In addition, our study contributes a number of new insights into the determinants of corporate purchase of property insurance.

BOUBAKRI, N. *Corporate governance and issues from the insurance industry.* 501-518. In this article, we review the literature and empirical research on the nature and consequences of corporate governance. We particularly assess the impact of corporate governance on firm performance and risk taking. While the article analyzes the general literature on corporate governance in publicly listed firms, we also discuss issues pertaining to the insurance industry. The article identifies avenues for future research.

CHENG, J.; ELYASIANI, E.; JIA, J. *Institutional ownership stability and risk taking: evidence from the life–health insurance industry*. 609–641. We investigate the relationship between risk taking of life–health (LH) insurers and stability of their institutional ownership within a simultaneous equation system model. Three main results are obtained. First, stable institutional ownership of is associated with lower total risk of LH insurers, supporting the prudent-man law hypothesis. Second, when investors are sorted in terms of stringency of the prudent-man restrictions, their negative effect on risk holds for all, except insurance companies, as owners of LH insurers. Third, large institutional owners do not raise the riskiness of the investee-firms, as proposed by the large shareholder hypothesis. Regulatory implications are drawn.

COLE, C. R.; HE, E.; MCCULLOUGH, K. A.; SEMYKINA, A.; SOMMER, D. W. *An empirical examination of stakeholder groups as monitoring sources in corporate governance*. 703–730.

Insurers are formally and informally monitored by a variety of stakeholders, including reinsurers, agents, outside board members, and regulators. While other studies have generally examined these stakeholders separately, they have not accounted for the fact that there is some relation among the stakeholder groups, and the presence of these groups is likely to be jointly determined. By empirically controlling for these potential interrelations, we create a more complete assessment of the impact of these stakeholders/monitors on insurers' risk taking. Specifically, we find that the presence of some stakeholders offsets the degree or presence of others, and that most stakeholders/monitors are associated with a reduction of overall firm risk.

ECKLES, D. L.; HALEK, M.; HE, E.; SOMMER, D. W.; ZHANG, R. *Earnings smoothing, executive compensation, and corporate governance: Evidence from the property-liability insurance industry*. 761–790. Unlike studies that estimate managerial bias, we utilize a direct measure of managerial bias in the U.S. insurance industry to investigate the effects of executive compensation and corporate governance on firms' earnings management behaviors. We find managers receiving larger bonuses and stock awards tend to make reserving decisions that serve to decrease firm earnings. Moreover, we examine the monitoring effect of corporate board structures in mitigating managers' reserve manipulation practices. We find managers are more likely to manipulate reserves in the presence of particular board structures. Similar results are not found when we employ traditional estimated measures of managerial bias.

HE, E.; SOMMER, D. W. *CEO turnover and ownership structure: evidence from the U.S. property–liability insurance industry*. 673–701. This article examines the impact of ownership structure on the relation between firm performance and chief executive officer (CEO) turnover in the U.S. property–liability insurance industry. Theoretical implications of stock versus mutual ownership structures on the performance–turnover relation are ambiguous. Our empirical results indicate that CEO turnover is less responsive to firm underwriting performance in mutual insurers compared to stock insurers. In fact, we find that while CEO turnover for stock firms is negatively related to prior performance, no such relationship is found for mutual insurers. These results hold while controlling for board structure and other relevant factors.

HE, E.; SOMMER, D. W.; XIE, X. *The impact of CEO turnover on property–liability insurer performance*. 583–608. Chief executive officer (CEO) turnover has long been an important topic in the academic literature. Previous research has focused mostly on the rationale for CEO turnovers, or circumstances that lead to CEO changes, with much less attention paid to how CEO turnovers affect future firm performance. We extend the literature regarding the impact of

CEO turnover on performance using data for U.S. property-liability insurers. Measuring firm performance with cost efficiency (CE) and revenue efficiency (RE) scores, we find strong support for the hypothesis that firms with a CEO turnover, especially those with a non-routine turnover, experience more favorable performance changes than firms without a CEO turnover.

HUANG, L.-Y.; LAI, G. C.; MCNAMARA, M.; WANG, J. *Corporate governance and efficiency: evidence from U.S. property-liability insurance industry*. 519-550. This study examines the relation between corporate governance and the efficiency of the U.S. property-liability insurance industry during the period from 2000 to 2007. We find a significant relation between efficiency and corporate governance (board size, proportion of independent directors on the audit committee, proportion of financial experts on the audit committee, director tenure, proportion of block shareholding, average number of directorships, proportion of insiders on the board, and auditor dependence). We also find property-liability insurers have complied with the Sarbanes-Oxley Act (SOX) to a large extent. Although SOX achieved the goal of greater auditor independence and might have prevented Enron-like scandals, it had some unexpected effects. For example, insurers became less efficient when they had more independent auditors because the insurers were unable to recoup the benefits of auditor independence.

MILIDONIS, A.; STATHOPOULOS, K. *Do U.S. insurance firms offer the “wrong” incentives to their executives?* 643-672. We examine the relation between executive compensation and market-implied default risk for listed insurance firms from 1992 to 2007. Shareholders are expected to encourage managerial risk sharing through equity-based incentive compensation. We find that long-term incentives and other share-based plans do not affect the default risk faced by firms. However, the extensive use of stock options leads to higher future default risk for insurance firms. We argue that this is because option-based incentives induce managerial risk-taking behavior, which seeks to maximize managerial payoff through equity volatility. This could be detrimental to the interests of shareholders, especially during a financial crisis.

MILLER, S. M. *Managerial discretion and corporate governance in publicly traded firms: Evidence from the property-liability insurance industry*. 731-760.

We study the incremental impact of corporate governance in mitigating managerial discretion, controlling for incentive alignment of managerial ownership. We extend the managerial discretion hypothesis to predict that for firms with the same set of governance tools, those that utilize governance tools more stringently to control agency costs will command greater contracting cost advantages, leading them to specialize in business with greater managerial discretion. Using 72 publicly traded insurers from 1994 to 2006, we find evidence supporting our hypothesis. Our findings complement the finance literature that focuses on the role of financing policies in mitigating agency costs of managerial discretion.

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CHANGKI K. A.; YANGHO C. *Securitization of longevity risk using percentile tranching* (pages) 885-906. Securitizations that transfer risk to the financial markets are a potential solution to longevity risk in the annuity business. The classical Lee-Carter model is applied to generate the future stochastic survival distribution. A method to design inverse survivor bonds using percentile

tranches and to calculate the security prices is presented. The percentile tranche method is a simple and practical way for the issuer to design and price the security. This method can serve to identify the risk–yield relationship, which can provide investors with clear insight regarding the appropriate choice of tranches.

COCCO, J. F.; LOPES, P. *Defined benefit or defined contribution? A study of pension choices.* 931–960. We solve an empirically parameterized life-cycle model of consumption and pension choices to show how expected earnings growth and risk affect the benefits of final-salary defined benefit (DB) pension plans, relative to pension plans that are defined contribution (DC) in nature. We use micro data on the pension choices of individuals to provide evidence consistent with the model predictions: (1) individuals who expect a higher growth rate of earnings are more likely to choose DB final-salary schemes, and (2) individuals who face a higher variance of persistent income shocks are less likely to choose DB final-salary schemes. We control for cohort and age fixed effects in the empirical analysis.

FONG, J. H. Y.; MITCHELL, O. S.; KOH, B. S. K. *Longevity risk management in Singapore's national pension system.* 961–982. Although annuities are a theoretically appealing way to manage longevity risk, in the real world relatively few consumers purchase them at retirement. To counteract the possibility of retirees outliving their assets, Singapore's Central Provident Fund, a national defined contribution pension scheme, has recently mandated annuitization of workers' retirement assets. More significantly, the government has entered the insurance market as a public-sector provider for such annuities. This article evaluates the money's worth of life annuities and discusses the impact of the government mandate and its role as an annuity provider on the insurance market.

GATZERT, N.; SCHMITT-HOERMANN, G. *Understanding the death benefit switch option in universal life policies.* 823–852. Universal life policies are the most popular insurance contract design in the United States. They provide either a level death benefit paying a fixed face amount or an increasing death benefit paying a fixed benefit plus the available cash value, and both types include the option to switch from one type to the other. In this article, we investigate the fact that—unlike a switch from level to increasing—a switch from an increasing death benefit to a level death benefit requires neither fees nor evidence of insurability. To assess the impact of the death benefit switch option, we develop a model framework of an increasing universal life insurance policy embedding this option. Consideration of heterogeneity with respect to mortality via a stochastic differential mortality factor enables an investigation of adverse exercise behavior. In a comprehensive simulation analysis, we quantify the net present value of the option from the insurer's perspective using risk-neutral valuation under stochastic interest rates assuming empirical exercise probabilities. Based on our results, we provide policy recommendations for life insurers.

HOYT, R. E.; LIEBENBERG, A. P. *The value of enterprise risk management.* 795–822. Enterprise risk management (ERM) has been the topic of increased media attention in recent years. The objective of this study is to measure the extent to which specific firms have implemented ERM programs and, then, to assess the value implications of these programs. We focus our attention in this study on U.S. insurers in order to control for differences that might arise from regulatory and market differences across industries. We simultaneously model the determinants of ERM and the effect of ERM on firm value. We estimate the effect of ERM on Tobin's Q, a standard proxy for firm value. We find a positive relation between firm value and the use of ERM. The ERM premium of roughly 20 percent is statistically and economically significant.

KOVACEVIC, R. M.; PFLUG, G. C. *Does insurance help to escape the poverty trap?—a ruin theoretic approach.* 1003–1028. Poverty trapping refers to the fact that poor people in developing countries cannot escape their poverty without help from outside. This is worsened by extreme events, for example, floods or hurricanes, sending people to poverty who have not been poor before. Often, insurance is seen as a way out. This article studies poverty trapping in the context of catastrophic risk and introduces a ruin-type model, combining deterministic growth with a stochastic loss model. We analyze the properties of the resulting piecewise deterministic Markov process, especially its trapping risk, and discuss for which groups of people insurance can reduce trapping probability.

LI, J. S.-H.; NG, A. C.-Y. *Canonical valuation of mortality-linked securities.* 853–884. A fundamental question in the study of mortality-linked securities is how to place a value on them. This is still an open question, partly because there is a lack of liquidly traded longevity indexes or securities from which we can infer the market price of risk. This article develops a framework for pricing mortality-linked securities on the basis of canonical valuation. This framework is largely nonparametric, helping us avoid parameter and model risk, which may be significant in other pricing methods. The framework is then applied to a mortality-linked security, and the results are compared against those derived from other methods.

PINQUET, J.; GUILLÉN, M.; AYUSO, M. *Commitment and lapse behavior in long-term insurance: a case study.* 983–1002. This article presents a case study of a portfolio of individual long-term insurance contracts sold by a Spanish mutual company. We describe the risk levels, the rating structure, and the implied cross-subsidies on a portfolio of policies providing health, life, and long-term care insurance. We show evidence of reclassification risk through the history of disability spells. We also analyze the lapse behavior and seek to provide a rationale for the portfolio's dynamics. We discuss the lack of commitment from the policyholders (lapses) and from the mutual company (which took a run-off decision). Finally, we draw conclusions regarding the design of such contracts.

SUN, W.; WEBB, A. *Valuing the longevity insurance acquired by delayed claiming of social security.* 907–930. Individuals can claim Social Security at any age from 62 to 70, although most claim at 62. We show that expected present value calculations substantially understate both the optimal claim age and the losses resulting from early claiming because they ignore the value of the additional longevity insurance acquired because of delay. Using numerical optimization techniques, we illustrate that the optimal claim age is between 67 and 70. We calculate that the amount by which benefits payable at suboptimal ages must be increased so that a household is indifferent between claiming at those ages and the optimal combination of ages can be as high as 19.0 percent.

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BERNARD, C.; MAJ, M.; VANDUFFEL, S. *Improving the design of financial products in a multidimensional black-scholes market.* 77–96. Using various techniques, authors have shown that in one-dimensional markets, complex (pathdependent) contracts are generally not optimal for rational consumers. In this paper we generalize these results to a multidimensional

Black-Scholes market. In such a market, we discuss optimal contracts for investors who prefer more to less and have a fixed investment horizon $T > 0$. First, given a desired probability distribution, we give an explicit form of the optimal contract that provides this distribution to the consumer. Second, in the case of risk-averse investors, we are able to propose two ways of improving the design of financial products. In all cases, the optimal payoff can be seen as a path-independent European option that is written on the so-called market portfolio. We illustrate the theory with a few well-known securities and strategies. For example, we show that a buy-and-hold investment strategy can be dominated by a series of power options written on the underlying market portfolio. We also analyze the inefficiency of a widely used portfolio insurance strategy called Constant Proportion Portfolio Insurance.

COWELL, M. J. *Discussion of "Mortality Projections for Social Security Programs in the United States," Alice H. Wade, Vol. 14, No. 3, 2010. 137-139.* This is a discussion of paper already published. The original paper was "Mortality Projections for Social Security Programs in the United States," Alice H. Wade, Vol. 14, No. 3, 2010.

DENUIT, M.; HABERMAN, S.; RENSHAW, A. *Longevity-indexed life annuities.* 97-111. This paper addresses the problem of the sharing of longevity risk between an annuity provider and a group of annuitants. An appropriate longevity index is designed in order to adapt the amount of the periodic payments in life annuity contracts. This accounts for unexpected longevity improvements experienced by a given reference population. The approach described in the present paper is in contrast with group self-annuitization, where annuitants bear their own risk. Here the annuitants bear only the nondiversifiable risk that the future mortality trend departs from that of the reference forecast. In that respect, the life annuities discussed in this paper are substitutes for reinsurance and securitization of longevity risk.

DUNCAN, I.; BEATTY, B.; DAY, B. *A risk-based evaluation methodology for cost effectiveness of chronic condition health management.* 1-12. A financial evaluation of the effectiveness of chronic disease health management programs would ideally take into account the health care costs of managed chronic member populations compared against the health care costs of comparable non managed chronic member populations. This paper considers one approach when a comparison chronic member population is not readily available.

The approach uses a non managed non chronic member population as the comparison group, applying a claims normalization methodology to the medical claims costs of the chronic and non chronic populations. The normalization process includes stratification by demographic and risk factors. The resulting savings factors are then modified to identify expected savings for single employer groups. The analysis develops savings factors at the book-of-business level, which are then applied to groups to estimate the savings at the group level. Separate savings factors are developed by age and sex, condition, and duration from initial chronic diagnosis. Results are generally intuitively reasonable: Savings are higher for members with longer duration since identification, as well as for members with more costly conditions (e.g., heart disease, comorbid conditions).

The effect-on-savings estimates of underlying factors such as age, duration, and condition have not been extensively examined in the health services literature. Our paper adds to the literature by examining the effect of duration, risk, and condition on savings from a management program while providing a methodology that may be followed by other practitioners to examine these effects in other populations.

FENG, R.; GARRIDO, J. *Actuarial applications of epidemiological models*. 112-136. The risk of a global avian flu or influenza A (H1N1) pandemic and the emergence of the worldwide SARS epidemic in 2002–2003 have led to a revived interest in the study of infectious diseases. Mathematical models have become important tools in analyzing the transmission dynamics and in measuring the effectiveness of controlling strategies. Research on infectious diseases in the actuarial literature goes only so far in setting up epidemiological models that better reflect the transmission dynamics. This paper attempts to build a bridge between epidemiological and actuarial modeling and set up an actuarial model that provides financial arrangements to cover the expenses resulting from the medical treatments of infectious diseases. Based on classical epidemiological compartment models, the first part of this paper proposes insurance policies and models to quantify the risk of infection and formulates financial arrangements, between an insurer and insureds, using actuarial methodology. For practical purposes, the second part employs a variety of numerical methods to calculate premiums and reserves. The last part illustrates the methods by designing insurance products for two well-known epidemics: the Great Plague in England and the SARS epidemic in Hong Kong.

LI, S.-H.; CHAN, W.-S.; CHEUNG, S.-H. *Structural changes in the lee-carter mortality indexes: detection and implications*. 13-31. In recent years mortality has improved considerably faster than had been predicted, resulting in unforeseen mortality losses for annuity and pension liabilities. Actuaries have considered various models to make stochastic mortality projections, one of which is the celebrated Lee-Carter model.

In using the Lee-Carter model, mortality forecasts are made on the basis of the assumed linearity of a mortality index, parameter kt , in the model. However, if this index is indeed not linear, forecasts will tend to be biased and inaccurate. A primary objective of this paper is to examine the linearity of this index by rigorous statistical hypothesis tests. Specifically, we consider Zivot and Andrews' procedure to determine if there are any structural breaks in the Lee-Carter mortality indexes for the general populations of England and Wales and the United States. The results indicate that there exists a statistically significant structural breakpoint in each of the indexes, suggesting that forecasters should be extra cautious when they extrapolate these indexes. Our findings also provide sound statistical evidence for some demographers' observation of an accelerated mortality decline after the mid-1970s.

PISCOPO, G.; HABERMAN, S. *The valuation of guaranteed lifelong withdrawal benefit options in variable annuity contracts and the impact of mortality risk*. 59-76. In light of the growing importance of the variable annuities market, in this paper we introduce a theoretical model for the pricing and valuation of guaranteed lifelong withdrawal benefit (GLWB) options embedded in variable annuity products. As the name suggests, this option offers a lifelong withdrawal guarantee; therefore, there is no limit on the total amount that is withdrawn over the term of the policy because if the account value becomes zero while the insured is still alive, he or she continues to receive the guaranteed amount annually until death. Any remaining account value at the time of death is paid to the beneficiary as a death benefit. We offer a specific framework to value the GLWB option in a market-consistent manner under the hypothesis of a static withdrawal strategy, according to which the withdrawal amount is always equal to the guaranteed amount. The valuation approach is based on the decomposition of the product into living and death benefits. The model makes use of the standard no-arbitrage models of mathematical finance, which extend the Black-Scholes framework to insurance contracts, assuming the fund follows a geometric Brownian motion and the insurance fee is paid, on an

ongoing basis, as a proportion of the assets. We develop a sensitivity analysis, which shows how the value of the product varies with the key parameters, including the age of the policyholder at the inception of the contract, the guaranteed rate, the risk-free rate, and the fund volatility. We calculate the fair fee, using Monte Carlo simulations under different scenarios. We give special attention to the impact of mortality risk on the value of the option, using a flexible model of mortality dynamics, which allows for the possible perturbations by mortality shock of the standard mortality tables used by practitioners. Moreover, we evaluate the introduction of roll-up and step-up options and the effect of the decision to delay withdrawing. Empirical analyses are performed, and numerical results are provided.

STALLARD, E. *Estimates of the incidence, prevalence, duration, intensity and cost of chronic disability among the US Elderly*. 32-58. The objective of this paper is to estimate the burden of chronic disability on the U.S. elderly population, using unisex and sex-specific measures of long-term care (LTC) service use, intensity, and costs. Multistate life-table analysis was performed of adjacent rounds of the National Long-Term Care Survey (NLTCs) from 1984, 1989, and 1994, using criteria introduced in the Health Insurance Portability and Accountability Act (HIPAA) of 1996 to stratify the disabled population according to level of disability based on ADL and cognitive impairment criteria. Rates of transition to and from nondisabled to disabled states and from all states to death were computed and analyzed for differences by age and sex. Rates of service use, intensity, and costs were computed conditional on age and sex. It was found that approximately 20% of the residual life expectancy at age 65 for males and 30% for females were spent in a state of chronic disability. For both sexes, the years of chronic disability above age 65 were split evenly between mild/moderate and severe disability. The expected costs of purchased LTC services were \$59,000 (includes home/community care and institutional care, in constant 2000 dollars), with substantial sex differences: \$29,000 for males versus \$82,000 for females. For both sexes, the overwhelming majority (92%) of the LTC costs were incurred during episodes of severe disability, with the remaining (8%) incurred during episodes of mild/moderate disability. Residual lifetime unpaid home/community care averaged 3,200 hours for males and 4,000 hours for females, with approximately one-third of those hours incurred during episodes of mild/moderate disability. The criteria for identifying severely disabled persons introduced by HIPAA effectively targeted the high-cost disabled subpopulation. This group accounted for the overwhelming majority of purchased LTC services, and a large majority of unpaid LTC services, over age 65. Sex differences in expected per capita lifetime LTC costs were substantial, with females outspending males 2.8 to 1.

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BLAKE, D.; BROCKETT, P.; COX, S.; MACMINN, R. *Longevity risk and capital markets: the 2009-2010 update*. 141-149. Introduction to this Special Issue of the North American Actuarial Journal which contains 10 contributions to the academic literature, all dealing with longevity risk and capital markets.

COUGHLAN, G. D.; KHALAF-ALLAH, M.; YE, Y.; KUMAR, S.; CAIRNS, A. J. G.; BLAKE, D.; DOWD, K. *Longevity hedging 101: a framework for longevity basis risk analysis and hedge effectiveness*. 150-176. Basis risk is an important consideration when hedging longevity risk with instruments based on longevity indices, since the longevity experience of the hedged exposure

may differ from that of the index. As a result, any decision to execute an index-based hedge requires a framework for (1) developing an informed understanding of the basis risk, (2) appropriately calibrating the hedging instrument, and (3) evaluating hedge effectiveness. We describe such a framework and apply it to a U.K. case study, which compares the population of assured lives from the Continuous Mortality Investigation with the England and Wales national population. The framework is founded on an analysis of historical experience data, together with an appreciation of the contextual relationship between the two related populations in social, economic, and demographic terms. Despite the different demographic profiles, the case study provides evidence of stable long-term relationships between the mortality experiences of the two populations. This suggests the important result that high levels of hedge effectiveness should be achievable with appropriately calibrated, static, index-based longevity hedges. Indeed, this is borne out in detailed calculations of hedge effectiveness for a hypothetical pension portfolio where the basis risk is based on the case study. A robustness check involving populations from the United States yields similar results.

D'AMATO, V.; DI LORENZO, E.; HABERMAN, S.; RUSSOLILLO, M.; SIBILLO, M. *The poisson log-bilinear lee-carter model: applications of efficient bootstrap methods to annuity analyses*. 315-333. Life insurance companies deal with two fundamental types of risks when issuing annuity contracts: financial risk and demographic risk. Recent work on the latter has focused on modeling the trend in mortality as a stochastic process. A popular method for modeling death rates is the Lee-Carter model. This methodology has become widely used, and various extensions and modifications have been proposed to obtain a broader interpretation and to capture the main features of the dynamics of mortality rates. In order to improve the measurement of uncertainty in survival probability estimates, in particular for older ages, the paper proposes an extension based on simulation procedures and on the bootstrap methodology. It aims to obtain more reliable and accurate mortality projections, based on the idea of obtaining an acceptable accuracy of the estimate by means of variance reducing techniques. In this way the forecasting procedure becomes more efficient. The longevity question constitutes a critical element in the solvency appraisal of pension annuities. The demographic models used for the cash flow distributions in a portfolio impact on the mathematical reserve and surplus calculations and affect the risk management choices for a pension plan. The paper extends the investigation of the impact of survival uncertainty for life annuity portfolios and for a guaranteed annuity option in the case where interest rates are stochastic. In a framework in which insurance companies need to use internal models for risk management purposes and for determining their solvency capital requirement, the authors consider the surplus value, calculated as the ratio between the market value of the projected assets to that of the liabilities, as a meaningful measure of the company's financial position, expressing the degree to which the liabilities are covered by the assets.

DOWD, K.; BLAKE, D.; CAIRNS, A. J. G. *A computationally efficient algorithm for estimating the distribution of future annuity values under interest-rate and longevity risks*. 237-247. This paper proposes a computationally efficient algorithm for quantifying the impact of interest rate risk and longevity risk on the distribution of annuity values in the distant future. The algorithm simulates the state variables out to the end of the horizon period and then uses a Taylor series approximation to compute approximate annuity values at the end of that period, thereby avoiding a computationally expensive "simulation-within-simulation" problem. Illustrative results suggest that annuity values are likely to rise considerably but are also quite uncertain. These findings have some unpleasant implications both for defined contribution pension plans and for defined benefit plan sponsors considering using annuities to hedge their exposure to these risks at some point in the future.

DOWD, K.; CAIRNS, A. J. G.; BLAKE, D.; COUGHLAN, G. D.; KHALAF-ALLAH, M. *A gravity model of mortality rates for two related populations*. 334-356. The mortality rate dynamics between two related but different-sized populations are modelled consistently using a new stochastic mortality model that we call the gravity model. The larger population is modeled independently, and the smaller population is modeled in terms of spreads (or deviations) relative to the evolution of the former, but the spreads in the period and cohort effects between the larger and smaller populations depend on gravity or spread reversion parameters for the two effects. The larger the two gravity parameters, the more strongly the smaller population's mortality rates move in line with those of the larger population in the long run. This is important where it is believed that the mortality rates between related populations should not diverge over time on grounds of biological reasonableness. The model is illustrated using an extension of the Age-Period-Cohort model and mortality rate data for English and Welsh males representing a large population and the Continuous Mortality Investigation assured male lives representing a smaller related population.

HANEWALD, K. *Explaining mortality dynamics: the role of macroeconomic fluctuations and cause of death trends*. 290-314. Using data for six OECD countries over the period 1950–2006, this paper studies the impact of macroeconomic fluctuations and cause of death trends on mortality dynamics in the Lee-Carter mortality forecasting model. The key results of this study are the following: (1) Periods can be identified in which the Lee-Carter mortality index k_t correlates significantly with macroeconomic fluctuations. (2) A few causes of death such as diseases of the circulatory system, influenza and pneumonia, and diabetes mellitus account for a large fraction of the variations in the Lee-Carter mortality index k_t . (3) Most cause-specific mortality rates show pronounced trends over the last few decades. These trends change the composition of deaths and alter how total mortality reacts to external factors such as macroeconomic fluctuations.

LI, J. S.-H.; HARDY, M. R. *Measuring basis risk involved in longevity hedges*. 177-200. In examining basis risk in index longevity hedges, it is important not to ignore the dependence between the population underlying the hedging instrument and the population being hedged. We consider four extensions to the Lee-Carter model that incorporate such dependence: Both populations are jointly driven by the same single time-varying index, the two populations are cointegrated, the populations depend on a common age factor, and there is an augmented common factor model in which a population-specific time-varying index is added to the common factor model with the property that it will tend toward a certain constant level over time. Using data from the female populations of Canada and the United States, we show the augmented common factor model is preferred in terms of both goodness-of-fit and ex post forecasting performance. This model is then used to quantify the basis risk in a longevity hedge of 65-year old Canadian females structured using a portfolio of q forward contracts predicated on U.S. female population mortality. The hedge effectiveness is estimated at 56% on the basis of longevity value at-risk and 81.61% on the basis of longevity risk reduction.

MAYHEW, L.; SMITH, D. *Human survival at older ages and the implications for longevity bond pricing*. 248-265. Governments are concerned about the future of pension plans, for which increasing longevity is judged to be an important risk to their future viability. We focus on human survival at age 65, the starting age point for many pension products. Using a simple model, we link basic measures of life expectancy to the shape of the human survival function and consider its various forms. The model is then used as the basis for investigating actual survival in England and Wales. We find that life expectancy is increasing at a faster rate than at any time in history, with no evidence of this trend slowing or any upper age limit. With interest growing in the use of

longevity bonds as a way to transfer longevity risks from pension providers to the capital markets, we seek to understand how longevity drift affects pension liabilities based on mortality rates at the point of annuitization, versus what actually happens as a cohort ages. The main findings are that longevity bonds are an effective hedge against longevity risk; however, it is not only the oldest old that are driving risk, but also more 65-year-olds reaching less extreme ages such as 80. In addition, we find that the possibility of future inflation and interest rates could be as an important a risk to annuities as longevity itself.

MILIDONIS, A.; LIN, Y.; COX, S. H. *Mortality regimes and pricing*. 266-289. Mortality dynamics are characterized by changes in mortality regimes. This paper describes a Markov regime-switching model that incorporates mortality state switches into mortality dynamics. Using the 1901–2005 U.S. population mortality data, we illustrate that regime-switching models can perform better than well-known models in the literature. Furthermore, we extend the 1992 Lee-Carter model in such a way that the time-series common risk factor to all cohorts has distinct mortality regimes with different means and volatilities. Finally, we show how to price mortality securities with this model.

RICHTER, A.; WEBER, F. *Mortality-indexed annuities: managing longevity risk via product design*. 212-236. Longevity risk has become a major challenge for governments, individuals, and annuity providers in most countries. In its aggregate form, the systematic risk of changes to general mortality patterns, it has the potential for causing large cumulative losses for insurers. Since obvious risk management tools, such as (re)insurance or hedging, are less suited for managing an annuity provider's exposure to this risk, we propose a type of life annuity with benefits contingent on actual mortality experience.

Similar adaptations to conventional product design exist with investment-linked annuities, and a role model for long-term contracts contingent on actual cost experience can be found in German private health insurance. By effectively sharing systematic longevity risk with policyholders, insurers may avoid cumulative losses. Policyholders also gain in comparison with a comparable conventional annuity product: Using a Monte Carlo simulation, we identify a significant upside potential for policyholders while downside risk is limited.

TSAI, J. T.; TZENG, L. Y.; WANG, J. L. *Hedging longevity risk when interest rates are uncertain*. 201-211. This paper proposes an asset liability management strategy to hedge the aggregate risk of annuity providers under the assumption that both the interest rate and mortality rate are stochastic. We assume that annuity providers can invest in longevity bonds, long-term coupon bonds, and short-term zero-coupon bonds to immunize themselves from the risks of the annuity for the equity holders subject to a required profit. We demonstrate that the optimal allocation strategy can lead to the lowest risk under different yield curves and mortality rate assumptions. The longevity bond can also be regarded as an effective hedging vehicle that significantly reduces the aggregate risk of the annuity providers.

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AHN, J. Y.; SHYAMALKUMAR, N. D. *Large sample behavior of the CTE and VaR estimators under importance sampling*. 393-416. The α -level value at risk (VaR) and the α -level conditional

tail expectation (CTE) of a continuous random variable X are defined as its α -level quantile (denoted by q_α) and its conditional expectation given the event $\{X \geq q_\alpha\}$, respectively. VaR is a popular risk measure in the banking sector, for both external and internal reporting purposes, while the CTE has recently become the risk measure of choice for insurance regulation in North America. Estimation of the CTE for company assets and liabilities is becoming an important actuarial exercise, and the size and complexity of these liabilities make inference procedures with good small sample performance very desirable. A common situation is one in which the CTE of the portfolio loss is estimated using simulated values, and in such situations use of variance reduction techniques such as importance sampling have proved to be fruitful. Construction of confidence intervals for the CTE relies on the availability of the asymptotic distribution of the normalized CTE estimator, and although such a result has been available to actuaries, it has so far been supported only by heuristics. The main goal of this paper is to provide an honest theorem establishing the convergence of the normalized CTE estimator under importance sampling to a normal distribution. In the process, we also provide a similar result for the VaR estimator under importance sampling, which improves upon an earlier result. Also, through examples we motivate the practical need for such theoretical results and include simulation studies to lend insight into the sample sizes at which these asymptotic results become meaningful.

FREES, E. W.; GAO, J.; ROSENBERG, M. A. *Predicting the frequency and amount of health care expenditures*. 377-392. This article extends the standard two-part model for predicting health care expenditures to the case where multiple events may occur within a one-year period. The first part of the extended model represents the frequency of events, such as the number of inpatient hospital stays or outpatient visits, and the second part models expenditure per event. Both component models also use independent variables that consist of an individual's demographic and access characteristics, socioeconomic status, health status, health insurance coverage, employment status, and industry classification. The second part of the model also includes a variable representing the number of events to predict the expenditure per event, thus capturing dependencies between the first and second parts. This article introduces closed-form predictors of annual total expenditures and demonstrates how to create simulated predictive distributions for individuals and groups. The data for this study are from the Medical Expenditure Panel Survey (MEPS). MEPS panels 7 and 8 from 2003 were used for estimation; panels 8 and 9 from 2004 were used to validate predictions. This annual expenditures model provided a better fit to the data than standard two-part models. The count variable was significant in predicting outpatient expenditures. The aggregate expenditures model provided better point predictions of held-out total expenditures than competing models, including the standard two-part model. The predictive distribution for aggregate expenditures for small groups is long tailed, with both the variability and skewness decreasing as the group size increases, an important point for programs designed to manage expenditures.

GAVRILOV, L. A.; GAVRILOVA, N. S. *Mortality measurement at advanced ages: a study of the social security administration death master file*. 432-447. Accurate estimates of mortality at advanced ages are essential to improving forecasts of mortality and the population size of the oldest old age group. However, estimation of hazard rates at extremely old ages poses serious challenges to researchers: (1) The observed mortality deceleration may be at least partially an artefact of mixing different birth cohorts with different mortality (heterogeneity effect); (2) standard assumptions of hazard rate estimates may be invalid when risk of death is extremely high at old ages and (3) ages of very old people may be exaggerated. One way of obtaining estimates of mortality at extreme ages is to pool together international records of persons

surviving to extreme ages with subsequent efforts of strict age validation. This approach helps researchers to resolve the third of the above-mentioned problems but does not resolve the first two problems because of inevitable data heterogeneity when data for people belonging to different birth cohorts and countries are pooled together. In this paper we propose an alternative approach, which gives an opportunity to resolve the first two problems by compiling data for more homogeneous single-year birth cohorts with hazard rates measured at narrow (monthly) age intervals. Possible ways of resolving the third problem of hazard rate estimation are elaborated. This approach is based on data from the Social Security Administration Death Master File (DMF). Some birth cohorts covered by DMF could be studied by the method of extinct generations.

Availability of month of birth and month of death information provides a unique opportunity to obtain hazard rate estimates for every month of age. Study of several single-year extinct birth cohorts shows that mortality trajectory at advanced ages follows the Gompertz law up to the ages 102–105 years without a noticeable deceleration. Earlier reports of mortality deceleration (deviation of mortality from the Gompertz law) at ages below 100 appear to be artefacts of mixing together several birth cohorts with different mortality levels and using cross-sectional instead of cohort data. Age exaggeration and crude assumptions applied to mortality estimates at advanced ages may also contribute to mortality underestimation at very advanced ages.

Jl, M.; HARDY, M.; LI, J. S.-H. *Markovian approaches to joint-life mortality*. 357-376. Many insurance products provide benefits that are contingent on the combined survival status of two lives. To value such benefits accurately, we require a statistical model for the impact of the survivorship of one life on another. In this paper we first set up two models, one Markov and one semi-Markov, to model the dependence between the lifetimes of a husband and wife. From the models we can measure the extent of three types of dependence: (1) the instantaneous dependence due to a catastrophic event that affect both lives, (2) the short-term impact of spousal death, and (3) the long-term association between lifetimes. Then we apply the models to a set of joint-life and last-survivor annuity data from a large Canadian insurance company. Given the fitted models, we study the impact of dependence on annuity values and examine the potential inaccuracy in pricing if we assume lifetimes are independent. Finally, we compare our Markovian models with two copula models considered in previous research on modeling joint-life mortality.

LIN, X.; LI, Y. *Optimal reinsurance and investment for a jump diffusion risk process under the CEV model*. 417-431. We consider an optimal reinsurance-investment problem of an insurer whose surplus process follows a jump-diffusion model. In our model the insurer transfers part of the risk due to insurance claims via a proportional reinsurance and invests the surplus in a “simplified” financial market consisting of a risk-free asset and a risky asset. The dynamics of the risky asset are governed by a constant elasticity of variance model to incorporate conditional heteroscedasticity. The objective of the insurer is to choose an optimal reinsurance-investment strategy so as to maximize the expected exponential utility of terminal wealth. We investigate the problem using the Hamilton-Jacobi-Bellman dynamic programming approach. Explicit forms for the optimal reinsurance investment strategy and the corresponding value function are obtained. Numerical examples are provided to illustrate how the optimal investment-reinsurance policy changes when the model parameters vary.

RAMSAY, C. M.; OGULEDO, V. I. *Optimum allocations to health care flexible spending accounts*. 448-467. Models used to derive optimal contributions to health care flexible spending accounts (FSAs) typically assume an employee’s household annual out-of-pocket health care expenses are

an absolutely continuously random variable. This assumption, however, ignores the fact that some employees may be able to accurately predict a portion of their household annual out-of-pocket health care expenses and often actually incur only those expenses during the plan year, implying that a mixed random variable may be more appropriate. In addition, data have shown that employees are setting contributions at lower levels than existing absolutely continuous models would suggest is optimal. Using a mixed model of household annual out-of-pocket health care expenses we prove that it is often optimal for employees to contribute an amount equal to their household annual predictable out-of-pocket expenses, thus avoiding the risk of forfeiture. We also propose a practical rule of thumb that employees may use for setting their FSA contributions. Overall, we recommend that employees use their FSAs to cover only their highly predictable out-of-pocket health care expenses rather than use their FSAs as a contingency fund to pay for unlikely or unexpected out of pocket health care expenses.

ROBINSON, R.; DESROCHERS, C. *Discussion of "Voluntary Termination of Life Insurance Policies: Evidence from the U.S. Market," Shi-jie Jiang, Vol. 14, No. 3, 2010. 468-472.* This is a discussion of paper already published. The original paper was "Voluntary Termination of Life Insurance Policies: Evidence from the U.S. Market," Shi-jie Jiang, Vol. 14, No. 3, 2010.

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BRAZAUSKAS, V.; KLEEFELD, A. *Folded and log-folded-t distributions as models for insurance loss data.* 59-74. A rich variety of probability distributions has been proposed in the actuarial literature for fitting of insurance loss data. Examples include: lognormal, log-t, various versions of Pareto, loglogistic, Weibull, gamma and its variants, and generalized beta of the second kind distributions, among others. In this paper, we supplement the literature by adding the log-folded-normal and log-folded-t families. Shapes of the density function and key distributional properties of the 'folded' distributions are presented along with three methods for the estimation of parameters: method of maximum likelihood; method of moments; and method of trimmed moments. Further, large and small-sample properties of these estimators are studied in detail. Finally, we fit the newly proposed distributions to data which represent the total damage done by 827 fires in Norway for the year 1988. The fitted models are then employed in a few quantitative risk management examples, where point and interval estimates for several value-at-risk measures are calculated.

HAUG, O.; DIMAKOS, X. K.; VARDAL, J. F.; ALDRIN, M.; MEZE-HAUSKEN, E. *Future building water loss projections posed by climate change.* 1-20. The insurance industry, like other parts of the financial sector, is vulnerable to climate change. Life as well as non-life products are affected and knowledge of future loss levels is valuable. Risk and premium calculations may be updated accordingly, and dedicated loss-preventive measures can be communicated to customers and regulators. We have established statistical claims models for the coherence between externally

inflicted water damage to private buildings in Norway and selected meteorological variables. Based on these models and downscaled climate predictions from the Hadley centre HadAM3 H climate model, the estimated loss level of a future scenario period (2071-2100) is compared to that of a control period (1961-1990). In spite of substantial estimation uncertainty, our analyses identify an incontestable increase in the claims level along with some regional variability. Of the uncertainties inherently involved in such predictions, only the error due to model fit is quantifiable.

JESSEN, A. H.; RIETDORF, N. *Diagonal effects in claims reserving*. 21-37. In this paper we present two different approaches to how one can include diagonal effects in non-life claims reserving based on run-off triangles. Empirical analyses suggest that the approaches in Zehnwrith (2003) and Kuang et al. (2008a, 2008b) do not work well with low-dimensional run-off triangles because estimation uncertainty is too large. To overcome this problem we consider similar models with a smaller number of parameters. These are closely related to the framework considered in Verbeek (1972) and Taylor (1977, 2000); the separation method. We explain that these models can be interpreted as extensions of the multiplicative Poisson models introduced by Hachemeister & Stanard (1975) and Mack (1991).

STANFORD, D. A.; YU, K.; REN, J. *Erlangian approximation to finite time ruin probabilities in perturbed risk models*. 38-58. In this paper, we consider a class of perturbed risk processes that have an underlying Markov structure, including Markov-modulated risk processes, and Sparre-Andersen risk processes when both inter-claim times and claim sizes are phase-type. We apply the Erlangization method to the risk process in the class in order to obtain an accurate approximation of the finite time ruin probability. In addition, we develop an efficient recursive procedure by recognizing a repeating structure in the probability matrices we work with. We believe the present work is among the first to either compute or approximate finite time ruin probabilities in the perturbed risk model.

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KIM, S.-Y.; WILLMOT, G. E. *The proper distribution function of the deficit in the delayed renewal risk model*. 118-137. The main focus of this paper is to extend the analysis of ruin-related quantities to the delayed renewal risk models. First, the background for the delayed renewal risk model is introduced and a general equation that is used as a framework is derived. The equation is obtained by conditioning on the first drop below the initial surplus level. Then, we consider the deficit at ruin among many random variables associated with ruin. The properties of the distribution function (DF) of the proper deficit are examined in particular.

LEVEILLE, G.; ADEKAMBI, F. *Covariance of discounted compound renewal sums with a stochastic interest rate*. 138-153. Formulas have been obtained for the moments of the discounted aggregate claims process, for a constant instantaneous interest rate, and for a claims number process that is an ordinary or a delayed renewal process. In this paper, we present explicit formulas on the first two moments and the joint moment of this risk process, for a non-trivial extension to a stochastic instantaneous interest rate. Examples are given for Erlang claims number processes, and for the Ho-Lee-Merton and the Vasicek interest rate models.

MITRIC, I.-R. *On a multi-threshold compound Poisson surplus process with interest*. 75-95. We consider a multi-threshold compound Poisson surplus process. When the initial surplus is between

any two consecutive thresholds, the insurer has the option to choose the respective premium rate and interest rate. Also, the model allows for borrowing the current amount of deficit whenever the surplus falls below zero. Starting from the integro-differential equations satisfied by the Gerber-Shiu function that appear in Yang et al. (2008), we consider exponentially and phase-type(2) distributed claim sizes, in which cases we are able to transform the integro-differential equations into ordinary differential equations. As a result, we obtain explicit expressions for the Gerber-Shiu function.

RUSSOLILLO, M.; GIORDANO, G.; HABERMAN, S. *Extending the Lee-Carter model: a three-way decomposition*. 96-117. In this paper, we focus on a Multi-dimensional Data Analysis approach to the Lee-Carter (LC) model of mortality trends. In particular, we extend the bilinear LC model and specify a new model based on a three-way structure, which incorporates a further component in the decomposition of the log-mortality rates. A multi-way component analysis is performed using the Tucker3 model. The suggested methodology allows us to obtain combined estimates for the three modes: (1) time, (2) age groups and (3) different populations. From the results obtained by the Tucker3 decomposition, we can jointly compare, in both a numerical and graphical way, the relationships among all three modes and obtain a time-series component as a leading indicator of the mortality trend for a group of populations. Further, we carry out a correlation analysis of the estimated trends in order to assess the reliability of the results of the three-way decomposition. The model's goodness of fit is assessed using an analysis of the residuals. Finally, we discuss how the synthesised mortality index can be used to build concise projected life tables for a group of populations. An application which compares 10 European countries is used to illustrate the approach and provide a deeper insight into the model and its implementation.

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EISENBERG, J.; SCHMIDLI, H. *Minimising expected discounted capital injections by reinsurance in a classical risk model*. 155-176. In this paper we consider a classical continuous time risk model, where the claims are reinsured by some reinsurance with retention level [unable to display equation], where [equation] means 'no reinsurance' and $b = 0$ means 'full reinsurance'. The insurer can change the retention level continuously. To prevent negative surplus the insurer has to inject additional capital. The problem is to minimise the expected discounted cost over all admissible reinsurance strategies. We show that an optimal reinsurance strategy exists. For some special cases we will be able to give the optimal strategy explicitly. In other cases the method will be illustrated only numerically.

JESSEN, A. H.; MIKOSCH, T.; SAMORODNITSKY, G. *Prediction of outstanding payments in a Poisson cluster model*. 214-237. We consider a simple Poisson cluster model for the payment numbers and the corresponding total payments for insurance claims arriving in a given year. Due to the Poisson structure one can give reasonably explicit expressions for the prediction of the payment numbers and total payments in future periods given the past observations of the payment numbers. One can also derive reasonably explicit expressions for the corresponding prediction errors. In the (a, b) class of Panjer's claim size distributions, these expressions can be evaluated by simple recursive algorithms. We study the conditions under which the predictions are asymptotically linear as the number of past payments becomes large. We also demonstrate that, in other regimes, the prediction may be far from linear. For example, a staircase-like pattern may arise as well. We illustrate how the theory works on real-life data, also in comparison with the chain ladder method.

PIGEON, M.; DENUIT, M. *Composite Lognormal–Pareto model with random threshold*. 177-192.

This paper further considers the composite Lognormal–Pareto model proposed by Cooray & Ananda (2005) and suitably modified by Scollnik (2007). This model is based on a Lognormal density up to an unknown threshold value and a Pareto density thereafter. Instead of using a single threshold value applying uniformly to the whole data set, the model proposed in the present paper allows for heterogeneity with respect to the threshold and let it vary among observations. Specifically, the threshold value for a particular observation is seen as the realization of a positive random variable and the mixed composite Lognormal–Pareto model is obtained by averaging over the population of interest. The performance of the composite Lognormal–Pareto model and of its mixed extension is compared using the well-known Danish fire losses data set.

SAVELLI, N.; CLEMENTE, G. P. *Hierarchical structures in the aggregation of premium risk for insurance underwriting*. 193-213. In the valuation of the Solvency II capital requirement, the correct appraisal of risk dependencies acquires particular relevance. These dependencies refer to the recognition of risk diversification in the aggregation process and there are different levels of aggregation and hence different types of diversification. For instance, for a non-life company at the first level the risk components of each single line of business (e.g. premium, reserve, and CAT risks) need to be combined in the overall portfolio, the second level regards the aggregation of different kind of risks as, for example, market and underwriting risk, and finally various solo legal entities could be joined together in a group. Solvency II allows companies to capture these diversification effects in capital requirement assessment, but the identification of a proper methodology can represent a delicate issue. Indeed, while internal models by simulation approaches permit usually to obtain the portfolio multivariate distribution only in the independence case, generally the use of copula functions can consent to have the multivariate distribution under dependence assumptions too. However, the choice of the copula and the parameter estimation could be very problematic when only few data are available. So it could be useful to find a closed formula based on Internal Models independence results with the aim to obtain the capital requirement under dependence assumption. A simple technique, to measure the diversification effect in capital requirement assessment, is the formula, proposed by Solvency II quantitative impact studies, focused on the aggregation of capital charges, the latter equal to percentile minus average of total claims amount distribution of single line of business (LoB), using a linear correlation matrix. On the other hand, this formula produces the correct result only for a restricted class of distributions, while it may underestimate the diversification effect. In this paper we present an alternative method, based on the idea to adjust that formula with proper calibration factors (proposed by Sandström (2007)) and appropriately extended with the aim to consider very skewed distribution too. In the last part considering different non-life multi-line insurers, we compare the capital requirements obtained, for only premium risk, applying the aggregation formula to the results derived by elliptical copulas and hierarchical Archimedean copulas.

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LU, B.; MACDONALD, A. S.; WATERS, H. R. *The genetics of breast and ovarian cancer IV: a model of breast cancer progression*. 239-266. Gui et al. (2006) in Part III of a series of papers, proposed a dynamic family history model of breast cancer and ovarian cancer in which the development of a family history was represented explicitly as a transition between states, and then applied this model to life insurance and critical illness insurance. In this study, the authors extend the model to income protection insurance. In this paper, Part IV of the series, the authors

construct and parameterise a semi-Markov model for the life history of a woman with breast cancer, in which events such as diagnosis, treatment, recovery and recurrence are incorporated. In Part V, we then show: (a) estimates of premium ratings depending on genotype or family history; and (b) the impact of adverse selection under various moratoria on the use of genetic information.

LU, B.; MACDONALD, A. S.; WATERS, H. R.; YU, F. *The genetics of breast and ovarian cancer V: application to income protection insurance*. 267-291. In part IV, we presented a comprehensive model of a life history of a woman at risk of breast cancer (BC), in which relevant events such as diagnosis, treatment, recovery and recurrence were represented explicitly, and corresponding transition intensities were estimated. In this part, the authors study some applications to income protection insurance (IPI) business. The authors calculate premiums based either on genetic test results or more practically on a family history of breast cancer. They then extend the model into an Income Protection Insurance model by incorporating rates of insurance-buying behaviour, in order to estimate the possible costs of adverse selection, in terms of increased premiums, under various moratoria on the use of genetic information.

VALDEZ, E. A.; XIAO, Y. *On the distortion of a copula and its margins*. 292-237. This article examines the notion of distortion of copulas, a natural extension of distortion within the univariate framework. We study three approaches to this extension: (1) distortion of the margins alone while keeping the original copula structure; (2) distortion of the margins while simultaneously altering the copula structure; and (3) synchronized distortion of the copula and its margins. When applying distortion within the multivariate framework, it is important to preserve the properties of a copula function. For the first two approaches, this is a rather straightforward result; however, for the third approach, the proof has been exquisitely constructed in Morillas (2005). These three approaches unify the different types of multivariate distortion that have scarcely scattered in the literature. Our contribution in this paper is to further consider this unifying framework: we give numerous examples to illustrate and we examine their properties particularly with some aspects of ordering multivariate risks. The extension of multivariate distortion can be practically implemented in risk management where there is a need to perform aggregation and attribution of portfolios of correlated risks. Furthermore, ancillary to the results discussed in this article, we are able to generalize the formula developed by Genest & Rivest (2001) for computing the distribution of the probability integral transformation of a random vector and extend it to the case within the distortion framework. For purposes of illustration, we applied the distortion concept to value excess of loss reinsurance for an insurance policy where the loss amount could vary by type of loss.

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KOCH, R. J. *Damages for personal injury and death: legal aspects relevant to actuarial assessments*. 111-134. In this paper the actuarial assessment of damages for personal injury and death is discussed in the context of South African law. The legal framework imposes a variety of calculation rules that need to be born in mind if an actuary is to produce a quality product. This framework changes with the passage of time. The purpose of the paper is to summarise the current state of affairs and highlight issues deserving of further actuarial discussion.

LOWTHER, M. W. *Promoting quality in the actuarial assessment of quantum of damages in South Africa*. 85-110. This paper applies a quality framework theory to a field of actuarial practice. The paper is relevant to the professionalism of actuaries in general, and to those who assess the quantum of damages in particular. Quality framework theories propose that practitioners need to apply a range of technical and normative capabilities to provide a quality professional service. This paper suggests the various Capabilities that are needed by actuaries in the field of assessment of the quantum of damages, and orders them by applying a quality framework. A methodology for practitioners to benchmark the quality of their practice is outlined. In South Africa, there is no formal curriculum, canon, or specific guidance for actuaries practising in this field. The paper therefore also contributes to the professionalisation of the field by reviewing and recording relevant literature, and provisionally filling gaps in it from personal experience of the author as practitioner in this field. The paper concludes by suggesting that this approach could also help professionalise other fields of actuarial practice.

REDDY, T. L.; THOMSON, R. J. *The capital-asset pricing model: the case of South Africa*. 43-84. This paper tests the empirical validity of the capital-asset pricing model (CAPM) for the South African share market. For the investigation, quarterly total returns from ten sectoral indices listed on the JSE Securities Exchange from 30 June 1995 to 30 June 2009, were used. As expressed in the securities market line, the CAPM suggests that higher risk, as measured by beta, is associated with higher expected returns. In addition, the theoretical underpinnings of the CAPM are that it explains expected excess return, and that the relationship between expected return and beta is linear. In this investigation the above-mentioned predictions of the CAPM were tested. Direct tests of the securities market line were made, using both prior betas and in-period betas. A nonparametric test was also made. Regression analysis was used to test hypotheses based on both individual sectoral indices and portfolios constructed from those indices according to their betas. These tests were made for individual years as well as for all periods combined. It was found that while, on the assumption that the residuals of the return-generating function are normally distributed, the CAPM could be rejected for certain periods, the use of the CAPM for long-term actuarial modelling in the South African market can be reasonably justified.

THOMSON, R. J. *The arbitrage-free equilibrium pricing of liabilities in an incomplete market: Application to a South African retirement fund*. 1-42. In prior work by the author the method of pricing the liabilities of a financial institution by means of dynamic mean-variance hedging is applied to an incomplete market that is nevertheless in equilibrium with homogeneous expectations. In subsequent work a long-term equilibrium model is developed and parameterised for the South African market. The aim of this paper is to apply the latter model to the pricing method with a view to quantifying the effects of non-additivity due to incompleteness, guarantees implicit in reasonable expectations of pension increases and the sensitivity of the price of illustrative liabilities to the parameters of the model. The application is to retirement-fund benefits in the South African market. In an unpublished application of the pricing method it was found that, except for quite short-term liabilities, the computational demands of the pricing algorithm became excessive. The main reason for this was that the algorithm calls for simulations within simulations: for each year of the term of liabilities, a large number of simulations is required, and for each such simulation another large number of simulations is required. In this article consideration is given to the reduction of the computational demands of the algorithm.

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