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ASTIN Bulletin

41(2), 2011

ALBRECHER, H.; CHEUNG, E. C. K.; THONHAUSER, S. *Randomized observation periods for the compound poisson risk model: dividends.* 645–672. In the framework of the classical compound Poisson process in collective risk theory, we study a modification of the horizontal dividend barrier strategy by introducing random observation times at which dividends can be paid and ruin can be observed. This model contains both the continuous-time and the discrete-time risk model as a limit and represents a certain type of bridge between them which still enables the explicit calculation of moments of total discounted dividend payments until ruin. Numerical illustrations for several sets of parameters are given and the effect of random observation times on the performance of the dividend strategy is studied.

AVANZI, B.; CASSAR, L. C.; WONG, B. *Modelling dependence in insurance claims process with Lévy copulas.* 575–609. In this paper we investigate the potential of Lévy copulas as a tool for modelling dependence between compound Poisson processes and their applications in insurance. We analyse characteristics regarding the dependence in frequency and dependence in severity allowed by various Lévy copula models. Through the introduction of new Lévy copulas and comparison with the Clayton Lévy copula, we show that Lévy copulas allow for a great range of dependence structures. Procedures for analysing the fit of Lévy copula models are illustrated by fitting a number of Lévy copulas to a set of real data from Swiss workers compensation insurance. How to assess the fit of these models with respect to the dependence structure exhibited by the dataset is also discussed. Finally, we provide a decomposition of the trivariate compound Poisson process and discuss how trivariate Lévy copulas model dependence in this multivariate setting.

AVANZI, B.; SHEN, J.; WONG, B. *Optimal dividends and capital injections in the dual model with diffusion.* 611–644. The dual model with diffusion is appropriate for companies with continuous expenses that are offset by stochastic and irregular gains. Examples include research-based or commission-based companies. In this context, Avanzi and Gerber (2008) showed how to determine the expected present value of dividends, if a barrier strategy is followed. In this paper, we further include capital injections and allow for (proportional) transaction costs both on dividends and capital injections. We determine the optimal dividend and (unconstrained) capital injection strategy (among all possible strategies) when jumps are hyperexponential. This strategy happens to be either a dividend barrier strategy without capital injections, or another dividend barrier strategy with forced injections when the surplus is null to prevent ruin. The latter is also shown to be the optimal dividend

and capital injection strategy, if ruin is not allowed to occur. Both the choice to inject capital or not and the level of the optimal barrier depend on the parameters of the model. In all cases, we determine the optimal dividend barrier and show its existence and uniqueness. We also provide closed form representations of the value functions when the optimal strategy is applied. Results are illustrated.

CHI, Y.; TAN, K. S. *Optimal reinsurance under VaR and CVaR risk measures*. 487–509. In this paper, we study two classes of optimal reinsurance models by minimizing the total risk exposure of an insurer under the criteria of value at risk (VaR) and conditional value at risk (CVaR). We assume that the reinsurance premium is calculated according to the expected value principle. Explicit solutions for the optimal reinsurance policies are derived over ceded loss functions with increasing degrees of generality. More precisely, we establish formally that under the VaR minimization model, (i) the stop-loss reinsurance is optimal among the class of increasing convex ceded loss functions; (ii) when the constraints on both ceded and retained loss functions are relaxed to increasing functions, the stop-loss reinsurance with an upper limit is shown to be optimal; (iii) and finally under the set of general increasing and left-continuous retained loss functions, the truncated stop-loss reinsurance is shown to be optimal. In contrast, under CVaR risk measure, the stop-loss reinsurance is shown to be always optimal. These results suggest that the VaR-based reinsurance models are sensitive with respect to the constraints imposed on both ceded and retained loss functions while the corresponding CVaR-based reinsurance models are quite robust.

CURRIE, I. D. *Modelling and forecasting the mortality of the very old*. 419–427. The forecasting of the future mortality of the very old presents additional challenges since data quality can be poor at such ages. We consider a two-factor model for stochastic mortality, proposed by Cairns, Blake and Dowd, which is particularly well suited to forecasting at very high ages. We consider an extension to their model which improves fit and also allows forecasting at these high ages. We illustrate our methods with data from the Continuous Mortality Investigation.

DONG, Y. *Fair valuation of life insurance contracts under a correlated jump diffusion model*. 429–447. In this paper, we study the fair valuation of participating life insurance contract, which is one of the most common life insurance products, under the jump diffusion model with the consideration of default risk. The participating life insurance contracts considered here can be expressed as portfolios of options as shown by Grosen and Jørgensen (1997). We use the Laplace transforms methods to price these options.

HÜRLIMANN, W. *Optimal reinsurance revisited point of view of cedent and reinsurer*. 547–474. It is known that the partial stop-loss contract is an optimal reinsurance form under the VaR risk measure. Assuming that market premiums are set according to the expected value principle with varying loading factors, the optimal reinsurance parameters of this contract are obtained under three alternative single and joint party reinsurance criteria: (i) strong minimum of the total retained loss VaR measure; (ii) weak minimum of the total retained loss VaR measure and maximum of the reinsurer's expected profit; (iii) weak minimum of the total retained loss VaR measure and minimum of the total variance risk measure. New conditions for financing in the mean simultaneously the cedent's and the reinsurer's required VaR economic capital are revealed for situations of pure risk transfer (classical reinsurance) or risk and profit transfer (design of internal reinsurance or reinsurance captive owned by the captive of a corporate firm).

JARNER, S. F.; KRYGER, E. M. *Modelling adult mortality in small populations: The SAINT Model*. 377–418. The mortality evolution of small populations often exhibits substantial

variability and irregular improvement patterns making it hard to identify underlying trends and produce plausible projections. We propose a methodology for robust forecasting based on the existence of a larger reference population sharing the same long-term trend as the population of interest. The reference population is used to estimate the parameters in a frailty model for the underlying intensity surface. A multivariate time series model describing the deviations of the small population mortality from the underlying mortality is then fitted and forecasted. Coherent long-term forecasts are ensured by the underlying frailty model while the size and variability of short- to medium-term deviations are quantified by the time series model. The frailty model is particularly well suited to describe the changing improvement patterns in old age mortality. We apply the method to Danish mortality data with a pooled international data set as reference population.

KLING, A.; RUEZ, F.; RUSS, J. *The impact of stochastic volatility on pricing, hedging, and hedge efficiency of withdrawal benefit guarantees in variable annuities*. 511–545. We analyze different types of guaranteed withdrawal benefits for life, the latest guarantee feature within variable annuities. Besides an analysis of the impact of different product features on the clients' payoff profile, we focus on pricing and hedging of the guarantees. In particular, we investigate the impact of stochastic equity volatility on pricing and hedging. We consider different dynamic hedging strategies for delta and vega risks and compare their performance. We also examine the effects if the hedging model (with deterministic volatility) differs from the data-generating model (with stochastic volatility). This is an indication for the model risk an insurer takes by assuming constant equity volatilities for risk management purposes, whereas in the real world volatilities are stochastic.

MACDONALD, A.; YU, F. *The impact of genetic information on the insurance industry: Conclusions from the 'bottom-up' modelling programme*. 343–376. We quantify the overall impact of genetic information on the insurance industry using the 'bottom-up' approach, in which detailed models are constructed of representative major genetic disorders. We consider six such disorders, namely adult polycystic kidney disease, early-onset Alzheimer's disease, Huntington's disease, myotonic dystrophy (MD), hereditary non-polyposis colorectal cancer; and breast/ovarian cancer. Actuarial models based on the epidemiological literature exist for all these except MD. We parameterise a suitable model of MD, then synthesize the results from all six models to estimate the adverse selection costs arising from restrictions on insurers' use of genetic information. These are all very small, only in the most extreme cases rising above 1% of premiums. In the worst case – females displaying 'extreme' adverse selection in a 'small' critical illness insurance market, with the use of family history banned – the cost is about 3% of premiums. Our model includes the most common single-gene disorders relevant to insurance, and includes representatives of most important classes of these disorders. While the 'bottom-up' approach could be continued by modelling more and more diseases, we suggest that our model is adequate to draw robust conclusions.

MOHR, C. *Market-consistent valuation of insurance liabilities by cost of capital*. 315–341. This paper investigates market-consistent valuation of insurance liabilities in the context of Solvency II among others and to some extent IFRS 4. We propose an explicit and consistent framework for the valuation of insurance liabilities which incorporates the Solvency II approach as a special case. The proposed framework is based on replication over multiple (one-year) time periods by a periodically updated portfolio of assets with reliable market prices, allowing for 'limited liability' in the sense that the replication can in general not always be continued. The asset portfolio consists of two parts: (1) assets whose market price defines the value of the insurance liabilities,

and (2) capital funds used to cover risk which cannot be replicated. The capital funds give rise to capital costs; the main exogenous input in the framework is the condition on when the investment of the capital funds is acceptable. We investigate existence of the value and show that the exact calculation of the value has to be done recursively backwards in time, starting at the end of the lifetime of the insurance liabilities. We derive upper bounds on the value and, for the special case of replication by risk-free one-year zero-coupon bonds, explicit recursive formulas for calculating the value. In the paper, we only partially consider the question of the uniqueness of the value. Valuation in Solvency II and IFRS 4 is based on representing the value as a sum of a 'best estimate' and a 'risk margin'. In our framework, it turns out that this split is not natural. Nonetheless, we show that a split can be constructed as a simplification, and that it provides an upper bound on the value under suitable conditions. We illustrate the general results by explicitly calculating the value for a simple example.

SALUZ, A.; GISLER, A.; WÜTHRICH, M. V. *Development pattern and prediction error for the stochastic Bornhuetter-Ferguson claims reserving method.* 279–313. We investigate the question how the development pattern in the Bornhuetter-Ferguson method should be estimated and derive the corresponding conditional mean square error of prediction (MSEP) of the ultimate claim prediction. An estimator of this conditional MSEP in a distribution-free model was given by Mack [9], whereas in Alai et al. [2] this conditional MSEP was studied in an over-dispersed Poisson model using the chain ladder development pattern. First we consider distributional models and derive estimators (maximum likelihood) for the development pattern taking all relevant information into account. Moreover, we suggest new estimators of the correlation matrix of these estimators and new estimators of the conditional MSEP. Our findings supplement some of Mack's results. The methodology is illustrated at two numerical examples.

SHI, P.; FREES, E. W. *Dependent loss reserving using copulas.* 449–486. Modeling dependencies among multiple loss triangles has important implications for the determination of loss reserves, a critical element of risk management and capital allocation practices of property-casualty insurers. In this article, we propose a copula regression model for dependent lines of business that can be used to predict unpaid losses and hence determine loss reserves. The proposed method, relating the payments in different run-off triangles through a copula function, allows the analyst to use flexible parametric families for the loss distribution and to understand the associations among lines of business. Based on the copula model, a parametric bootstrap procedure is developed to incorporate the uncertainty in parameter estimates. To illustrate this method, we consider an insurance portfolio consisting of personal and commercial automobile lines. When applied to the data of a major US property-casualty insurer, our method provides comparable point prediction of unpaid losses with the industry's standard practice, chain-ladder estimates. Moreover, our flexible structure allows us to easily compute the entire predictive distribution of unpaid losses. This procedure also readily yields accident year reserves, calendar year reserves, as well as the aggregate reserves. One important implication of the dependence modeling is that it allows analysts to quantify the diversification effects in risk capital analysis. We demonstrate these effects by calculating commonly used risk measures, including value at risk and conditional tail expectation, for the insurer's combined portfolio of personal and commercial automobile lines.

SIGRIST, F.; STAHEL, W. A. *Using the censored gamma distribution for modelling fractional response variables with an application to loss given default.* 673–710. Regression models for limited continuous dependent variables having a non-negligible probability of attaining exactly their limits are presented. The models differ in the number of parameters and in their flexibility.

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Fractional data being a special case of limited dependent data, the models also apply to variables that are a fraction or a proportion. It is shown how to fit these models and they are applied to a Loss Given Default dataset from insurance to which they provide a good fit.

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Australian Actuarial Journal

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ASHER, A. *Salary linked home finance: reducing interest rate, inflation and idiosyncratic salary risks.* 117–148. It is possible to develop an alternative housing finance instrument that matches the cash flow, and reduces the risks faced, by homeowners and pension funds. The instrument would also reduce the liquidity constraints faced by new and existing homeowners, and eliminate the cash flow tilt imposed by high inflation. Moral hazard and anti-selection risks are likely to restrict the market to employees of large institutions, but such an instrument would encourage greater flows of funds from superannuation into housing. Other obstacles to its introduction can be overcome.

BUTT, A. *Management of closed defined benefit superannuation schemes – an investigation using simulations.* 27–86. This study investigates the actuarial monitoring of closed defined benefit superannuation schemes. This is done via a simulation approach of a model scheme, with economic and decrement factors varying stochastically. The desires of trustees and employer-sponsors are expressed numerically and the distribution of these desires analysed from the simulated output. In addition, a single objective function is developed, balancing the desires of all parties, in order to quantify the optimal use of investment and contribution strategies. In addition, adjustments to the model scheme are made to investigate their effect on the use of these strategies.

GORST, T. *Fresh insights – Australian/NZ home lending default risk.* 1–25. By using Basel 2 ('B2') risk and capital data published by the four largest Australian banks since 2008, this paper analyses Australian/NZ home lending credit default risk by comparing recent default experience against an implied 'through the cycle' default probability.

LU, Z.; LI, S. *Estimating Value-at-Risk for portfolios: skewed-EWMA forecasting* via *copula.* 87–115. With the increasing complexity of risks, how to estimate the risk of portfolios with complex dependencies is challenging. Recently, Lu and Huang (2007) [Z Lu and H Huang, Estimating value at risk: from JP Morgan's standard-EWMA to skewed-EWMA forecasting, Proceedings of the Australasian Finance and Banking Conference, 12–14 December 2007, Sydney] proposed a skewed-EWMA [exponentially weighted moving average] procedure to calculate value-at-risk (VaR) for individual financial assets, which is derived from an asymmetric Laplace distribution and takes into account both skewness and heavy tails of the return

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distribution that are adaptive to the time-varying nature in practice by adjusting shape parameter in the distribution. In this paper, [the authors] extend the skewed-EWMA procedure to estimating the risk of complex portfolios with dependencies modelled via copula. Monte Carlo simulation procedure that combines copula techniques with skewed-EWMA forecasting is developed. The empirical back-testing of the VaR forecasting demonstrates that the proposed method can be a useful tool in estimating extreme risks of complex portfolios.

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Geneva Papers on Risk and Insurance

37(1), 2012

BIENER, C.; ELING, M. *Insurability in microinsurance markets: an analysis of problems and potential solutions.* 77–107. This paper provides a comprehensive analysis of the insurability of risks in microinsurance markets. Our aim is to enhance the understanding of impediments to and facilitators of microinsurance from an economic perspective and outline potential solutions. The motivation for conducting this analysis arises from two important aspects. (1) Despite strong growth of microinsurance markets in recent years, more than 90 per cent of the poor population in developing countries have limited or no access to insurance. (2) Industry practitioners frequently highlight problems in the insurability of risks that hinder the development of microinsurance. We review 131 papers and find that the most severe problems stem from insufficient resources for risk evaluation, small size of insurance groups, information asymmetries and the size of the insurance premium. On the basis of the analysis, we discuss a number of potential solutions such as, for example, a cooperative microinsurance architecture.

GUPTA, M.; PRAKASH, P.; RANGAN, N. *Governance and shareholder response to chief risk officer appointments.* 108–124. This study examines the recent, significant growth in the appointments of Chief Risk Officers (CROs), the role of a CRO, and whether such appointments benefit shareholders. We find that the market is more likely to react positively to a CRO appointment for a firm with weak corporate governance. In particular, the lower the proportion of outside directors the greater is the likelihood of a positive market reaction to CRO appointments, suggesting that CRO appointments are associated with better future governance by firms' shareholders. Finally, firms with higher tax and product risk also experience increases in stock prices when they appoint CROs.

HECHT, C.; HANEWALD, K. *Who responds to tax reforms?: evidence from the life insurance market.* 5–26. We exploit the natural experiment of the 2005 income tax reform in Germany to study the effects of tax incentives on consumer behaviour in life insurance markets. Our empirical analysis of socio-demographic, economic and psychological household characteristics elicited in the German SAVE study shows that two very different consumer groups buy (endowment) life insurance before and after the tax reform. We find that education plays a central role in reactions to the modified tax environment. Our stylised characterisation of "arbitrageur"

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and "straggler" buyers will assist both life insurance firms and regulatory authorities in designing effective policies.

KELLY, M.; KLEFFNER, A.; LEADBETTER, D. *Structure, principles and effectiveness of insurance regulation in the 21st century: Insights from Canada.* 155–174. The 2007–2009 financial crisis resulted in failures of many large financial institutions and among the G8 countries, only Canada did not have to provide financial support to distressed financial institutions. We first examine the existing Canadian regulatory architecture in relationship to underlying principles arising from the public theory of regulation. Elements of the Canadian regulatory framework that contributed to the success of the insurance industry in weathering the crisis include the presence of a federal regulator who monitors system-wide issues also ensures consistent solvency standards; investment guidelines that encourage prudent risk-taking; and a holistic approach to insurer monitoring. A comparison of the Canadian experience with that of other jurisdictions highlights the importance of a holistic risk management approach to firm viability, especially in light of the inherent risks arising from complex group structures. A lesson from the crisis is the need for effective ex ante and ex post cross-border and holistic supervision as most distressed institutions belonged to large complex groups operating in multiple regulatory jurisdictions.

KLEIN, R. *Principles for insurance regulation: An evaluation of current practices and potential reforms.* 175–199. The recent financial crisis and its cascading effects on the global economy have drawn increased attention to the regulation of financial institutions including insurance companies. While many observers would argue that insurance companies were not significant contributors to the crisis, the role of insurance companies in the financial economy and their potential vulnerability to systemic risk have become matters of considerable interest to policy-makers and regulators. In this context, this paper examines the basic economic principles that should govern the regulation of insurance and employs these principles in assessing current regulatory practices and potential reforms. Specifically, it articulates the basic rationale for insurance regulation, which is the remediation of market failures where regulation can enhance social welfare. In insurance, the principal market failures that warrant regulatory intervention are severe asymmetric information problems and principal-agent conflicts that could lead some insurance companies to incur excessive financial risk and/or engage in abusive market practices that harm consumers. This provides an economic basis for the regulation of insurers' financial condition and market conduct. At the same time, the regulatory measures that are employed to correct market failures should be efficient and effective. Judged against these principles, the systems for solvency and market conduct regulation in the United States warrant significant improvement. There appears to be little or no justification for regulating insurance rates in competitive markets and the states should move forward with full deregulation of insurance prices. The EU appears to be much farther ahead in terms of implementing best practices in the regulation of insurers' financial condition under its Solvency II initiative. It is also much closer to the desirable goal of full price deregulation than the United States.

LEE, C.-C.; CHANG, C.-H. *Globalisation and convergence of international life insurance markets.* 125–154. Using panel data of 39 countries over the period 1979–2007, this paper is the first to empirically examine the influence of the KOF index of globalisation (overall and its three main sub-indices) on the development and convergence of international life insurance markets by a panel co-integration technique. We find that globalisation has a significant impact on the development of international life insurance markets and on reducing the deviation between individual countries' life insurance penetration and the world average. Economic and social

dimensions exert a similar effect as well, and the effect of economic globalisation is higher, while the effect of political dimension is not significant. In addition, social globalisation plays a dominant role on the interactive influence of different dimensions of globalisation, implying that socio-cultural factors are a latent factor behind economic or political influence. Finally, most countries' structural breaks coincide with the fast growth wave of international life insurance markets.

LIEDTKE, PATRICK M. *Editorial: Moving insurance*. 1–4.

THEIS, A.; WOLGAST, M. *Regulation and reform of rating agencies in the European Union: an insurance industry perspective*. 47–76. This article investigates the current discussion on the regulatory framework for credit rating agencies (CRAs) from the perspective of the insurance industry, focusing on the European Union. It becomes apparent that the new European system of regulation and supervision of CRAs conforms well to general principles of economic theory and can be expected to resolve many issues of concern. In contrast, some of the additional policy options currently discussed in Europe could involve substantial costs and risks for market participants and the financial system without contributing further to the objectives of CRA reform.

THOMAS, R. G. *Non-risk price discrimination in insurance: market outcomes and public policy*. 27–46. This paper considers price discrimination in insurance, defined as systematic price variations based on individual customer data but unrelated to those customers' expected losses or other marginal costs (sometimes characterised as "price optimisation"). An analysis is given of one type of price discrimination, "inertia pricing", where renewal prices are higher than prices for risk-equivalent new customers. The analysis suggests that the practice intensifies competition, leading to lower aggregate industry profits; customers in aggregate pay lower prices, but not all customers are better off; and the high level of switching between insurers is inefficient for society as a whole. Other forms of price discrimination may be more likely to increase aggregate industry profits. Some public policy issues relating to price discrimination in insurance are outlined, and possible policy responses by regulators are considered. It is suggested that competition will tend to lead to increased price discrimination over time, and that this may undermine public acceptance of traditional justifications for risk-related pricing.

Geneva Papers on Risk and Insurance

37(2), 2012

JOHNSTON, J. S. *Disasters and decentralisation*. 228–256. Climate change may potentially increase the magnitude of losses from natural hazards, but the United States experience shows that the primary reason for escalating losses is policy failure. It is well known that centralised, taxpayer-funded ex post disaster relief has actually encouraged development in risky jurisdictions and also weakened incentives for ex ante precautions in such jurisdictions (moral or "charity" hazard). Less well known and analysed is the role played by centralised ex ante development subsidies – often masquerading as protective investment – in distorting incentives. This paper develops a simple three jurisdiction model in which homogeneous jurisdictions decide by majority vote in a centralised legislature on the centralised (federal) share of ex post loss and centralised spending an ex ante development in a Beneficiary jurisdiction, taking into account how these decisions about centralised spending impact local Beneficiary jurisdiction incentives for precautions against ex post loss. The model shows that the marginal cost of ex ante federal development spending may be greater for a Beneficiary jurisdiction than for a Contractor

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jurisdiction. This somewhat technical result has an observable implication: evidence that a small fraction of ex post loss in a Beneficiary jurisdiction is centrally compensated (shared across jurisdictions) is evidence that ex ante development subsidies there may be truly precautionary on net; conversely, evidence that a Beneficiary jurisdiction has a large share of its ex post hazard loss compensated by centralised disaster relief suggests that the ex ante development subsidies received by that jurisdiction did more to encourage new development and increase the amount at risk than they did to protect existing development. The model is extended to consider how ex post loss sharing impacts the demand for federally subsidised disaster insurance and other related issues.

KAPPHAN, I.; CALANCA, P.; HOLZKAEMPER, A. *Climate change, weather insurance design and hedging effectiveness.* 286–317. Insurers have relied on historical data to design weather insurance contracts. In light of climate change, we examine the effects of this practice on the hedging effectiveness and profitability of insurance contracts. Using synthetic crop and weather data for today's and future climatic conditions we derive adjusted weather insurance contracts that account for shifts in the distribution of weather and yields. In our scenario, hedging benefits from adjusted contracts almost triple and expected profits increase by about 240 per cent. We further investigate the effect on risk reduction (for the insured) and profits (for the insurer) from hedging future weather risk with non-adjusted contracts based on historical data. In this case, insurers generate profits that are significantly smaller than for adjusted contracts, or even face substantial losses. Moreover, non-adjusted contracts that create higher profits than the adjusted counterparts cause negative hedging benefits for the insured.

KOUSKY, C.; COOKE, R. *Explaining the failure to insure catastrophic risks.* 206–227. It has often been observed that homeowners fail to purchase disaster insurance. Explanations have ranged from behavioural biases to information search costs. We show that the decision to forego disaster insurance may be quite rational. Solvency-constrained insurers are required to have access to enough capital to cover a particular percentile of their aggregate loss distribution. When insuring risks with loss distributions characterised by fat tails, micro-correlations or tail dependence, insurers need to charge a price that is many times the expected loss in order to meet their solvency constraint. Homeowners, facing a budget constraint and a constraint that their utility with insurance exceeds that without it, may find the required loadings too high to make insurance purchase an optimal decision.

MAYNARD, T.; RANGER, N. *What role for "long-term insurance" in adaptation?: an analysis of the prospects for and pricing of multi-year insurance contracts.* 318–339. Multi-year insurance has been proposed as a tool to incentivise policy-holders to invest in property-level adaptation. In a world of rising natural catastrophe risks, such autonomous adaptations could have significant benefits for the property owner, the insurer and society. We review some arguments made in respect of multi-year contracts and provide new analyses on their price implications. We conclude that even under conditions of known and stationary risk, initial capital requirements could be around 50 per cent higher for a 10-year contract than an annual contract and the annual premium around 5.5 per cent higher; in the real world of changing and uncertain risks, premiums would be even higher. We also conclude that multi-year contracts have several additional disadvantages that are likely to limit their demand and availability in the general retail insurance market. For adaptation, we conclude that other tools, such as risk-based premiums and loans for adaptation tied to the property, have greater potential.

PAUDEL, Y. *A comparative study of public-private catastrophe insurance systems: Lessons from current practices.* 257–285. Natural disasters risk is increasing in several regions around the

world as a result of socio-economic development and climate change. This indicates the importance of establishing affordable and sustainable natural disaster risk management and compensation arrangements. Given the complexity of insuring extreme risks, insurers and governments often cooperate in catastrophe insurance systems. This paper presents a comparative study of the main components and a broad range of indicators of fully private and fully public, as well as public-private (PP) insurance systems, for extreme events, in ten countries. This analysis results in the following nine main recommendations for policymakers who aim to establish new, or improve existing, insurance arrangements for natural disasters: (1) mandatory participation requirements are advisable to achieve a high market penetration rate; (2) adequate monitoring and enforcement mechanisms need to be put in place to ensure compliance with these requirements; (3) the government needs to take responsibility for part of the (extreme) damage in order to keep an insurance system financially viable and affordable; (4) private insurance companies should participate in a PP insurance scheme by selling and administering policies and by covering medium-sized losses; (5) the integration in systems of risk transferring mechanisms is advisable; (6) it is advisable that governments stimulate the building-up of insurers' reserves by providing tax exemptions; (7) risk mitigation policies should be carefully integrated in a natural disaster insurance system; (8) a detailed assessment and mapping of risk provides the basis for an effective mitigation policy; (9) insurance should provide financial incentives for policyholders to take risk mitigation measures.

PETSETI, A.; NEKTARIOS, M. *Proposal for a national earthquake insurance programme for Greece.* 377–400. It is proposed that Greece undertakes the establishment of a national earthquake insurance programme for homeowners that will replace the ex post disaster relief by the State when an earthquake occurs. Greece is seismically the most active region in the whole Mediterranean. By employing four different catastrophe models, it has been estimated that the economic loss to the residential stock of a 1-in-200 year event is likely to be greater than 22 billion euros; for a 1-in-100 year event is about 14 billion euros; for an 1-in-25 year event is 5 billion euros; and for a 1-in-5 year event is 1.3 billion euros. This potential loss severity exposes the inherent limitations of the ex post funding approach to natural disasters adopted by successive Greek governments and underscores the urgent need for establishing a National Earthquake Insurance Programme. It is proposed that the earthquake coverage should be compulsory and the management of the insurance programme be based on the principle of a public–private partnership. The objective of the programme would be to provide affordable earthquake insurance, up to a maximum amount, to all homeowners, on the basis of risk-based premiums. A comprehensive and unique data bank of the residential stock in the country has been developed, which will be very useful to the local insurance industry as well as to reinsurers.

PRETTENTHALER, F.; ALBRECHER, H.; KOBERLA, J.; KORTSCHAK, D. *Risk and insurability of storm damages to residential buildings in Austria.* 340–364. This paper develops a stochastic model to assess storm risk in Austria, which relates wind speed and actual losses. By virtue of a building-stock-value-weighted wind index, we use suitably normalised historical loss data of residential buildings over 12 years and corresponding wind speed data to calibrate the model. Subsequently, additional wind speed data is used to generate further scenarios and to obtain loss curves for storm risk that give rise to storm insurance loss quantiles and corresponding solvency capital requirements both on the aggregate and on the regional level. We also investigate the diversification effect across regions and use tools from extreme value theory to assess the insurability of storm risk in Austria in general.

SCHEEL, I.; HINNERICHSEN, M. *The impact of climate change on precipitation-related insurance risk: A study of the effect of future scenarios on residential buildings in Norway.*

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365–376. Climate change is likely to increase the future risk of weather-related damage to buildings worldwide. This challenge is faced by society in general, but the insurance industry is particularly important in the management of the anticipated increase in future risk. In addition to adjusting premiums appropriately and gradually, they can play an important role in prevention. It is crucial to know which areas are vulnerable and to what extent. In this paper, a spatial regression model for linking weather-related insurance losses for residential buildings to meteorological and hydrological covariates is coupled with three plausible scenarios for the future climate in order to project the future number of weather-related residential building insurance losses in Norway. The model is trained on observed daily insurance loss and weather data at the municipality level. Our results indicate a dramatic increase in the projected future weather-related insurance risk in many parts of Norway. The procedure can be extended and applied to other areas globally.

SCHWARZE, R. *Insurance law and economics research for natural hazard management in a changing climate: Editorial*. 201–205.

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Geneva Risk and Insurance Review

36(2), 2011

AGLIARDI, E.; ANDERGASSEN, R. *(S,s)-adjustment strategies and hedging under Markovian dynamics*. 112–131. We study the destabilizing effect of hedging strategies under Markovian dynamics with transaction costs. Once transaction costs are taken into account, continuous portfolio re-hedging is no longer an optimal strategy. Using a non-optimizing (local in time) strategy for portfolio rebalancing, explicit dynamics for the price of the underlying asset are derived, focusing in particular on excess volatility and feedback effects of these portfolio insurance strategies. Moreover, it is shown how these latter depend on the heterogeneity of the insured payoffs. Finally, conditions are derived under which it may be still reasonable, from a practical viewpoint, to implement Black–Scholes strategies.

CHEMARIN, S.; ORSET, C. *Innovation and information acquisition under time inconsistency and uncertainty*. 132–173. When an agent invests in new industrial activities, he has a limited initial knowledge of his project's returns. Acquiring information allows him both to reduce the uncertainty on the dangerousness of this project and to limit potential damages that it might cause on people's health and on the environment. In this paper, we study whether there exist situations in which the agent does not acquire information. We find that an agent with time-consistent preferences, as well as an agent with hyperbolic ones, will acquire information unless its cost exceeds the direct benefit they could get with this information. Nevertheless, a hyperbolic agent may remain strategically ignorant and, when he does acquire information, he will acquire less information than a time-consistent type. Moreover, a hyperbolic-discounting type who behaves as a time-consistent agent in the future is more inclined to stay ignorant. We then emphasize that this strategic ignorance depends on the degree of precision of the information. Finally, we analyse the role that existing liability rules could play as an incentive to acquire information under uncertainty and with regard to the form of the agent's preferences.

GOLLIER, C. *On the underestimation of the precautionary effect in discounting.* 95–111. Using the extended Ramsey rule, the socially efficient rate is the difference between a wealth effect and a precautionary effect of economic growth. This second effect is increasing in the degree of uncertainty affecting the future. In the literature, it is usually calibrated by estimating the historical volatility of the growth of GDP in a specific country. In this paper, I show that using cross-section data tends to magnify uncertainty, and to reduce the discount rate. Using a data set covering 190 countries over the period 1969–2010, I justify using a much smaller discount rate of approximately 0.7 per cent per year for time horizons exceeding 40 years.

HAU, A. *Optimal brokerage commissions for fair insurance: a first order approach.* 189–201. This paper studies a principal-agent insurance brokerage problem with a risk-averse principal (an insured) and a risk-neutral agent (a broker). The concept of "mean-preserving, spread-reducing" (MPSR) effort is introduced to model the broker's activities. Using the first-order approach, it is shown that under some common conditions, the insured may "concavify" the reward function to induce the risk-neutral agent to exert MPSR brokering effort. These conditions, together with an additional condition, guarantee the validity of the first-order approach even when the monotone likelihood ratio condition (used exclusively to justify the first-order approach) is violated.

TRUFFIN, J.; ALBRECHER, H.; DENUIT, M. M. *Properties of a risk measure derived from ruin theory.* 174–188. This paper studies a risk measure inherited from ruin theory and investigates some of its properties. Specifically, we consider a value-at-risk (VaR)-type risk measure defined as the smallest initial capital needed to ensure that the ultimate ruin probability is less than a given level. This VaR-type risk measure turns out to be equivalent to the VaR of the maximal deficit of the ruin process in infinite time. A related Tail-VaR-type risk measure is also discussed.

WANG, K. C.; PENG, J.-L.; SUN, Y.-Y.; CHANG, Y.-C. *The asymmetric information problem in Taiwan's cancer insurance market.* 202–219. This paper investigates the problem of asymmetric information in Taiwan's cancer insurance market. Through the survey data, we find evidence of adverse selection existing in this market. Furthermore, we collect additional information on the individual, and find that the individual's family cancer history contains additional valuable information. It can not only more accurately predict the probability of contracting cancer, as well as predict the willingness to purchase extended cancer insurance, but it can also help to mitigate the severity of adverse selection in the insurance market.

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BOURLES, R.; HENRIET, D. *Risk-sharing contracts with asymmetric information.* 27–56. We examine how risk-sharing is impacted by asymmetric information on the probability distribution of wealth. We define the optimal incentive compatible agreements in a two-agent model with two levels of wealth. When there is complete information on the probability of the different outcomes, the resulting allocation satisfies the mutuality principle (which states that everyone's final wealth depends only upon the aggregate wealth of the economy). This is no longer true when agents have private information regarding their probability distribution of wealth. Asymmetry of information (i) makes ex-post equal sharing unsustainable between two low-risk agents, and (ii) induces exchanges when agents have the same realization of wealth.

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CHIU, W. H. *Risk aversion, downside risk aversion and paying for stochastic improvements.* 1–26. This paper considers the relationship between risk preferences and the willingness to pay for stochastic improvements. We show that if the stochastic improvement satisfies a double-crossing condition, then a decision maker with utility v is willing to pay more than a decision maker with utility u, if v is both more risk averse and less downside risk averse than u. As the condition always holds in the case of self-protection, the result implies novel characterizations of individuals' willingness to pay to reduce the probability of loss. By establishing a general result on the correspondence between an individual's willingness to pay, and his optimal purchase of stochastic improvement when there is a given relationship between stochastic improvements and the amount paid for them, we further show that all results on the willingness to pay can be applied directly to characterize the conditions under which a more risk averse individual will optimally choose to buy more stochastic improvement. Generalizations of existing results on optimal choice of self-protection can be obtained as corollaries.

HARDELIN, J.; LEMOYNE DE FORGES, S. *Raising capital in an insurance oligopoly market.* 83–108. We consider an oligopoly market where firms offer insurance coverage against a risk characterised by aggregate uncertainty. Firms behave as if they were risk averse for a standard reason of costly external finance. The model consists in a two-stage game where firms choose their internal capital level at stage one and compete on price at stage two. We characterise the subgame perfect Nash equilibria of this game and focus attention on the strategic impact of insurers capital choice. We discuss the model with regard to the insurance industry specificities and regulation.

TAN, K. S.; WENG, C. *Enhancing insurer value using reinsurance and value-at-risk criterion.* 109–140. The quest for optimal reinsurance design has remained an interesting problem among insurers, reinsurers, and academicians. An appropriate use of reinsurance could reduce the underwriting risk of an insurer and thereby enhance its value. This paper complements the existing research on optimal reinsurance by proposing another model for the determination of the optimal reinsurance design. The problem is formulated as a constrained optimization problem with the objective of minimizing the value-at-risk of the net risk of the insurer while subjecting to a profitability constraint. The proposed optimal reinsurance model, therefore, has the advantage of exploiting the classical trade-off between risk and reward. Under the additional assumptions that the reinsurance premium is determined by the expectation premium principle and the ceded loss function is confined to a class of increasing and convex functions, explicit solutions are derived. Depending on the risk measure's level of confidence, the safety loading for the reinsurance premium, and the expected profit guaranteed for the insurer, we establish conditions for the existence of reinsurance. When it is optimal to cede the insurer's risk, the optimal reinsurance design could be in the form of pure stop-loss reinsurance, quota-share reinsurance, or a combination of stop-loss and quota-share reinsurance.

THOMANN, C.; PASCALAU, R.; VON DER SCHULENBURG, J. M. G. *Corporate management of highly dynamic risks:: Evidence from the demand for terrorism insurance in Germany.* 57–82. This paper investigates a corporation's risk management response to highly dynamic risks. Using a unique data set on the German terrorist insurance market, the paper tests whether corporate risk managers have a clear understanding of the probability distribution of highly dynamic risks or if risk managers learn from severe losses and base their decisions upon day-to-day experience. The paper further investigates whether risk managers become more confident in their risk management decisions over time. For this purpose, we apply Viscusi's prospective reference

theory to a corporate context. We find that firms learn from single events when making their risk management decisions, and that risk managers become more confident with their risk management decisions over time.

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AHCAN, A. *Statistical analysis of model risk concerning temperature residuals and its impact on pricing weather derivatives.* 131–138. In this paper we model the daily average temperature via an extended version of the standard Ornstein Uhlenbeck process driven by a Levy noise with seasonally adjusted asymmetric ARCH process for volatility. More precisely, we model the disturbances with the Normal inverse Gaussian (NIG) and Variance gamma (VG) distribution. Besides modelling the residuals we also compare the prices of January 2010 out of the money call and put options for two of the Slovenian largest cities Ljubljana and Maribor under normally distributed disturbances and NIG and VG distributed disturbances. The results of our numerical analysis demonstrate that the normal model fails to capture adequately tail risk, and consequently significantly misprices out of the money options. On the other hand prices obtained using NIG and VG distributed disturbances fit well to the results obtained by bootstrapping the residuals. Thus one should take extreme care in choosing the appropriate statistical model.

ANWAR, S.; ZHENG, M. *Competitive insurance market in the presence of ambiguity.* 79–84. Within the context of a competitive insurance market, this paper examines the impact of ambiguity on the behavior of buyers and sellers. Ambiguity is described through a probability measure on an extended state space that includes extra ambiguous states. It is shown that if insurers face the same or less ambiguity than their customers, a unique equilibrium exists where customers are fully insured. On the other hand, if insurers face more ambiguity than their customers, customers will be under insured and it is even possible that customers may not purchase any insurance.

BOHNERT, A.; GATZERT, N. *Analyzing surplus appropriation schemes in participating life insurance from the insurer's and the policyholder's perspective.* 64–78. This paper examines the impact of three surplus appropriation schemes often inherent in participating life insurance contracts on the insurer's shortfall risk and the net present value from an insured's viewpoint. (1) In case of the bonus system, surplus is used to increase the guaranteed death and survival benefit, leading to higher reserves; (2) the interest-bearing accumulation increases only the survival benefit by accumulating the surplus on a separate account; and (3) surplus can also be used to shorten the contract term, which results in an earlier payment of the survival benefit and a reduced sum of premium payments. The pool of participating life insurance contracts with death and survival benefit is modeled actuarially with annual premium payments; mortality rates are generated based on an extension of the Lee-Carter (1992) model, and the asset process follows a geometric Brownian motion. In a simulation analysis, we then compare the influence of different asset portfolios and shocks to mortality on the insurer's risk situation and the policyholder's net

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present value for the three surplus schemes. Our findings demonstrate that, even though the surplus distribution and thus the amount of surplus is calculated the same way, the type of surplus appropriation scheme has a substantial impact on the insurer's risk exposure and the policyholder's net present value.

CAI, J.; WEI, W. *On the invariant properties of notions of positive dependence and copulas under increasing transformations.* 43–49. Notions of positive dependence and copulas play important roles in modeling dependent risks. The invariant properties of notions of positive dependence and copulas under increasing transformations are often used in the studies of economics, finance, insurance and many other fields. In this paper, we examine the notions of the conditionally increasing (CI), the conditionally increasing in sequence (CIS), the positive dependence through the stochastic ordering (PDS), and the positive dependence through the upper orthant ordering (PDUO). We first use counterexamples to show that the statements in Theorem 3.10.19 of Müller and Stoyan (2002) about the invariant properties of CIS and CI under increasing transformations are not true. We then prove that the invariant properties of CIS and CI hold under strictly increasing transformations. Furthermore, we give rigorous proofs for the invariant properties of PDS and PDUO under increasing transformations. These invariant properties enable us to show that a continuous random vector is PDS (PDUO) if and only of its copula is PDS (PDUO). In addition, using the properties of generalized left-continuous and right-continuous inverse functions, we give a rigorous proof for the invariant property of copulas under increasing transformations on the components of any random vector. This result generalizes Proposition 4.7.4 of Denuit et al. (2005) and Proposition 5.6. of McNeil et al. (2005).

CAI, J.; WEI, W. *Optimal reinsurance with positively dependent risks.* 57–63. In the individual risk model, one is often concerned about positively dependent risks. Several notions of positive dependence have been proposed to describe such dependent risks. In this paper, we assume that the risks in the individual risk model are positively dependent through the stochastic ordering (PDS). The PDS risks include independent, comonotonic, conditionally stochastically increasing (CI) risks, and other interesting dependent risks. By proving the convolution preservation of the convex order for PDS random vectors, we show that in individualized reinsurance treaties, to minimize certain risk measures of the retained loss of an insurer, the excess-of-loss treaty is the optimal reinsurance form for an insurer with PDS dependent risks among a general class of individualized reinsurance contracts. This extends the study in Denuit and Vermandele (1998) on individualized reinsurance treaties to dependent risks. We also derive the explicit expressions for the retentions in the optimal excess-of-loss treaty in a two-line insurance business model.

CHEN, D.; MAO, T.; PAN, X.; HU, T. *Extreme value behavior of aggregate dependent risks.* 99–108. Consider a portfolio of n identically distributed risks with dependence structure modeled by an Archimedean survival copula. Wüthrich (2003) and Alink et al. (2004) proved that the probability of a large aggregate loss scales like the probability of a large individual loss, times a proportionality factor. This factor depends on the dependence strength and the tail behavior of the individual risk, denoted by, and according to whether the tail behavior belongs to the maximum domain of attraction of the Fréchet, the Weibull or the Gumbel distribution, respectively. We investigate properties of the factors and with respect to the dependence parameter and/or the tail behavior parameter, and revisit the asymptotic behavior of conditional tail expectations of aggregate risks for the Weibull and the Gumbel cases by using a different method. The main results strengthen and complement some results in [Alink et al., 2004] and [Alink et al., 2005] Barbe et al. (2006), and Embrechts et al. (2009).

GIACOMETTI, R.; BERTOCCHI, M.; RACHEV, S. T.; FABOZZI, F. J. *A comparison of the Lee–Carter model and AR–ARCH model for forecasting mortality rates.* 85–93. With the decline in the mortality level of populations, national social security systems and insurance companies of most developed countries are reconsidering their mortality tables taking into account the longevity risk. The Lee and Carter model is the first discrete-time stochastic model to consider the increased life expectancy trends in mortality rates and is still broadly used today. In this paper, we propose an alternative to the Lee–Carter model: an AR(1)–ARCH(1) model. More specifically, we compare the performance of these two models with respect to forecasting age-specific mortality in Italy. We fit the two models, with Gaussian and t-student innovations, for the matrix of Italian death rates from 1960 to 2003. We compare the forecast ability of the two approaches in out-of-sample analysis for the period 2004–2006 and find that the AR(1)–ARCH(1) model with t-student innovations provides the best fit among the models studied in this paper.

GONG, L.; BADESCU, A. L.; CHEUNG, E. C. K. *Recursive methods for a multi-dimensional risk process with common shocks.* 109–120. In this paper, a multi-dimensional risk model with common shocks is studied. Using a simple probabilistic approach via observing the risk processes at claim instants, recursive integral formulas are developed for the survival probabilities as well as for a class of Gerber–Shiu expected discounted penalty functions that include the surplus levels at ruin. Under the assumption of exponential or mixed Erlang claims, the recursive integrals can be simplified to give recursive sums which are computationally more tractable. Numerical examples including an optimal capital allocation problem are also given towards the end.

KALUSZKA, M.; KRZESZOWIEC, M. *Pricing insurance contracts under Cumulative Prospect Theory.* 159–166. The aim of this paper is to introduce a premium principle which relies on Cumulative Prospect Theory by Kahneman and Tversky. Some special cases of this premium principle have already been studied in the actuarial literature. In the paper, properties of this premium principle are examined.

LANDSMAN, Z.; MAKOV, U. E. *Translation-invariant and positive-homogeneous risk measures and optimal portfolio management in the presence of a riskless component.* 94–98. Risk portfolio optimization, with translation-invariant and positive-homogeneous risk measures, leads to the problem of minimizing a combination of a linear functional and a square root of a quadratic functional for the case of elliptical multivariate underlying distributions. This problem was recently treated by the authors for the case when the portfolio does not contain a riskless component. When it does, however, the initial covariance matrix S becomes singular and the problem becomes more complicated. In the paper we focus on this case and provide an explicit closed-form solution of the minimization problem, and the condition under which this solution exists. The results are illustrated using data of 10 stocks from the NASDAQ Computer Index.

MITRIC, I.-R.; BADESCU, A. L.; STANFORD, D. A. *On the absolute ruin problem in a Sparre Andersen risk model with constant interest.* 167–178. In this paper, we extend the work of Mitric and Sendova (2010), which considered the absolute ruin problem in a risk model with debit and credit interest, to renewal and non-renewal structures. Our first results apply to MAP processes, which we later restrict to the Sparre Andersen renewal risk model with interclaim times that are generalized Erlang (n) distributed and claim amounts following a Matrix-Exponential (ME) distribution (see for e.g. Asmussen and O'Cinneide (1997)). Under this scenario, we present a general methodology to analyze the Gerber–Shiu discounted penalty function defined at absolute ruin, as a solution of high-order linear differential equations with non-constant coefficients.

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Closed-form solutions for some absolute ruin related quantities in the generalized Erlang (2) case complement the results obtained under the classical risk model by Mitric and Sendova (2010).

O'HARE, C.; LI, Y. *Explaining young mortality.* 12–25. Stochastic modeling of mortality rates focuses on fitting linear models to logarithmically adjusted mortality data from the middle or late ages. Whilst this modeling enables insurers to project mortality rates and hence price mortality products it does not provide good fit for younger aged mortality. Mortality rates below the early 20's are important to model as they give an insight into estimates of the cohort effect for more recent years of birth. It is also important given the cumulative nature of life expectancy to be able to forecast mortality improvements at all ages. When we attempt to fit existing models to a wider age range, 5–89, rather than 20–89 or 50–89, their weaknesses are revealed as the results are not satisfactory. The linear innovations in existing models are not flexible enough to capture the non-linear profile of mortality rates that we see at the lower ages. In this paper, we modify an existing 4 factor model of mortality to enable better fitting to a wider age range, and using data from seven developed countries our empirical results show that the proposed model has a better fit to the actual data, is robust, and has good forecasting ability.

PANSERA, J. *Discrete-time local risk minimization of payment processes and applications to equity-linked life-insurance contracts.* 1–11. The authors develop a theory of local risk minimization for payment processes in discrete time, and apply this theory to the pricing and hedging of equity-linked life-insurance contracts. Thus, we extend the work of Møller, 2001a T. Møller, Hedging equity-linked life insurance contracts. North American Actuarial Journal, 5 2 (2001), pp. 79–95. Møller (2001a) in several directions: from risk minimization (which is done under a martingale measure) to local risk minimization (which is done under an arbitrary measure), from single claims to payment processes, from complete financial markets to possibly incomplete financial markets, from a single risky asset to several risky assets, and from finite state spaces to general state spaces. Moreover, we show that, when tradable financial assets are independent of mortality, a locally risk-minimizing hedging strategy for most claims in the combined financial and mortality market (such as those arising from equity-indexed annuities) may be expressed as the product of two simpler locally risk-minimizing hedging strategies: one for a purely financial claim, the other for a traditional (i.e. non-equity-linked) life-insurance claim. Finally, the authors also show, under general assumptions, that the minimal measure for the combined market is the product of the minimal measure for the financial market and the physical measure for the mortality.

ROSSELLO, D. *Arbitrage in skew Brownian motion models.* 50–56. Empirical skewness of asset returns can be reproduced by stochastic processes other than the Brownian motion with drift. Some authors have proposed the skew Brownian motion for pricing as well as interest rate modelling. Although the asymmetric feature of random return involved in the stock price process is driven by a parsimonious one-dimensional model, we will show how this is intrinsically incompatible with a modern theory of arbitrage in continuous time. Application to investment performance and to the Black–Scholes pricing model clearly emphasize how this process can provide some kind of arbitrage.

TANG, Q.; YANG, F. *On the Haezendonck–Goovaerts risk measure for extreme risks.* 217–227. In this paper, we are interested in the calculation of the Haezendonck–Goovaerts risk measure, which is defined via a convex Young function and a parameter q (0,1) representing the confidence level. We mainly focus on the case in which the risk variable follows a distribution function from

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a max-domain of attraction. For this case, we restrict the Young function to be a power function and we derive exact asymptotics for the Haezendonck–Goovaerts risk measure as q 1. As a subsidiary, we also consider the case with an exponentially distributed risk variable and a general Young function, and we obtain an analytical expression for the Haezendonck–Goovaerts risk measure.

TONG, B.; WU, C.; XU, W. *Risk concentration of aggregated dependent risks: The second-order properties.* 139–149. Under the current regulatory guidelines for banks and insurance companies, the quantification of diversification benefits due to risk aggregation plays a prominent role. In this paper we establish second-order approximation of risk concentration associated with a random vector in terms of Value at Risk (VaR) within the methodological framework of second-order regular variation and the theory of Archimedean copula. Moreover, we find that the rate of convergence of the first-order approximation of risk concentration depends on the interplay between the tail behavior of the marginal loss random variables and their dependence structure. Specifically, we find that the rate of convergence is determined by either the second-order parameter (1) of Archimedean copula generator or the second-order parameter ( ) of the tail margins, leading to either the so-called dependence dominated case or margin dominated case.

VAN GULICK, G.; DE WAEGENAERE, A.; NORDE, H. *Excess based allocation of risk capital.* 26–42. In this paper we propose a new rule to allocate risk capital to portfolios or divisions within a firm. Specifically, we determine the capital allocation that minimizes the excesses of sets of portfolios in a lexicographical sense. The excess of a set of portfolios is defined as the expected loss of that set of portfolios in excess of the amount of risk capital allocated to them. The underlying idea is that large excesses are undesirable, and therefore the goal is to determine the allocation for which the largest excess is as small as possible. We show that this allocation rule yields a unique allocation, and that it satisfies some desirable properties. We also show that the allocation can be determined by solving a series of linear programming problems.

WANG, T.; YOUNG, V. R. *Optimal commutable annuities to minimize the probability of lifetime ruin.* 200–216. We find the minimum probability of lifetime ruin of an investor who can invest in a market with a risky and a riskless asset and who can purchase a commutable life annuity. The surrender charge of a life annuity is a proportion of its value. Ruin occurs when the total of the value of the risky and riskless assets and the surrender value of the life annuity reaches zero. We find the optimal investment strategy and optimal annuity purchase and surrender strategies in two situations: (i) the value of the risky and riskless assets is allowed to be negative, with the imputed surrender value of the life annuity keeping the total positive; (ii) the value of the risky and riskless assets is required to be non-negative. In the first case, although the individual has the flexibility to buy or sell at any time, we find that the individual will not buy a life annuity unless she can cover all her consumption via the annuity and she will never sell her annuity. In the second case, the individual surrenders just enough annuity income to keep her total assets positive. However, in this second case, the individual's annuity purchasing strategy depends on the size of the proportional surrender charge. When the charge is large enough, the individual will not buy a life annuity unless she can cover all her consumption, the so-called safe level. When the charge is small enough, the individual will buy a life annuity at a wealth lower than this safe level.

WANG, W.-Y.; HU, Y. *Optimal loss-carry-forward taxation for the Lévy risk model.* 121–130. In the spirit of Albrecher and Hipp (2007), Albrecher et al. (2008b) and Kyprianou and Zhou (2009), we consider the reserve process of an insurance company which is governed by [formula

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unable to display], where X is a spectrally negative Levy process with the usual exclusion of negative subordinator or deterministic drift, [formula unable to display] the running supremum of X, and [formula unable to display] the rate of loss-carry-forward tax at time t which is subject to the taxation allocation policy p and is a function of [formula unable to display]. The objective is to find the optimal policy which maximizes the total (discounted) taxation pay-out: [formula unable to display], where [formula unable to display] and [formula unable to display] refer to the expectation corresponding to the law of X such that [formula unable to display], and the time of ruin, respectively. With the scale function of X denoted by [formula unable to display] and [formula unable to display] allowed to vary in, two situations are considered.

ZHAO, H.; RONG, X. *Portfolio selection problem with multiple risky assets under the constant elasticity of variance model.* 179–190. This paper focuses on the constant elasticity of variance (CEV) model for studying the utility maximization portfolio selection problem with multiple risky assets and a risk-free asset. The Hamilton–Jacobi–Bellman (HJB) equation associated with the portfolio optimization problem is established. By applying a power transform and a variable change technique, we derive the explicit solution for the constant absolute risk aversion (CARA) utility function when the elasticity coefficient is −1 or 0. In order to obtain a general optimal strategy for all values of the elasticity coefficient, we propose a model with two risky assets and one risk-free asset and solve it under a given assumption. Furthermore, we analyze the properties of the optimal strategies and discuss the effects of market parameters on the optimal strategies. Finally, a numerical simulation is presented to illustrate the similarities and differences between the results of the two models proposed in this paper.

ZHAO, X.; ZHOU, X. *Copula models for insurance claim numbers with excess zeros and time-dependence.* 191–199. This paper develops two copula models for fitting the insurance claim numbers with excess zeros and time-dependence. The joint distribution of the claims in two successive periods is modeled by a copula with discrete or continuous marginal distributions. The first model fits two successive claims by a bivariate copula with discrete marginal distributions. In the second model, a copula is used to model the random effects of the conjoint numbers of successive claims with continuous marginal distributions. Zero-inflated phenomenon is taken into account in the above copula models. The maximum likelihood is applied to estimate the parameters of the discrete copula model. A two-step procedure is proposed to estimate the parameters in the second model, with the first step to estimate the marginals, followed by the second step to estimate the unobserved random effect variables and the copula parameter. Simulations are performed to assess the proposed models and methodologies.

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BARZ, C.; MULLER, A. *Comparison and bounds for functionals of future lifetimes consistent with life tables.* 229–235. We derive a new crossing criterion of hazard rates to identify a stochastic order relation between two random variables. We apply this crossing criterion in the context of life tables to derive stochastic ordering results among three families of fractional age assumptions: the family of linear force of mortality functions, the family of quadratic survival functions and the power family. Further, this criterion is used to derive tight bounds for functionals of future lifetimes that exhibit an increasing force of mortality with given one-year survival probabilities. Numerical examples illustrate our findings.

BO, L.; SONG, R.; TANG, D.; WANG, T.; YANG, X. *Levy risk model with two-sided jumps and a barrier dividend strategy.* 280–291. In this paper, we consider a general Lévy risk model with two-sided jumps and a constant dividend barrier. We connect the ruin problem of the ex-dividend risk process with the first passage problem of the Lévy process reflected at its running maximum. We prove that if the positive jumps of the risk model form a compound Poisson process and the remaining part is a spectrally negative Lévy process with unbounded variation, the Laplace transform (as a function of the initial surplus) of the upward entrance time of the reflected (at the running infimum) Lévy process exhibits the smooth pasting property at the reflecting barrier. When the surplus process is described by a double exponential jump diffusion in the absence of dividend payment, we derive some explicit expressions for the Laplace transform of the ruin time, the distribution of the deficit at ruin, and the total expected discounted dividends. Numerical experiments concerning the optimal barrier strategy are performed and new empirical findings are presented.

CHRISTIANSEN, M. C.; DENUIT, M. M.; LAZAR, D. *The Solvency II square-root formula for systematic biometric risk.* 257–265. In this paper, we develop a model supporting the so-called square-root formula used in Solvency II to aggregate the modular life SCR. Describing the insurance policy by a Markov jump process, we can obtain expressions similar to the square-root formula in Solvency II by means of limited expansions around the best estimate. Numerical illustrations are given, based on German population data. Even if the square-root formula can be supported by theoretical considerations, it is shown that the QIS correlation matrix is highly questionable.

COSSETTE, H.; MAILHOT, M.; MARCEAU, E. *TVaR-based capital allocation for multivariate compound distributions with positive continuous claim amounts.* 247–256. In this paper, we consider a portfolio of n dependent risks X1,…,Xn and we study the stochastic behavior of the aggregate claim amount [unable to display]. Our objective is to determine the amount of economic capital needed for the whole portfolio and to compute the amount of capital to be allocated to each risk X1,…,Xn. To do so, we use a top–down approach. For (X1,…,Xn), we consider risk models based on multivariate compound distributions defined with a multivariate counting distribution. We use the TVaR to evaluate the total capital requirement of the portfolio based on the distribution of S, and we use the TVaR-based capital allocation method to quantify the contribution of each risk. To simplify the presentation, the claim amounts are assumed to be continuously distributed. For multivariate compound distributions with continuous claim amounts, we provide general formulas for the cumulative distribution function of S, for the TVaR of S and the contribution to each risk. We obtain closed-form expressions for those quantities for multivariate compound distributions with gamma and mixed Erlang claim amounts. Finally, we treat in detail the multivariate compound Poisson distribution case. Numerical examples are provided in order to examine the impact of the dependence relation on the TVaR of S, the contribution to each risk of the portfolio, and the benefit of the aggregation of several risks.

HAINAUT, D. *Multidimensional Lee–Carter model with switching mortality processes.* 236-246. This paper proposes a multidimensional Lee–Carter model, in which the time dependent components are ruled by switching regime processes. The main feature of this model is its ability to replicate the changes of regimes observed in the mortality evolution. Changes of measure, preserving the dynamics of the mortality process under a pricing measure, are also studied. After a review of the calibration method, a 2D, 2-regimes model is fitted to the male and female French population, for the period 1946–2007. Our analysis reveals that one regime corresponds to longevity conditions observed during the decade following the second world war, while the second regime is related to longevity improvements observed during the last 30 years.

To conclude, we analyze, in a numerical application, the influence of changes of measure affecting transition probabilities, on prices of life and death insurances.

OZKOK, E.; STREFTARIS, G.; WATERS, H. R.; WILKIE, A. D. *Bayesian modelling of the time delay between diagnosis and settlement for Critical Illness Insurance using a Burr generalised-linear-type model*. 266–279. We discuss Bayesian modelling of the delay between dates of diagnosis and settlement of claims in Critical Illness Insurance using a Burr distribution. The data are supplied by the UK Continuous Mortality Investigation and relate to claims settled in the years 1999–2005. There are non-recorded dates of diagnosis and settlement and these are included in the analysis as missing values using their posterior predictive distribution and MCMC methodology. The possible factors affecting the delay (age, sex, smoker status, policy type, benefit amount, etc.) are investigated under a Bayesian approach. A 3-parameter Burr generalised-linear-type model is fitted, where the covariates are linked to the mean of the distribution. Variable selection using Bayesian methodology to obtain the best model with different prior distribution setups for the parameters is also applied. In particular, Gibbs variable selection methods are considered, and results are confirmed using exact marginal likelihood findings and related Laplace approximations. For comparison purposes, a lognormal model is also considered.

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BELZUNCE, F.; SUAREZ-LLORENS, A.; SORDO, M. A. *Comparison of increasing directionally convex transformations of random vectors with a common copula*. 385–390. Let X and Y be two random vectors in Rn sharing the same dependence structure, that is, with a common copula. As many authors have pointed out, results of the following form are of interest: under which conditions, the stochastic comparison of the marginals of X and Y is a sufficient condition for the comparison of the expected values for some transformations of these random vectors? Assuming that the components are ordered in the univariate dispersive order–which can be interpreted as a multivariate dispersion ordering between the vectors–the main purpose of this work is to show that a weak positive dependence property, such as the positive association property, is enough for the comparison of the variance of any increasing directionally convex transformation of the vectors. Some applications in premium principles, optimization and multivariate distortions are described.

DA SILVO FILHO, O. C.; ZIEGELMANN, F. A.; DUEKER, M. J. *Modeling dependence dynamics through copulas with regime switching*. 346–356. Measuring dynamic dependence between international financial markets has recently attracted great interest in financial econometrics because the observed correlations rose dramatically during the 2008–09 global financial crisis. Here, we propose a novel approach for measuring dependence dynamics. We include a hidden Markov chain (MC) in the equation describing dependence dynamics, allowing the unobserved time-varying dependence parameter to vary according to both a restricted ARMA process and an unobserved two-state MC. Estimation is carried out via the inference for the margins in conjunction with filtering/smoothing algorithms. We use block bootstrapping to estimate the covariance matrix of our estimators. Monte Carlo simulations compare the performance of regime switching and no switching models, supporting the regime-switching specification. Finally the proposed approach is applied to empirical data, through the study of the S&P500 (USA), FTSE100 (UK) and BOVESPA (Brazil) stock market indexes.

DHAENE, J.; LINDERS, D.; SCHOUTENS, W.; VYNCKE, D. *The herd behavior index: A new measure for the implied degree of co-movement in stock markets.* 357–370. We introduce a new and easy-to-calculate measure for the expected degree of herd behaviour or co-movement between stock prices. This forward looking measure is model-independent and based on observed option data. It is baptized the Herd Behavior Index (HIX). The degree of co-movement in a stock market can be determined by comparing the observed market situation with the extreme (theoretical) situation under which the whole system is driven by a single factor. The HIX is then defined as the ratio of an option-based estimate of the risk-neutral variance of the market index and an option-based estimate of the corresponding variance in case of the extreme single factor market situation. The HIX can be determined for any market index provided an appropriate series of vanilla options is traded on this index as well as on its components. As an illustration, we determine historical values of the 30-days HIX for the Dow Jones Industrial Average, covering the period January 2003 to October 2009.

DICKSON, D. C. M. *The joint distribution of the time to ruin and the number of claims until ruin in the classical risk model.* 334–337. We use probabilistic arguments to derive an expression for the joint density of the time to ruin and the number of claims until ruin in the classical risk model. From this we obtain a general expression for the probability function of the number of claims until ruin. We also consider the moments of the number of claims until ruin and illustrate our results in the case of exponentially distributed individual claims. Finally, we briefly discuss joint distributions involving the surplus prior to ruin and deficit at ruin.

DIERS, D.; ELING, M.; MAREK, S. D. *Dependence modeling in non-life insurance using the Bernstein copula.* 430–436. This paper illustrates the modeling of dependence structures of non-life insurance risks using the Bernstein copula. We conduct a goodness-of-fit analysis and compare the Bernstein copula with other widely used copulas. Then, we illustrate the use of the Bernstein copula in a value-at-risk and tail-value-at-risk simulation study. For both analyses we utilize German claims data on storm, flood, and water damage insurance for calibration. Our results highlight the advantages of the Bernstein copula, including its flexibility in mapping inhomogeneous dependence structures and its easy use in a simulation context due to its representation as mixture of independent Beta densities. Practitioners and regulators working toward appropriate modeling of dependences in a risk management and solvency context can benefit from our results.

GUERRA, M.; CENTENO, M. L. *Are quantile risk measures suitable for risk-transfer decisions?* 446–461. Although controversial from the theoretical point of view, quantile risk measures are widely used by institutions and regulators. In this paper, we use a unified approach to find the optimal treaties for an agent who seeks to minimize one of these measures, assuming premium calculation principles of various types. We show that the use of measures like Value at Risk or Conditional Tail Expectation as optimization criteria for insurance or reinsurance leads to treaties that are not enforceable and/or are clearly bad for the cedent. We argue that this is one further argument against the use of quantile risk measures, at least for the purpose of risk-transfer decisions.

HABERMAN, S.; RENSHAW, A. *Parametric mortality improvement rate modelling and projecting.* 309–333. We investigate the modelling of mortality improvement rates and the feasibility of projecting mortality improvement rates (as opposed to projecting mortality rates), using parametric predictor structures that are amenable to simple time series forecasting. This leads to our proposing a parallel dual approach to the direct parametric modelling and projecting of

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mortality rates. Comparisons of simulated life expectancy predictions (by the cohort method) using the England and Wales population mortality experiences for males and females under a variety of controlled data trimming exercises are presented in detail and comparisons are also made between the parallel modelling approaches.

HUANG, R. J. *Ambiguity aversion, higher-order risk attitude and optimal effort.* 338–345. In this paper, we examine whether a more ambiguity-averse individual will invest in more effort to shift her initial starting wealth distribution toward a better target distribution. We assume that the individual has ambiguous beliefs regarding two target (starting) distributions and that one distribution is preferred to the other. We find that an increase in ambiguity aversion will decrease (increase) the optimal effort when the cost of effort is non-monetary. When the cost of effort is monetary, the effect depends on whether the individual would make more effort when the target (starting) distribution is the preferred distribution than the target (starting) distributions, the inferior one. We further characterize the individual's higher-order risk preferences to examine the sufficient conditions.

LEVANTESI, S.; MENZIETTI, M. *Managing longevity and disability risks in life annuities with long term care.* 391–401. The aim of the paper is twofold. Firstly, it develops a model for risk assessment in a portfolio of life annuities with long term care benefits. These products are usually represented by a Markovian Multi-State model and are affected by both longevity and disability risks. Here, a stochastic projection model is proposed in order to represent the future evolution of mortality and disability transition intensities. Data from the Italian National Institute of Social Security (INPS) and from Human Mortality Database (HMD) are used to estimate the model parameters. Secondly, it investigates the solvency in a portfolio of enhanced pensions. To this aim a risk model based on the portfolio risk reserve is proposed and different rules to calculate solvency capital requirements for life underwriting risk are examined. Such rules are then compared with the standard formula proposed by the Solvency II project.

LI, X.; YOU, Y. *On allocation of upper limits and deductibles with dependent frequencies and comonotonic severities.* 423–429. With the assumption of Archimedean copula for the occurrence frequencies of the risks covered by an insurance policy, this note further investigates the allocation problem of upper limits and deductibles addressed in Hua and Cheung (2008a). Sufficient conditions for a risk averse policyholder to well allocate the upper limits and the deductibles are built, respectively.

LIANG, Z.; YOUNG, V. R. *Dividends and reinsurance under a penalty for ruin.* 437–445. We find the optimal dividend strategy in a diffusion risk model under a penalty for ruin, as in Thonhauser and Albrecher (2007), although we allow for both a positive and a negative penalty. Furthermore, we determine the optimal proportional reinsurance strategy, when so-called expensive reinsurance is available; that is, the premium loading on reinsurance is greater than the loading on the directly written insurance. One can think of our model as taking the one in Taksar (2000, Section 6) and adding a penalty for ruin. We use the Legendre transform to obtain the optimal dividend and reinsurance strategies. Not surprisingly, the optimal dividend strategy is a barrier strategy. Also, we investigate the effect of the penalty P on the optimal strategies. In particular, we show that the optimal barrier increases with respect to P, while the optimal proportion retained and the value function decrease with respect to P. In the end, we explore the time of ruin, and find that the expected time of ruin increases with respect to P under a net profit condition.

LUCIANO, E.; REGIS, L.; VIGNA, E. *Delta–Gamma hedging of mortality and interest rate risk.* 402–412. One of the major concerns of life insurers and pension funds is the increasing longevity

of their beneficiaries. This paper studies the hedging problem of annuity cash flows when mortality and interest rates are stochastic. We first propose a Delta–Gamma hedging technique for mortality risk. The risk factor against which to hedge is the difference between the actual mortality intensity in the future and its "forecast" today, the forward intensity. We specialize the hedging technique first to the case in which mortality intensities are affine, then to Ornstein–Uhlenbeck and Feller processes, providing actuarial justifications for this selection. We show that, without imposing no arbitrage, we can get equivalent probability measures under which the HJM condition for no arbitrage is satisfied. Last, we extend our results to the presence of both interest rate and mortality risk. We provide a UK calibrated example of Delta–Gamma hedging of both mortality and interest rate risk.

MAO, T.; HU, T. *Characterization of left-monotone risk aversion in the RDEU model.* 413–422. We extend the characterization of the left-monotone risk aversion developed by Ryan (2006) to the case of unbounded random variables. The notion of weak convergence is insufficient for such an extension. It requires the solution of a host of delicate convergence problems. To this end, some further intrinsic properties of the location independent risk order are investigated. The characterization of the right-monotone risk aversion for unbounded random variables is also mentioned. Moreover, we remove the gap in the proof of the main result in Ryan (2006).

MCNEIL, A. J.; SMITH, A. D. *Multivariate stress scenarios and solvency.* 299–308. We show how the probabilistic concepts of half-space trimming and depth may be used to define convex scenario sets Qa for stress testing the risk factors that affect the solvency of an insurance company over a prescribed time period. By choosing the scenario in Qa which minimizes net asset value at the end of the time period, we propose the idea of the least solvent likely event (LSLE) as a solution to the forward stress testing problem. By considering the support function of the convex scenario set Qa, we establish theoretical properties of the LSLE when financial risk factors can be assumed to have a linear effect on the net assets of an insurer. In particular, we show that the LSLE may be interpreted as a scenario causing a loss equivalent to the Value-at-Risk (VaR) at confidence level a, provided the a-quantile is a sub-additive risk measure on linear combinations of the risk factors. In this case, we also show that the LSLE has an interpretation as a per-unit allocation of capital to the underlying risk factors when the overall capital is determined according to the VaR. These insights allow us to define alternative scenario sets that relate in similar ways to coherent measures, such as expected shortfall. We also introduce the most likely ruin event (MLRE) as a solution to the problem of reverse stress testing.

RAMSAY, C. M.; OGULEDO, V. I. *Insurance pricing with complete information, state-dependent utility, and production costs.* 462–469. We consider a group of identical risk-neutral insurers selling single-period indemnity insurance policies. The insurance market consists of individuals with common state-dependent utility function who are identical except for their known accident probability q. Insurers incur production costs (commonly called expenses or transaction costs by actuaries) that are proportional to the amount of insurance purchased and to the premium charged. By introducing the concept of insurance desirability, we prove that the existence of insurer expenses generates a pair of constants qmin and qmax that naturally partitions the applicant pool into three mutually exclusive and exhaustive groups of individuals: those individuals with accident probability q [0,qmin) are insurable but do not desire insurance, those individuals with accident probability q [qmin,qmax] are insurable and desire insurance, and those individuals with accident probability q (qmax,1] desire insurance but are uninsurable. We also prove that, depending on the level of q and the marginal rate of substitution between states,

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it may be optimal for individuals to buy complete (full) insurance, partial insurance, or no insurance at all. Finally, we prove that when q is known in monopolistic markets (i.e., markets with a single insurer), applicants may be induced to "over insure" whenever partial insurance is bought.

WU, H.; LI, Z. *Multi-period mean–variance portfolio selection with regime switching and a stochastic cash flow.* 371–384. This paper investigates a non-self-financing portfolio optimization problem under the framework of multi-period mean–variance with Markov regime switching and a stochastic cash flow. The stochastic cash flow can be explained as capital additions or withdrawals during the investment process. Specially, the cash flow is the surplus process or the risk process of an insurer at each period. The returns of assets and amount of the cash flow all depend on the states of a stochastic market which are assumed to follow a discrete-time Markov chain. We analyze the existence of optimal solutions, and derive the optimal strategy and the efficient frontier in closed-form. Several special cases are discussed and numerical examples are given to demonstrate the effect of cash flow.

XU, M.; HU, T. *Stochastic comparisons of capital allocations with applications.* 293–298. This paper studies capital allocation problems using a general loss function. Stochastic comparisons are conducted for general loss functions in several scenarios: independent and identically distributed risks; independent but non-identically distributed risks; comonotonic risks. Applications in optimal capital allocations and policy limits allocations are discussed as well.

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AHN, S.; KIM, J. H. T.; RAMASWAMI, V. *A new class of models for heavy tailed distributions in finance and insurance risk.* 43–52. Many insurance loss data are known to be heavy-tailed. In this article we study the class of Log phase-type (LogPH) distributions as a parametric alternative in fitting heavy tailed data. Transformed from the popular phase-type distribution class, the LogPH introduced by Ramaswami exhibits several advantages over other parametric alternatives. We analytically derive its tail related quantities including the conditional tail moments and the mean excess function, and also discuss its tail thickness in the context of extreme value theory. Because of its denseness proved herein, we argue that the LogPH can offer a rich class of heavy-tailed loss distributions without separate modeling for the tail side, which is the case for the generalized Pareto distribution (GPD). As a numerical example we use the well-known Danish fire data to calibrate the LogPH model and compare the result with that of the GPD. We also present fitting results for a set of insurance guarantee loss data.

ANASTASIADIS, S.; CHUKOVA, S. *Multivariate insurance models: An overview.* 222–227. This literature review summarizes the results from a collection of research papers that relate to modeling insurance claims and the processes associated with them. We consider work by more than 55 authors, published or presented between 1971 and 2008.

ARBENZ, P.; HUMMEL, C.; MAINIK, G. *Copula based hierarchical risk aggregation through sample reordering.* 122–133. For high-dimensional risk aggregation purposes, most popular copula classes are too restrictive in terms of attainable dependence structures. These limitations aggravate with increasing dimension. We study a hierarchical risk aggregation method which is flexible in high dimensions. With this method it suffices to specify a low dimensional copula for

each aggregation step in the hierarchy. Copulas and margins of arbitrary kind can be combined. We give an algorithm for numerical approximation which introduces dependence between originally independent marginal samples through reordering.

AZCUE, P.; MULER, N. *Optimal dividend policies for compound Poisson processes: The case of bounded dividend rates*. 26–42. We consider in this paper the optimal dividend problem for an insurance company whose uncontrolled reserve process evolves as a classical Cramér–Lundberg model with arbitrary claim-size distribution. Our objective is to find the dividend payment policy which maximizes the cumulative expected discounted dividend pay-outs until the time of bankruptcy imposing a ceiling on the dividend rates. We characterize the optimal value function as the unique bounded viscosity solution of the associated Hamilton–Jacobi–Bellman equation. We prove that there exists an optimal dividend strategy and that this strategy is stationary with a band structure. We study the regularity of the optimal value function. We find a characterization result to check optimality even in the case where the optimal value function is not differentiable. We construct examples where the claim-size distribution is smooth but the optimal dividend policy is not threshold and the optimal value function is not differentiable. We study the survival probability of the company under the optimal dividend policy. We also present examples where the optimal dividend policy has infinitely many bands even in the case that the claim-size distribution has a bounded density.

BELLINI, F.; GIANIN, E. R. *Haezendonck–Goovaerts risk measures and Orlicz quantiles*. 107–114. In this paper, we study the well-known Haezendonck–Goovaerts risk measures on their natural domain, that is on Orlicz spaces and, in particular, on Orlicz hearts. We provide a dual representation as well as the optimal scenario in such a representation and investigate the properties of the minimizer (that we call Orlicz quantile) in the definition of the Haezendonck–Goovaerts risk measure. Since Orlicz quantiles fail to satisfy an internality property, bilateral Orlicz quantiles are also introduced and analyzed.

DAS, S.; KRATZ, M. *Alarm system for insurance companies: A strategy for capital allocation*. 53–65. One possible way of risk management for an insurance company is to develop an early and appropriate alarm system before the possible ruin. The ruin is defined through the status of the aggregate risk process, which in turn is determined by premium accumulation as well as claim settlement outgo for the insurance company. The main purpose of this work is to design an effective alarm system, i.e. to define alarm times and to recommend augmentation of capital of suitable magnitude at those points to reduce the chance of ruin. To draw a fair measure of effectiveness of alarm system, comparison is drawn between an alarm system, with capital being added at the sound of every alarm, and the corresponding system without any alarm, but an equivalently higher initial capital. Analytical results are obtained in general setup and this is backed up by simulated performances with various types of loss severity distributions. This provides a strategy for suitably spreading out the capital and yet addressing survivability concerns at factory level.

DASSIOS, A.; ZHAO, H. *Ruin by dynamic contagion claims*. 93–106. In this paper, we consider a risk process with the arrival of claims modelled by a dynamic contagion process, a generalisation of the Cox process and Hawkes process introduced by Dassios and Zhao (2011). We derive results for the infinite horizon model that are generalisations of the Cramér–Lundberg approximation, Lundberg's fundamental equation, some asymptotics as well as bounds for the probability of ruin. Special attention is given to the case of exponential jumps and a numerical example is provided.

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FAUST, R.; SCHMEISER, H.; ZEMP, A. *A performance analysis of participating life insurance contracts.* 158–171. Participating life insurance contracts are one of the most important products in the European life insurance market. Even though these contract forms are very common, only very little research has been conducted in respect to their performance. Hence, we conduct a performance analysis to provide a decision support for policyholders. We decompose a participating life insurance contract in a term life insurance and a savings part and simulate the cash flow distribution of the latter. Simulation results are compared with cash flows resulting from two benchmarks investing in the same portfolio of assets but without investment guarantees and bonus distribution schemes, in order to measure the impact of these two product features. To provide a realistic picture within the two alternatives, we take transaction costs and wealth transfers between different groups of policyholders into account. We show that the payoff distribution strongly depends on the initial reserve situation and managerial discretion. Results indicate that policyholders will in general profit from a better payoff distribution of the participating life insurance compared to a mutual fund benchmark but not compared to an exchange-traded fund benchmark portfolio.

FROSTIG, E.; PITTS, S. M.; POLITIS, KONSTADINOS. *The time to ruin and the number of claims until ruin for phase-type claims.* 19–25. We consider a renewal risk model with phase-type claims, and obtain an explicit expression for the joint transform of the time to ruin and the number of claims until ruin, with a penalty function applied to the deficit at ruin. The approach is via the duality between a risk model with phase-type claims and a particular single server queuing model with phase-type customer inter-arrival times; see Frostig (2004). This result specializes to one for the probability generating function of the number of claims until ruin. We obtain explicit expressions for the distribution of the number of claims until ruin for exponentially distributed claims when the inter-claim times have an Erlang-n distribution.

GERBER, H. U.; SHIU, E. S. W.; YANG, H. *Valuing equity-linked death benefits and other contingent options: A discounted density approach.* 73–92. Motivated by the Guaranteed Minimum Death Benefits in various deferred annuities, we investigate the calculation of the expected discounted value of a payment at the time of death. The payment depends on the price of a stock at that time and possibly also on the history of the stock price. If the payment turns out to be the payoff of an option, we call the contract for the payment a (life) contingent option. Because each time-until-death distribution can be approximated by a combination of exponential distributions, the analysis is made for the case where the time until death is exponentially distributed, i.e., under the assumption of a constant force of mortality. The time-until-death random variable is assumed to be independent of the stock price process which is a geometric Brownian motion. Our key tool is a discounted joint density function. A substantial series of closed-form formulas is obtained, for the contingent call and put options, for lookback options, for barrier options, for dynamic fund protection, and for dynamic withdrawal benefits. In a section on several stocks, the method of Esscher transforms proves to be useful for finding among others an explicit result for valuing contingent Margrabe options or exchange options. For the case where the contracts have a finite expiry date, closed-form formulas are found for the contingent call and put options. From these, results for De Moivre's law are obtained as limits. We also discuss equity-linked death benefit reserves and investment strategies for maintaining such reserves. The elasticity of the reserve with respect to the stock price plays an important role. Whereas in the most important applications the stopping time is the time of death, it could be different in other applications, for example, the time of the next catastrophe.

GOOVAERTS, M.; LINDERS, D.; VAN WEERT, K.; TANK, F. *On the interplay between distortion, mean value and Haezendonck-Goovaerts risk measures.* 10–18. In the actuarial

research, distortion, mean value and Haezendonck–Goovaerts risk measures are concepts that are usually treated separately. In this paper we indicate and characterize the relation between these different risk measures, as well as their relation to convex risk measures. While it is known that the mean value principle can be used to generate premium calculation principles, we will show how they also allow to generate solvency calculation principles. Moreover, we explain the role provided for the distortion risk measures as an extension of the Tail Value-at-Risk (TVaR) and Conditional Tail Expectation (CTE).

HAN, N.-W.; HUNG, M.-W. *Optimal asset allocation for DC pension plans under inflation.* 172–181. In this paper, the stochastic dynamic programming approach is used to investigate the optimal asset allocation for a defined-contribution pension plan with downside protection under stochastic inflation. The plan participant invests the fund wealth and the stochastic interim contribution flows into the financial market. The nominal interest rate model is described by the Cox–Ingersoll–Ross (Cox et al., 1985) dynamics. To cope with the inflation risk, the inflation indexed bond is included in the asset menu. The retired individuals receive an annuity that is indexed by inflation and a downside protection on the amount of this annuity is considered. The closed-form solution is derived under the CRRA utility function. Finally, a numerical application is presented to characterize the dynamic behavior of the optimal investment strategy.

HAPP, S.; MERZ, M.; WUTHRICH, M. V. *Claims development result in the paid-incurred chain reserving method.* 66–72. We present the one-year claims development result (CDR) in the paid-incurred chain (PIC) reserving model. The PIC reserving model presented in Merz and Wüthrich (2010) is a Bayesian stochastic claims reserving model that considers simultaneously claims payments and incurred losses information and allows for deriving the full predictive distribution of the outstanding loss liabilities. In this model we study the conditional mean square error of prediction (MSEP) for the one-year CDR uncertainty, which is the crucial uncertainty view under Solvency II.

LANIADO, H.; LILLO, R. E.; PELLEREY, F.; ROMO, J. *Portfolio selection through an extremality stochastic order.* 1–9. In this paper, we introduce a new multivariate stochastic order that compares random vectors in a direction which is determined by a unit vector, generalizing the previous upper and lower orthant orders. The main properties of this new order, together with its relationships with other multivariate stochastic orders, are investigated and, we present some examples of application in the determination of optimal allocations of wealth among risks in single period portfolio problems.

LI, Z.; ZENG, Y.; LAI, Y. *Optimal time-consistent investment and reinsurance strategies for insurers under Heston's SV model.* 191–203. This paper considers the optimal time-consistent investment and reinsurance strategies for an insurer under Heston's stochastic volatility (SV) model. Such an SV model applied to insurers' portfolio problems has not yet been discussed as far as we know. The surplus process of the insurer is approximated by a Brownian motion with drift. The financial market consists of one risk-free asset and one risky asset whose price process satisfies Heston's SV model. Firstly, a general problem is formulated and a verification theorem is provided. Secondly, the closed-form expressions of the optimal strategies and the optimal value functions for the mean–variance problem without pre-commitment are derived under two cases: one is the investment–reinsurance case and the other is the investment-only case. Thirdly, economic implications and numerical sensitivity analysis are presented for our results. Finally, some interesting phenomena are found and discussed.

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MARRI, F.; FURMAN, E. *Pricing compound Poisson processes with the Farlie–Gumbel–Morgenstern dependence structure.* 151–157. Convenient expressions for the Esscher pricing functional in the context of the compound Poisson processes with dependent loss amounts and loss inter-arrival times are developed. To this end, the moment generating function of the aforementioned dependent processes is derived and studied. Various implications of the dependence are discussed and exemplified numerically.

MELNIKOV, A.; SMIRNOV, I. *Dynamic hedging of conditional value-at-risk.* 182–190. In this paper, the problem of partial hedging is studied by constructing hedging strategies that minimize conditional value-at-risk (CVaR) of the portfolio. Two dual versions of the problem are considered: minimization of CVaR with the initial wealth bounded from above, and minimization of hedging costs subject to a CVaR constraint. The Neyman–Pearson lemma approach is used to deduce semi-explicit solutions. Our results are illustrated by constructing CVaR-efficient hedging strategies for a call option in the Black–Scholes model and also for an embedded call option in an equity-linked life insurance contract.

NAJAFABADI, A. T. P.; HATAMI, H.; NAJAFABADI, M. O. *A maximum-entropy approach to the linear credibility formula.* 216–221. Payandeh [Payandeh Najafabadi, A.T., 2010. A new approach to credibility formula. Insurance: Mathematics and Economy 46, 334–338] introduced a new technique to approximate a Bayes' estimator with the exact credibility's form. This article employs a well known and powerful maximum-entropy method (MEM) to extend results of Payandeh Najafabadi (2010) to a class of linear credibility, whenever claim sizes have been distributed according to the logconcave distributions. Namely, (i) it employs the maximum-entropy method to approximate an appropriate Bayes' estimator (with respect to either the square-error or the Linex loss functions and general increasing and bounded prior distribution) by a linear combination of claim sizes; (ii) it establishes that such an approximation coincides with the exact credibility formula whenever the require conditions for the exact credibility (see below) are held. Some properties of such an approximation are discussed. Application to crop insurance has been given.

PENG, L.; QI, Y.; WANG, R.; YANG, J. *Jackknife empirical likelihood method for some risk measures and related quantities.* 142–150. Quantifying risks is of importance in insurance. In this paper, we employ the jackknife empirical likelihood method to construct confidence intervals for some risk measures and related quantities studied by Jones and Zitikis (2003). A simulation study shows the advantages of the new method over the normal approximation method and the naive bootstrap method.

SHI, P. *Multivariate longitudinal modeling of insurance company expenses.* 204–215. Insurers, investors and regulators are interested in understanding the behaviour of insurance company expenses, due to the high operating cost of the industry. Expense models can be used for prediction, to identify unusual behavior, and to measure firm efficiency. Current literature focuses on the study of total expenses that consist of three components: underwriting, investment and loss adjustment. A joint study of expenses by type is to deliver more information and is critical in understanding their relationship. This paper introduces a copula regression model to examine the three types of expenses in a longitudinal context. In our method, elliptical copulas are employed to accommodate the between-subject contemporaneous and lag dependencies, as well as the within-subject serial correlations of the three types. Flexible distributions are allowed for the marginals of each type with covariates incorporated in distribution parameters. A model validation procedure based on a t-plot method is proposed for in-sample and out-of-sample

validation purposes. The multivariate longitudinal model effectively addresses the typical features of expenses data: the heavy tails, the strong individual effects and the lack of balance. The analysis is performed using property–casualty insurance company expenses data from the National Association of Insurance Commissioners of years 2001–2006. A unique set of covariates is determined for each type of expenses. We found that underwriting expenses and loss adjustment expenses are complements rather than substitutes. The model is shown to be successful in efficiency classification. Also, a multivariate predictive density is derived to quantify the future values of an insurer's expenses.

WILLMOT, G. E.; WOO, J.-K. *On the analysis of a general class of dependent risk processes.* 134–141. A generalized Sparre Andersen risk process is examined, whereby the joint distribution of the interclaim time and the ensuing claim amount is assumed to have a particular mathematical structure. This structure is present in various dependency models which have previously been proposed and analyzed. It is then shown that this structure in turn often implies particular functional forms for joint discounted densities of ruin related variables including some or all of the deficit at ruin, the surplus immediately prior to ruin, and the surplus after the second last claim. Then, employing a fairly general interclaim time structure which involves a combination of Erlang type densities, a complete identification of a generalized Gerber–Shiu function is provided. An application is given applying these results to a situation involving a mixed Erlang type of claim amount assumption. Various examples and special cases of the model are then considered, including one involving a bivariate Erlang mixture model.

ZHU, L.; LI, H. *Tail distortion risk and its asymptotic analysis.* 115–121. A distortion risk measure used in finance and insurance is defined as the expected value of potential loss under a scenario probability measure. In this paper, the tail distortion risk measure is introduced to assess tail risks of excess losses modeled by the right tails of loss distributions. The asymptotic linear relation between tail distortion and value-at-risk is derived for heavy-tailed losses with the linear proportionality constant depending only on the distortion function and the tail index. Various examples involving tail distortions for location-invariant, scale-invariant, and shape-invariant loss distribution families are also presented to illustrate the results.

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AI, J.; BROCKETT, P. L.; COOPER, W. W.; GOLDEN, L. L. *Enterprise Risk Management through strategic allocation of capital.* 29–56. This article presents a conceptual framework for operationalizing strategic enterprise risk management (ERM) in a general firm. We employ a risk-constrained optimization approach to study the capital allocation decisions under ERM. Given the decision maker's risk appetite, the problem of holistically managing enterprise-wide hazard, financial, operational, and real project risks is treated by maximizing the expected total return on capital, while trading off risks simultaneously in Value-at-Risk type of constraints. This approach explicitly quantifies the concepts of risk appetite and risk prioritization in light of the firm's default and financial distress avoidance reflected in its target credit rating. Our framework

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also allows the firm to consider a multi – period planning horizon so that changing business environments can be accounted for. We illustrate the implementation of the framework through a numerical example. As an initial conceptual advancement, our formulation is capable of facilitating more general ERM modeling within a consistent strategic framework, where idiosyncratic variations of firms and different modeling assumptions can be accommodated. Managerial implications are also discussed.

BERRY-STÖLZLE, T. R.; BORN, P. *The effect of regulation on insurance pricing: the case of Germany.* 129–164. This article analyzes the impact of policy form regulation on the unit price of insurance and determinants of premium changes using the 1994 deregulation of the German property–liability market as a natural experiment. Our result show that policy form regulation did not increase prices above competitive levels. Factors influencing premium changes are significantly different for the two time periods, pre- and post-deregulation, indicating that regulation affects insurance pricing. Focusing on highly competitive lines after deregulation, we find a significant price decrease, and this decrease is offset by higher prices in the remaining other lines.

BOMMIER, A.; VILLENEUVE, B. *Risk aversion and the value of risk to life.* 77–104. The standard literature on the value of life relies on Yaari's (1965) model, which includes an implicit assumption of risk neutrality with respect to life duration. To overpass this limitation, we extend the theory to a simple variety of preferences that are not necessarily additively separable. The enlargement we propose is relevant for the evaluation of life-saving programs: current practice, we estimate, puts too little weight on mortality risk reduction of the young. Our correction exceeds in magnitude that introduced by the switch from the notion of number of lives saved to the notion of years of life saved.

BOTZEN, W. J. W. *Book review: At war with the weather: managing large-scale risks in a new era of catastrophes.* 301–304. Book review.

BRAUN, A.; GATZERT, N.; SCHMEISER, H. *Performance and risks of open-end life settlement funds.* 193–230. In this article, we comprehensively analyze open-end funds dedicated to investing in U.S. senior life settlements. We begin by explaining their business model and the roles of institutions involved in the transactions of such funds. Next, we conduct the first empirical analysis of life settlement fund return distributions as well as a performance measurement, including a comparison to other asset classes. Since the funds contained in our data set cover a large fraction of this relatively young segment of the capital markets, representative conclusions can be derived. Even though the empirical results suggest that life settlement funds offer attractive returns paired with low volatility and are virtually uncorrelated with other asset classes, we find latent risk factors such as liquidity, longevity, and valuation risks. Since these risks did generally not materialize in the past and are hence largely not reflected by the historical data, they cannot be captured by classical performance measures. Thus, caution is advised in order not to overestimate the performance of this asset class.

CARRIQUIRY, M. A.; OSGOOD, D. E. *Index insurance, probabilistic climate forecasts, and production.* 287–300. Index insurance and probabilistic seasonal forecasts are becoming available in developing countries to help farmers manage climate risks in production. Although these tools are intimately related, work has not been done to formalize the connections between them. We investigate the relationship between the tools through a model of input choice under uncertainty, forecasts, and insurance. While it is possible for forecasts to undermine insurance,

we find that when contracts are appropriately designed, there are important synergies between forecasts, insurance, and effective input use. Used together, these tools overcome barriers preventing the use of imperfect information in production decision making.

DHAENE, J.; TSANAKAS, A.; VALDEZ, E. A.; VANDUFFEL, S. *Optimal capital allocation principles*. 1–28. This article develops a unifying framework for allocating the aggregate capital of a financial firm to its business units. The approach relies on an optimization argument, requiring that the weighted sum of measures for the deviations of the business unit's losses from their respective allocated capitals be minimized. The approach is fair insofar as it requires capital to be close to the risk that necessitates holding it. The approach is additionally very flexible in the sense that different forms of the objective function can reflect alternative definitions of corporate risk tolerance. Owing to this flexibility, the general framework reproduces several capital allocation methods that appear in the literature and allows for alternative interpretations and possible extensions.

GHOSH, C.; HILLIARD, J. I. *The value of contingent commissions in the property–casualty insurance industry: Evidence from stock market returns*. 165–192. Insurance producer compensation has incorporated contingent commissions for decades. In 2004, the New York State Attorney General sued insurers and brokers, alleging compensation abuses and calling for elimination of some forms of contingent commissions. Daily stock price return data reveal negative announcement-period portfolio returns for property–casualty carriers, suggesting expected negative cash flow effects. Firm-level losses were related to intensity of contingent commission use, suggesting that the effects of such regulatory changes would be felt most by firms that relied on contingent commissions. Investors believed contingent commissions were valuable not only for producers but also for carriers.

KAPUR, K.; KARACA-MANDIC, P.; GATES, S. M.; FULTON, B. *Do small-group health insurance regulations influence small business size?* 231–260. State small-group health insurance reforms, implemented in the 1990s, aimed at controlling the variability of health insurance premiums and to improve access to health insurance. These reforms only affected firms within a specific size range, and as a result, they may have affected the size of small firms around the legislative threshold and may also have affected the propensity of small firms to offer health insurance. We examine the relationship between small-group reform and firm size and find evidence that small firms just below the regulatory threshold that were offering health insurance grew in order to bypass reforms.

LEVERTY, J. T. *The cost of duplicative regulation: evidence from risk retention groups*. 105–128. A vast majority of insurers are regulated by each state in which they conduct business; however, a small subset of specialized firms, risk retention groups (RRGs), are largely exempt from most aspects of duplicative regulation no matter how many states they operate. This article analyzes the differences between RRGs and standard insurers specializing in commercial liability insurance to determine the cost of duplicative regulation. The costs associated with multi-state regulation are significantly higher than those for single-entity regulation. These high regulatory compliance costs reduce the technical efficiency of firms, deter firms from operating in additional states, and increase the price of insurance.

LOHSE, T.; ROBLEDO, J. R.; SCHMIDT, U. *Self-insurance and self-protection as public goods*. 57–76. Many public goods provide utility by insuring against hazardous events. Those public

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goods can have self-insurance and self-protection character. For both situations we analyze the efficient public provision level and the provision level resulting from Nash behavior in a private provision game. We consider the interaction of public goods as insurance devices with market insurance. The availability of market insurance reduces the provision level of the public good for both public and private provision, regardless of whether we consider self-insurance or self-protection. Moreover, we show that Nash behavior has always a larger impact than the availability of market insurance.

WOODARD, J. D.; SCHNITKEY, G. D.; SHERRICK, B. J.; LOZANO-GRACIA, N.; ANSELIN, L. *A spatial econometric analysis of loss experience in the U.S. crop insurance program.* 261–286. Patterns in loss-ratio experience in the U.S. corn insurance market are investigated with a spatial econometric model. The results demonstrate systematic geographically related misratings and provide estimates of the impacts of several observable factors on the magnitude of misrating in the program. The model is used to estimate actuarial cross-subsidizations across the primary corn-producing states and counties. The impacts of the primary factors are substantial, resulting in net premium transfers of approximately 26 percent of total premiums annually. The misratings likely have important insurance demand, welfare, and land-use implications.

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North American Actuarial Journal

15(4), 2011

COSTABILE, M.; MASSABO, I.; RUSSO, E. *Fair valuation of equity-linked policies under insurer default risk.* 517–534. We consider the problem of computing the fair value of equity-linked policies with an interest rate guarantee when the insurer is subject to credit risk. The framework is developed based on modern financial theory using the no-arbitrage principle. In this context, an equity-linked policy is considered as a vulnerable contingent claim that expires before maturity if the firm asset value reaches a pre-specified default threshold depending on the firm's liabilities. We derive a closed form formula in a continuous-time environment to compute the fair value of the contract. We also develop a discrete time model that allows us to address fair evaluation when the policy embeds a surrender option.

COWELL, M. J. *Discussion of: "Human survival at older ages and the implications for longevity bond pricing"* 553–558. This is a discussion of the paper "Human survival at older ages and the implications for longevity bond pricing" by Leslie Mayhew and David Smith, June, 2011.

KIM, J. H. T. *Capital allocation using the bootstrap.* 499–516. This paper investigates the use of the bootstrap in capital allocation. In particular, for the distortion risk measure (DRM) class, we show that the exact bootstrap estimate is available in analytic form for the allocated capital. We then theoretically justify the bootstrap bias correction for the allocated capital induced from the concave DRM when the conditional mean function is strictly monotone. A numerical example shows a trade-off exists between the bias reduction and variance increase in bootstrapping the allocated capital. However, unlike the aggregate capital case, the variance increase of the bias-corrected allocated capital estimate substantially outweighs the benefit of bias correction,

making the bootstrap bias correction at the allocated capital level not as useful. Overall, the exact bootstrap without bias correction offers an efficient method for determining allocation over the ordinary re-sampling bootstrap estimate and the empirical counterpart.

LIN, H.-J.; WEN, M.-M.; YANG, C. C. *Effects of risk management on cost efficiency and cost*function *of the U.S. Property and liability insurers*. 487–498. This paper adopts the one-step stochastic frontier approach to investigate the impact of risk management tools of derivatives and reinsurance on cost efficiency of U.S. property-liability insurance companies. The stochastic frontier approach considers both the mean and variance of cost efficiency. The sample includes both stock and mutual insurers. Among the findings, the cost function of the entire sample carries the concavity feature, and insurers tend to use financial derivatives for firm value creation. The results also show that for the entire sample the use of derivatives enhances the mean of cost efficiency but accompanied with larger efficiency volatility. Nevertheless, the utilization of financial derivatives mitigates efficiency volatility for mutual insurers. This research provides important insights for the practice of risk management in the property-liability insurance industry.

TAYLOR, G. *A statistical basis for claims experience monitoring*. 535–552. By claims experience monitoring is meant the systematic comparison of the forecasts from a claims model with claims experience as it emerges subsequently. In the event that the stochastic properties of the forecasts are known, the comparison can be represented as a collection of probabilistic statements. This is stochastic monitoring. This paper defines this process rigorously in terms of statistical hypothesis testing. If the model is a regression model (which is the case for most stochastic claims models), then the natural form of hypothesis test is a number of likelihood ratio tests, one for each parameter in the valuation model. Such testing is shown to be very easily implemented by means of generalized linear modeling software. This tests the formal structure of the claims model and is referred to as microtesting. There may be other quantities (e.g., amount of claim payments in a defined interval) that require testing for practical reasons. This sort of testing is referred to as macrotesting, and its formulation is also discussed.

WANG, R.; PENG, L. *Jackknife empirical likelihood intervals for Spearman's rho*. 475–486. In connection with copulas, rank correlation such as Kendall's tau and Spearman's rho has been employed in risk management for summarizing dependence between two variables and estimating parameters in bivariate copulas and elliptical models. In this paper a jackknife empirical likelihood method is proposed to construct confidence intervals for Spearman's rho without estimating the asymptotic variance. A simulation study confirms the advantages of the proposed method.

North American Actuarial Journal

16(1), 2012

BERNARD, C.; LUDKOVSKI, M. *Impact of counterparty risk on the reinsurance market*. 87–111. We investigate the impact of counterparty risk (from the insurer's viewpoint) on contract design in the reinsurance market. We study a multiplicative default risk model with partial recovery and where the probability of the reinsurer's default depends on the loss incurred by the insurer. The reinsurer (reinsurance seller) is assumed to be risk-neutral, while the insurer (reinsurance buyer) is risk-averse and uses either expected utility or a conditional tail expectation risk criterion. We show that generally the reinsurance buyer wishes to overinsure above a deductible level, and that many of the standard comparative statics cease to hold. We also derive the properties of stop-loss

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insurance in our model and consider the possibility of divergent beliefs about the default probability. Classical results are recovered when default risk is loss-independent or there is zero recovery rate. Results are illustrated with numerical examples.

JONG, P. De. *Modeling dependence between loss triangles.* 74–86. A critical problem in property and casualty insurance is forecasting incurred but as yet unpaid losses. Forecasts and risk margins are often based on individual loss triangles with each triangle corresponding to a different line of business. Different lines of business are often dependent, and overall risk margins must reflect this dependence. This article develops, implements, and applies a model for loss triangle dependence. The model facilitates the structuring and measurement of dependence. One possible structure is where payments in different triangles in the same calendar year are related. Dependence is modeled with a Gaussian copula, and it is moderated by quantities called communalities that measure the relative impact of cross-dependence in each triangle. Dependence can be structured in terms of factor models. Methods reduce to relatively simple calculations in the case of marginal normal distributions. Procedures are applied to U.S. loss triangle data. The impact of loss triangle dependence on risk margins is considered.

KIESENBAUER, D. *Main determinants of lapse in the German life insurance industry.* 52–73. This paper studies the determinants of lapse in the German life insurance industry. Logistic regression models are employed using data on macroeconomic indicators and company characteristics of 133 German life insurers from 1997 to 2009. Five different product categories are considered (endowment, annuity, term life, group, and other). The findings indicate that the main lapse determinants are very similar across all product categories, except that the direction of impact is reversed for the product category "other," which consists almost exclusively of unit linked business. In particular, the interest rate and emergency fund hypotheses are supported only for unit-linked business, while these hypotheses do not hold for the remaining product categories. Overall, the analysis provides an understanding of lapse dynamics related to economic indicators and company characteristics. The derived models can be used to predict lapse rates for the different product categories considered. The results are important for insurance company managers, regulators, and life insurance customers.

KOLKIEWICZ, A.; LIU, Y. *Semi-static hedging for GMWB in variable annuities.* 112–140. The Guaranteed Minimum Withdrawal Benefit (GMWB) is an option embedded in a variable annuity that guarantees the policyholder to get the initial investment back by making periodic withdrawals regardless of the impact of poor market performance. In the paper we discuss methods of pricing and hedging of some versions of GMWBs. In particular we develop a method of constructing semi-static hedging strategies that offer several advantages over dynamic hedging. The idea is to first find the closest path-independent option to the guarantee, or its liability part, and then to construct a portfolio of traded European options that approximates the optimal option. This strategy requires fewer portfolio adjustments than delta hedging and outperforms the latter when there are random jumps in the underlying price. We illustrate the proposed method with numerical examples.

LIN, Y.; WEN, M.-M.; YU, J. *Enterprise risk management: strategic antecedents, risk integration and performance.* 1–28. The current literature on the adoption of enterprise risk management (ERM) abstracts from the issue of its strategic context. Accounting for the interplay between ERM and various individual risk management (IRM) practices, this paper presents a theoretical basis to study the strategic determinants, risk integration, and value creation of ERM. We tested

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hypotheses with data from the U.S. property and casualty insurance industry. Our results show that insurers with more reinsurance purchase and greater geographic diversification are more likely to adopt ERM. After ERM initiation, the magnitude of certain IRM adjustments is substantial. The market responds negatively to ERM adoption. ERM displays a strong negative correlation with firm value with a discount of 5% (4%) in terms of Tobin's Q (ROA).

SHI, P.; BASU, S.; MEYERS, G. G. *A Bayesian log-normal model for multivariate loss reserving.* 29–51. The correlation among multiple lines of business plays an important role in quantifying the uncertainty of loss reserves for insurance portfolios. To accommodate correlation, most multivariate loss-reserving methods focus on the pairwise association between corresponding cells in multiple run-off triangles. However, such practice usually relies on the independence assumption across accident years and ignores the calendar year effects that could affect all open claims simultaneously and induce dependencies among loss triangles. To address this issue, we study a Bayesian log-normal model in the prediction of outstanding claims for dependent lines of business. In addition to the pairwise correlation, our method allows for an explicit examination of the correlation due to common calendar year effects. Further, different specifications of the calendar year trend are considered to reflect valuation actuaries' prior knowledge of claim development. In a case study, we analyze an insurance portfolio of personal and commercial auto lines from a major U.S. property-casualty insurer. It is shown that the incorporation of calendar year effects improves model fit significantly, though it contributes substantively to the predictive variability. The availability of the realizations of predicted claims permits us to perform a retrospective test, which suggests that extra prediction uncertainty is indispensable in modern risk management practices.

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Scandinavian Actuarial Journal

1, 2012

DRIESKENS, D.; HENRY, M.; WALHIN, J.-F.; WIELANDTS, J. *Stochastic projection for large individual losses.* 1–39. In this paper we investigate how to estimate ultimate values of large losses. The method is based on the development of individual losses and therefore allows to compute the netting impact of excess of loss reinsurance. In particular the index clause is properly accounted for. A numerical example based on real-life data is provided.

LÉVEILLÉ, G.; ADÉKAMBI, F. *Joint moments of discounted compound renewal sums.* 40–55. The first two moments and the covariance of the aggregate discounted claims have been found for a stochastic interest rate, from which the inflation rate has been subtracted, and for a claims number process that is an ordinary or a delayed renewal process. Hereafter we extend the preceding results by presenting recursive formulas for the joint moments of this risk process, for a constant interest rate, and non-recursive formulas for higher joint moments when the interest rate is stochastic. Examples are given for exponential claims inter-arrival times and for the Ho-Lee-Merton interest rate model.

NOCON, A. S.; SCOTT, W. F. *An extension of the Whittaker–Henderson method of graduation.* 70–79. We present an outline and historical summary of the Whittaker–Henderson method of graduation (or data smoothing), together with an extension of the method in which the graduated values are obtained by minimising a Whittaker–Henderson criterion subject to constraints. Examples are given, using data for the global average temperature anomaly and for a set of share prices, in which the proposed method appears to give good results.

SHIMIZU, Y. *Non-parametric estimation of the Gerber–Shiu function for the Wiener–Poisson risk model.* 56–69. A non-parametric estimator of the Gerber–Shiu function is proposed for a risk process with a compound Poisson claim process plus a diffusion perturbation; the Wiener–Poisson risk model. The estimator is based on a regularized inversion of an empirical-type estimator of the Laplace transform of the Gerber–Shiu function. We show the weak consistency of the estimator in the sense of an integrated squared error with the rate of convergence.

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Variance

5 (1), 2011

BOUCHER, J.-P.; DENUIT, M.; GUILLÉN, M. *Correlated random effects for hurdle models applied to claim counts.* 68–81. New models for panel data that consist of a generalization of the hurdle model are presented and are applied to modeling a panel of claim counts. Correlated random effects are assumed for the two processes involved to allow for dependence among all the contracts held by the same insured. A method to obtain a posteriori distribution of the random effects as well as predictive distributions of the number of claims is presented. A numerical illustration of reported insurance claims shows that if independence between random effects is assumed, then the variance of a priori premiums may be underestimated. If dependence between random effects is considered, then the predicted number of claims given past observations and covariate information and its variance is also larger than the one obtained when independence is assumed.

CLARK, D. R. *Credibility for a tower of excess layers.* 32–44. In pricing excess of loss reinsurance, the traditional method for applying credibility is as a weighted average of two estimates of expected loss: one from experience rating and a second from exposure rating. This paper will show how this method can be improved by incorporating loss estimates from lower layers; producing a multifactor credibility-weighted estimate of expected loss. The method described is based on minimum variance criteria, whereby the resulting credibility-weighted estimator has a lower variance than any other combination of the individual estimators. It is shown that the multifactor credibility model can be presented as a simple recursive procedure for practical application.

DALEY, T. V. *Catastrophes and workers compensation ratemaking.* 13–31. The National Council on Compensation Insurance (NCCI) changed its workers compensation ratemaking methodology to improve the treatment of large individual claims and catastrophic multiclaim events related to the perils of industrial accidents, earthquake, and terrorism. NCCI worked with a well known modeling firm to determine provisions for catastrophic events on a state basis. This paper describes the new methodology that NCCI has filed in many states. We discuss how certain traditional areas of aggregate ratemaking were modified: loss development including the tail factor, trend, capping losses, and application of excess provisions. The paper also documents for

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the first time in Casualty Actuarial Society literature how computer modeling was applied in workers compensation to determine loss costs by state.

PARSA, R. A.; KLUGMAN, S. A. *Copula regression.* 45–54. Regression analysis is one of the most commonly used statistical methods. But in its basic form, ordinary least squares (OLS) is not suitable for actuarial applications because the relationships are often nonlinear and the probability distribution of the dependent variable may be non-normal. One approach that has been successful in overcoming these challenges is the generalized linear model (GLM), which requires that the dependent variable have a distribution from the exponential family. In this paper, we present copula regression as an alternative to OLS and GLM. The major advantage of a copula regression is that there are no restrictions on the probability distributions that can be used. In this paper, we will present the formulas and algorithms necessary for conducting a copula regression analysis using the normal copula. However, the ideas presented here can be used with any copula function that can incorporate multiple variables with varying degrees of association.

ZIMBIDIS, A. A. *Pricing in a competitive insurance market driven by fractional noise.* 55–67. Motivated by the empirical evidence of the long-range dependency found within the Greek motor insurance market, we formulate a particular stochastic pricing model in a continuous framework. We assume the structure of a competitive insurance market where the business volume of each company is directly related to the existing relativity between the company's premium and the market's average premium. Using a simple demand function and modeling the movements of the market via a fractional Brownian motion, we derive the optimal premium control strategy. Finally, we support the importance of the specific approach by a short application. It is shown that the optimal premium strategy is considerably different under the absence or existence of the long-range dependency.

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