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ASTIN Bulletin

Volume **35** (2), 2005

Bäuerle, N. & Grübel, R. *Multivariate counting processes: copulas and beyond.* 379-408. Multivariate stochastic processes with Poisson marginals are of interest in insurance and finance; they can be used to model the joint behaviour of several claim arrival processes, for example. We discuss various methods for the construction of such models, with particular emphasis on the use of copulas. An important class of multivariate counting processes with Poisson marginals arises if the events of a background Poisson process with constant intensity are moved forward in time by a random amount and possibly deleted; here we think of the events of the background process as triggering later claims in different categories. We discuss structural aspects of these models, their dependence properties together with stochastic order aspects, and also some related computational issues. Various actuarial applications are indicated.

Centeno, M. de L. & Andrade E Silva, J. M. *Applying the proportional hazard premium calculation principle.* 409-425. In this paper, we discuss the application of the proportional hazard premium calculation principle.

In Section 2 we propose a method to calculate the proportional hazard premium of a compound risk when severity distribution is subexponential.

In Section 3 we use the empirical distribution to calculate the premium when the proportional hazard principle is applied, which leads to a systematic under-estimation of the premium. After studying the bias of the premium calculated using this non-parametric approach we take advantage of the bootstrap technique with subsampling to reduce it.

Emms, P. & Haberman, S. *Pricing general insurance using optimal control theory.* 427-453. Insurance premiums are calculated using optimal control theory by maximising the terminal wealth of an insurer under a demand law. If the insurer sets a low premium to generate exposure then profits are reduced, whereas a high premium leads to reduced demand. A continuous stochastic model is developed, which generalises the deterministic discrete model of Taylor (1986). An attractive simplification of this model is that existing policyholders should pay the premium rate currently set by the insurer. It is shown that this assumption leads to a bang-bang optimal premium strategy, which cannot be optimal for the insurer in realistic applications.

The model is then modified by introducing an accrued premium rate representing the accumulated premium rates received from existing and new customers. Policyholders pay the premium rate in force at the start of their contract and pay this rate for the duration of the policy. It is shown that, for two demand functions, an optimal premium strategy is well-defined and smooth for certain parameter choices. It is shown for a linear demand function that these strategies yield the optimal dynamic premium if the market average premium is lognormally distributed.

Golubin, A. Y. *Pareto-optimal contracts in an insurance market.* 363-378. In distinction to the Borch's model of a reinsurance market, this paper treats the problem of optimal risk exchange

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in an insurance market where treaties are allowed between the insurer and each insured only, not among insureds themselves. A characterization of the Pareto-optimal contract is found. It is shown that the indemnity function in the contract is of a coinsurance kind. We also present a way of finding Pareto-optimal contracts under individual rationality constraints. The obtained results are compared with those of the known model of risk exchange in a reinsurance market.

HELMS, F., CZADO, C. & GSCHLÖßL, S. *Calculation of LTC premiums based on direct estimates of transition probabilities.* 455-469. In this paper we model the life-history of LTC-patients using a Markovian multi-state model in order to calculate premiums for a given LTC-plan. Instead of estimating the transition intensities in this model we use the approach suggested by Andersen et al. (2003) for a direct estimation of the transition probabilities. Based on the Aalen-Johansen estimator, an almost unbiased estimator for the transition matrix of a Markovian multi-state model, we calculate so-called pseudo-values, known from Jackknife methods. Further, we assume that the relationship between these pseudo-values and the covariates of our data are given by a GLM with the logit as link-function. Since the GLMs do not allow for correlation between successive observations we use instead the "Generalized Estimating Equations" (GEEs) to estimate the parameters of our regression model. The approach is illustrated using a representative sample from a German LTC portfolio.

KALUSZKA, M. *Truncated stop loss as optimal reinsurance agreement in one-period models.* 337-349. We consider several one-period reinsurance models and derive a rule which minimizes the ruin probability of the cedent for a fixed reinsurance risk premium. The premium is calculated according to the economic principle, generalized zero-utility principle, Esscher principle or mean-variance principles. It turns out that a truncated stop loss is an optimal treaty in the class of all reinsurance contracts. The result is also valid for models not involving ruin probability. An example is the Arrow model with the Kahneman-Tversky value function.

MANGO, D. F. *Insurance capital as a shared asset.* 471-486. Merton and Perold (1993) offered a framework for determining risk capital in a financial firm based on the cost of the implicit guarantee the firm provides to its subsidiaries to make up any operating shortfall. Merton and Perold assume the price of such guarantees is observable from the market at large. For an insurer, this may not be a realistic assumption. This paper proposes an insurance-specific framework for determining the cost of those parental guarantees, and utilizing that cost in pricing and portfolio mix evaluation. An insurer's capital is treated as a shared asset, with the insurance contracts in the portfolio having simultaneous rights to access potentially all that share capital. By granting underwriting capacity, an insurer's management team is implicitly issuing a set of options to draw upon the common capital pool — similar in structure to letters of credit (LOC), except they are not loans but grants. The paper will (i) discuss the valuation of parental guarantees, beginning with Merton and Perold; (ii) treat insurer capital as a shared asset and explore the dual nature of insurer capital usage cost; (iii) offer a method for determining insurer capital usage cost; and (iv) demonstrate how this method could be used for product pricing and portfolio mix evaluation using economic value added concepts.

NG, A. C. Y. & YANG, H. *Lundberg-type bounds for the joint distribution of surplus immediately before and at ruin under a Markov-modulated risk model.* 351-361. In this paper, we consider a Markov-modulated risk model (also called Markovian regime switching insurance risk model). Following Asmussen (2000, 2003), by using the theory of Markov additive process, an exponential martingale is constructed and Lundberg-type upper bounds for the joint distribution of surplus immediately before and at ruin are obtained. As a natural corollary, bounds for the distribution of the deficit at ruin are obtained. We also present some numerical results to illustrate the tightness of the bound obtained in this paper.

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Geneva Risk and Insurance Review

Volume **31**(1), 2006

Breuer, M. *Optimal insurance contracts without the non-negativity constraint on indemnities: revisited.* 5-9. In the literature on optimal indemnity schedules, indemnities are usually restricted to be non-negative. Keeler [1974] and Gollier [1987] show that this constraint might well bind: insured could get higher expected utility if insurance contracts would allow payments from the insured to the insurer at some losses. This paper extends Collier's findings by allowing for negative indemnity payments for a broader class of insurers' cost functions and argues that the indemnity schedule derived here is more appropriate for practical applications (e.g. in health insurance).

Decamps, J.-P. & Lovo, S. *A note on risk aversion and herd behavior in financial markets.* 35-42. We show that differences in market participants risk aversion can generate herd behavior in stock markets where assets are traded sequentially. This in turn prevents learning of market's fundamentals. These results are obtained without introducing multidimensional uncertainty or transaction cost.

Huang, R. J. & Tzeng, L. Y. *The design of an optimal insurance contract for irreplaceable commodities.* 11-21. This paper discusses optimal insurance contract for irreplaceable commodities. To describe the dual impacts on individuals when a loss occurs to the insured irreplaceable commodities, we use a state-dependent and bivariate utility function, which includes both the monetary wealth and sentimental value as two arguments. We show that over (full, partial) insurance is optimal when a decrease in sentimental value will increase (not change, decrease, respectively) the marginal utility of monetary wealth. Moreover, a non-zero deductible exists even without administration costs. Furthermore, we demonstrate that a positive fixed reimbursement is optimal if (1) the premium is actuarially fair, (2) the monetary loss is a constant, and (3) the utility function is additively separable and the marginal utility of money is higher in the loss state than in the no-loss state. We also characterize comparative statics of fixed-reimbursement insurance under an additively separable preference assumption.

Kling, A., Russ, J. & Schmeiser, H. *Analysis of embedded options in individual pension schemes in Germany.* 43-60. Newly introduced government-subsidized pension products in Germany are required to contain a promise by the seller to provide a "money-back guarantee" at the end of the term. The client is also given the right to stop paying premiums at any time (paid-up option). In this case, the amount of all premiums paid must also be guaranteed by the seller at maturity, no matter when the client stopped paying the premiums. Previous analyses of guarantees in such government-subsidized pension products have ignored this additional option. Within a generalized Black/Scholes framework, we analyze the value of the paid-up option for different products, market scenarios, and client behavior. Our results indicate that

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the paid-up option significantly increases the value of the money-back guarantee. Furthermore, we find that reducing volatility by shifting the client's assets from stocks to bonds as maturity approaches is a suitable means of reducing the risk arising from the "pure" money-back guarantee but much less effective in reducing the risk arising from the paid-up option.

Lai, L.-H. *Underwriting profit margin of P/L insurance in the fuzzy-ICAPM.* 23-34. The ICAPM is used to study the underwriting profit margin of the P/L insurance company, including the insurances of automobile damage, automobile liability and fire, in which the parameters are the symmetric or non-symmetric triangular fuzzy numbers. From the ten-year data of a company in Taiwan we determine the lower and upper limits associated with the various α-level of the fuzzy numbers. Our results show that the best-fitting parameters of the model from our data are the asymmetric triangular fuzzy numbers. The skew factors in each insurance are determined, which could be used to perform the forecasting of the underwriting profit margin. Our results show that the systematic risk in the fuzzy environment (with best-fitting value of skew factor) becomes larger than that in the crisp environment. However, the insurance underwriting leverage and insurance financial leverage in the fuzzy environment are smaller than those in the crisp environment.

Marini, F. *Optimal financial crises: a note on Allen and Gale.* 61-66. This note provides an example of an optimal banking panic. We construct a model in which a banking panic is triggered by the banker, not the depositors. When the banker receives a pessimistic information on the return on the bank's assets, he liquidates them prematurely in order to protect his capital. In the face of this liquidation, all depositors withdraw their funds prematurely. The premature liquidation of the bank's assets strengthens the bank's balance sheet. As a result, the banking panic does not cause bank failure and the government should not try to prevent the panic. Such a panic occurred in 1857 in the United States.

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Insurance: Mathematics & Economics

Volume **38**(3), 2006

Belzunce, F., Ortega, E.-M., Pellerey, F. & Ruiz, J. M. *Variability of total claim amounts under dependence between claims severity and number of events.* 460-468. Dependencies among random numbers of summands in random sums or among summands have been widely studied in recent literature, and several applications have been developed in actuarial sciences and reliability, where dependencies among risks or lifetimes are quite usual in common problems. In this note we derive stochastic comparisons for random sums when the summands and number of summands depend on a common random environment. The main results presented here describe how such dependence among the random environmental parameters influences the variability of random vectors of sums. As a corollary, we provide stochastic bounds for total claim amounts. Other applications and a discussion of a related result are included.

Brito, M. & Moreira Freitas, A. C. *Weak convergence of a bootstrap geometric-type estimator with applications to risk theory.* 571-584. Based on least square considerations, Brito and Moreira Freitas [Brito, M., Moreira Freitas, A. C., 2003. Limiting behaviour of a geometric-type estimator for tail indices. *Insurance: Math. Econ.*, **33**, 211-226] proposed a geometric-type estimator for estimating an exponential tail coefficient. We consider here

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the tail bootstrap method introduced by Bacro and Brito [Bacro, J. N., Brito, M., 1998. A tail bootstrap procedure for estimating the tail Pareto index. J. Stat. Plan. Infer. 71, 245-260] and show that this procedure works for this estimator. Moreover, we extend the application given in Brito and Moreira Freitas [Brito, M., Moreira Freitas, A. C., 2003. Limiting behaviour of a geometric-type estimator for tail indices. *Insurance: Math. Econ.*, **33**, 211-226], by showing that the results obtained may be applied to the related problem of estimating the adjustment coefficient in the Sparre Andersen model, under the standard conditions.

CHEN, Z. & KULPERGER, R. *Minimax pricing and Choquet pricing.* 518-528. The Choquet pricing and minimax pricing, which are nonlinear expectations, have been widely used in economics, finance and insurance as an alternative to traditional mathematical expectation. However, it is usually not easy to calculate these due to their nonlinearity. In this paper, we consider the calculation of a class of Choquet expectations and minimax expectations obtained from the pricing of a contingent claim with multiple prior probability measures. We show that both the Choquet pricing and minimax pricing of some European options are same, although this result is not in general true for non-European options.

DOWD, K., CAIRNS, A. J. G. & BLAKE, D. *Mortality-dependent financial risk measures.* 427-440. This paper uses a recently developed two-factor stochastic mortality model to estimate financial risk measures for four illustrative types of mortality-dependent financial position: investments in zero-coupon longevity bonds; investments in longevity bonds that pay annual survivor-dependent coupons; and two examples of an insurer's annuity book that are each hedged by a longevity bond, one based on the annuity book and hedge having the same reference cohort, and the other not. The risk measures estimated are the value-at-risk, the expected shortfall and a spectral risk measure based on an exponential risk-aversion function. Results are reported on a model calibrated on data provided by the UK Government Actuary's Department, both with and without underlying parameter uncertainty.

FROSTIG, E. & DENUIT, M. *Monotonicity results for portfolios with heterogeneous claims arrival processes.* 484-494. Loosely speaking, actuaries believe that the heterogeneity of the risks tends to increase dangerousness. This in turn leads to requiring more economic capital. This paper aims to formalize this intuitive idea. More specifically, vectors of compound sums will be considered, with different claim frequency distributions and/or different claim severity distributions. The effect of increasing the heterogeneity will be studied with the help of majorization. Various multivariate integral stochastic orderings will be used to compare situations according to their level of heterogeneity.

JAIMUNGAL, S. & WANG, T. *Catastrophe options with stochastic interest rates and compound Poisson losses.* 469-483. We analyze the pricing and hedging of catastrophe put options under stochastic interest rates with losses generated by a compound Poisson process. Asset prices are modeled through a jump-diffusion process which is correlated to the loss process. We obtain explicit closed form formulae for the price of the option, and the hedging parameters Delta, Gamma and Rho. The effects of stochastic interest rates and variance of the loss process on the option's price are illustrated through numerical experiments. Furthermore, we carry out a simulation analysis to hedge a short position in the catastrophe put option by using a Delta–Gamma–Rho neutral self-financing portfolio. We find that accounting for stochastic interest rates, through Rho hedging, can significantly reduce the expected conditional loss of the hedged portfolio.

KRVAVYCH, Y. & SHERRIS, M. *Enhancing insurer value through reinsurance optimization.* 495-517. The paper investigates the demand for reinsurance in insurer risk management. The insurer's objective is to maximize shareholder value under a solvency constraint imposed by a

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regulatory authority. In a one period model of a regulated market where the required solvency level is fixed, an insurer is assumed to maintain solvency using two control variables: reinsurance and risk capital supplied by shareholders. Two alternative regulatory constraints are considered in the paper. In the first one the required risk capital is determined at the beginning of the period independently of the reinsurance decision. In the second model insurers can reduce the required minimal level of risk capital taking into account reinsurance. The first model does not create a demand for reinsurance in a frictionless market, however, there is demand for reinsurance in this model under the presence of corporate tax and financial distress costs. An optimal tradeoff between the required minimal level of the risk capital and purchase of reinsurance occurs in the second model. The impact of taxation and financial distress costs on the demand for reinsurance is quantified and assessed using the models.

KUNKLER, M. *Modelling negatives in stochastic reserving models.* 540-555. Incremental loss data triangles regularly contain negative values, which may be due to salvage, subrogation and/or conservative case reserve estimates. Assumptions made by many stochastic claims reserving models are not always satisfied when negative values occur in incremental loss data triangles. This paper takes advantage of a mixture model [Kunkler, M., 2004. Modelling zeros in stochastic reserving models. Insurance: Mathematics and Economics 34, 23-35] to combine both a reflected and a regular generalised linear model to extend many previous stochastic claims reserving models for incremental loss data triangles that contain both positive and negative values.

LADOUCETTE, S. A. & TEUGELS, J. L. *Analysis of risk measures for reinsurance layers.* 630-639. We analyze common risk measures for reinsurance layers defined in terms of lower and upper retentions. In particular, we consider the Value-at-Risk, the variance, the coefficient of variation, the dispersion and the reduction effect. In a first part, we compute some risk measures for a general layer. In a second part, we compare several risk measures among the different layers in a reinsurance chain.

LI, S. & DICKSON, D. C. M. *The maximum surplus before ruin in an Erlang (n) risk process and related problems.* 529-539. We study the distribution of the maximum surplus before ruin in a Sparre Andersen risk process with the inter-claim times being Erlang(n) distributed. This distribution can be analyzed through the probability that the surplus process attains a given level from the initial surplus without first falling below zero. This probability, viewed as a function of the initial surplus and the given level, satisfies a homogeneous integro-differential equation with certain boundary conditions. Its solution can be expressed as a linear combination of n linearly independent particular solutions of the homogeneous integro-differential equation. Explicit results are obtained when the individual claim amounts are rationally distributed. When n=2, all the results can be expressed explicitly in terms of the non-ruin probability. We apply our results by looking at (i) the maximum severity of ruin and (ii) the distribution of the amount of dividends under a constant dividend barrier.

RENSHAW, A. E. & HABERMAN, S. *A cohort-based extension to the Lee-Carter model for mortality reduction factors.* 556-570. The Lee–Carter modelling framework is extended through the introduction of a wider class of generalised, parametric, non-linear models. This permits the modelling and extrapolation of age-specific cohort effects as well as the more familiar age-specific period effects. The choice of error distribution is generalised.

RIESNER, M. *Hedging life insurance contracts in a Lévy process financial market.* 599-608. Starting from the model of Møller [Risk-minimizing hedging strategies for unit-linked life insurance contracts. ASTIN Bulletin 28 (1998) 17-47] we derive analogously, but for an

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incomplete financial market, a (locally) risk-minimizing hedging strategy for unit-linked life insurance contracts represented by the pure endowment and the term insurance. The incomplete financial market is exemplarily given by a general Lévy-driven model. We investigate the Föllmer–Schweizer decomposition of their intrinsic value. Additionally, we compare our results to the ones obtained by Møller [Risk-minimizing hedging strategies for unit-linked life insurance contracts. ASTIN Bulletin 28 (1998) 17-47] and show how they are affected by replacing the complete financial market by an incomplete one.

VANDEWALLE, B. & BEIRLANT, J. *On univariate extreme value statistics and the estimation of reinsurance premiums.* 441-459. In this paper, we consider the estimation of insurance premiums for excess-of-loss reinsurance policies in excess of a high retention level. Special attention is paid to Wang's premium principle and heavy-tailed distributions, for which estimators of small exceedance probabilities allow the estimation of reinsurance premiums. Next to the construction of estimators, we also consider the corresponding asymptotic results and illustrate the finite sample behavior through a real insurance application as well as simulations.

VELLEKOOP, M. H., VD KAMP, A. A. & POST, B. A. *Pricing and hedging guaranteed returns on mix funds.* 585-598. In this paper we propose a valuation and hedging strategy for a guaranteed minimal rate of return on a mix fund, which participates in both bonds and stocks. For the case where a fixed amount of money is invested, we show that a European put option on the mix fund replicates the cash flows of this guarantee at all times and using the arbitrage-free pricing methodology, the market value of the guarantee can be obtained explicitly. Using historical data, we show that modeling the correlation between equity and bond returns is of fundamental importance when the stochastic nature of the term structure of interest rates is taken into account. For this model we define a hedging strategy which shows how the dependency of the option on the changing yield of the bond fund can be hedged away using mix fund contracts. We also show how Monte Carlo methods can be used to analyze the case where the guarantee is given on periodically invested fixed amounts of money instead of one single payment.

YEO, K. L. & VALDEZ, E. A. *Claim dependence with common effects in credibility models.* 609-629. Several credibility models found in published literature have largely been single dimensional in the sense that the observable claims are derived from a single individual risk or a single group of homogeneous risks over a period of time. In the case where the additional dimension of observing different individual risks or different groups of risks are allowed for, the assumption of independence across the observable claims is often made. This is a matter of convenience and mathematical tractability, though in general, everyone agrees this may seem unrealistic. As such, dependence must be taken into account when modelling risks for assessing credibility premiums. In this paper, we introduce the notion of modelling claim dependence across individuals and simultaneously across time within individuals using common effects. The resulting model is then used to predict expected claims given the history of all observable claims. It is well-known that this conditional expectation actually gives the best predictor of the next period claim for a single individual in the mean-squared error sense. We express this conditional expectation in the form of a credibility premium. We further give illustrative examples to demonstrate the ideas.

INSURANCE: MATHEMATICS & ECONOMICS

Volume **39**(1), 2006

BAKKEN, H., LINDSET, S. & OLSON, L. H. *Pricing of multi-period rate of return guarantees: the*

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Monte Carlo approach. 135-149. The uncertain yearly returns on both life and pension insurance policies are often bounded from below by a minimum guaranteed rate of return. It turns out that this yearly, or multi-period guarantee can have a very high economic value. However, because determining this value is a problem of high dimension, obtaining an estimate of it can be rather difficult and time-consuming. In this paper we present a numerical valuation method for estimating the market value of the multi-period guarantee when the uncertainty in the interest rates is modeled in a Heath, Jarrow, and Morton framework with an exponential volatility structure.

Gómez-Déniz, E., Pérez-Sánchez, J. M. & Vázquez-Polo, F. J. *On the use of posterior regret* Γ*-minimax actions to obtain credibility premiums.* 115-121. Computing premiums in a Bayesian context requires the use of a prior distribution that the unknown risk parameter follows in the heterogeneous portfolio. Following the methodology that an actuary only has vague information about this parameter and therefore is unable to specify a simple prior, we choose a class Γ of priors and compute posterior regret Γ-minimax premiums which can be written, under appropriate likelihoods and priors, as a credibility formula.

Josa-Fombellida, R. & Rincón-Zapatero, J. P. *Optimal investment decisions with a liability: the case of defined benefit pension plans.* 81-98. In this paper the optimal management of an aggregated dynamic pension fund is studied. To cover the promised liabilities to workers at the age of retirement, the plan sponsor continuously manages time-varying funds. He or she can choose the rate of contribution to the fund, the investment in a given number of risky assets, and a security with constant rate of return. The problem of maximizing the probability that the fund assets achieve some prescribed goal before some undesirable lower value, or ruin point, is first considered. Secondly, the problem of minimizing (*resp*. maximizing) the expected discounted cost of reaching a ruin point (*resp*. beating a desired objective) is solved. Finally, maximization of utility function when the fund can suddenly terminate is analyzed. The main finding is that optimal investment policies are of constant proportionality type.

Lo, C. H., Fung, W. K. & Zhu, Z. Y. *Generalized estimating equations for variance and covariance parameters in regression credibility models.* 99-113. We propose a regression credibility model that extends the one introduced by Hachemeister [Hachemeister, C. A., 1975. Credibility for regression models with application to trend. In: Kahn, P. M. (Ed.), Credibility: Theory and Applications. Academic Press, New York, pp. 129-163] by encapsulating a moving average error structure. Generalized estimating equations (GEE) are developed to estimate the unknown variance and covariance parameters. A comprehensive account is presented to demonstrate the implementation of the Bühlmann and Bühlmann–Straub frameworks under the model proposed and how GEE estimators are worked out within these two frameworks. A simulation study is conducted to compare the performance of the proposed GEE estimators with the alternative Bühlmann, Bühlmann–Straub, and Cossette and Luong's [Cossette, H., Luong, A., 2003. Generalised least squares estimators for creditability regression models with moving average errors. IME 32] GLS estimators. The GEE estimators are found to perform well, especially when the error terms are correlated.

Moore, K. S. & Young, V. R. *Optimal insurance in a continuous-time model.* 47-68. We seek the optimal dynamic consumption, investment, and insurance strategies for an individual who seeks to maximize her expected discounted utility of consumption and bequest over a fixed or random horizon, such as her random future lifetime. Thus, we incorporate an insurable loss and random horizon into the classical consumption and investment framework of Merton. We determine that if the premium is proportional to the expected payout, then the optimal per-claim insurance is deductible insurance; thus, we extend this result for static models to our dynamic setting. We compute the value function and optimal controls for many examples and contrast their qualitative properties, including the impact of the investor's horizon (or

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mortality) on the optimal controls and the interaction between the demand for insurance and the risky asset. We employ the Markov Chain approximation method of Kushner for those examples for which closed form solutions are not available.

NORBERG, R. *Dynamic greeks.* 123-133. The sensitivity of a price (or premium or reserve) to changes in its arguments is given by its derivatives, in finance known as "greeks". Differential equations for sensitivities are obtained by simply differentiating the differential equation and the side condition that uniquely determine the price function. The device opens up prospects of efficient computation of greeks for a wide range of price functions in parametric models. It is applied here to examples in the Black–Merton–Scholes model and in a Markov chain model. Mathematical issues arising are, firstly, to construct the differential equation for the primary function and, secondly, to prove that the sensitivities actually exist. General resolutions to these problems seem not to be in reach, so only some special situations are discussed here.

PHÉLIPPÉ-GUINVARC'H, M. V. & CORDIER, J. E. *A private management strategy for the crop yield insurer: a theoretical approach and tests.* 35-46. The agricultural economic literature shows the difficulties of managing insurance contracts that include systemic risk. The aim of this paper is to present an approach for overcoming such difficulties. The approach is applied to a crop yield insurance contract but can be extended to other insurance contracts such as revenue or crop margin ones. The recommended strategy pools risk as common to insurance contracts. Additionally, the strategy transfers the pooled risk to financial markets in order to manage the systemic risks component. The financial market model includes a crop yield futures contract, a price futures contract and a zero-coupon bond. This strategy allows for a risk-free intermediation in insurance contracts with a high systemic risk component.

ROSAZZA GIANIN, E. *Risk measures via* g*-expectations.* 19-34. This paper shows how *g*-expectations and conditional g-expectations provide some families of static and dynamic risk measures. Conversely, some sufficient conditions for a dynamic risk measure to be induced by a conditional *g*-expectation are provided. A financial interpretation of the functional *g* will be given.

SANGÜESA, C. *Approximations of ruin probabilities in mixed Poisson models with lattice claim amounts.* 69-80. In this work we study uniform error bounds for approximations of the ruin probability in a mixed Poisson model with lattice claim amounts. The approximations considered are constructed by rounding the record lows up, down or to the midpoint. We observe how a round-to-the-midpoint approximation produces qualitatively better results than the other two methods, as in this case we can give error bounds which are uniformly bounded in the parameters of the model. We relate this approximation problem to an appropriate representation of the ruin probability in terms of Steklov operators. In our proofs, we use general results concerning the decrease of the Levy's concentration function for sums of independent and identically distributed random variables.

TAN, J. & YANG, X. *The compound binomial model with randomized decisions on paying dividends.* 1-18. Consider a discrete time risk process based on the compound binomial model. The insurer pays a dividend of 1 with a probability q_0 when the surplus is greater than or equal to a non-negative integer x. We will derive recursion formulas and an asymptotic estimate for the ruin probability, the probability function of the surplus prior to the ruin time, and the severity of ruin, etc.

TSAI, C. C.-L. *On the stop-loss transform and order for the surplus process perturbed by diffusion.* 151-170. In this paper we extend the results obtained in [Chang, Y., Pai, J. S., 2003. IME 32] to ones based on the surplus process perturbed by diffusion. We first study the stop-loss transforms of the random variables for the maximal aggregate loss. Then we propose

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theorems for the order of stop-loss transforms of ruin probabilities for two surplus processes perturbed by diffusion associated with different claim size random variables of same mean. We also find that an exponentially distributed random variable is less, in the meaning of the first stop-loss order, than a mixture of two exponentials with the same mean. Finally, a numerical example is given to illustrate these theorems.

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JOURNAL OF RISK AND INSURANCE

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BALLOTTA, L., HABERMAN, S. & WANG, N. *Guarantees in with-profit and unitized with-profit life insurance contracts: fair valuation problem in presence of the default option.* 97-121. The purpose of the article is to apply contingent claim theory to the valuation of the type of participating life insurance policies commonly sold in the UK. The article extends the techniques developed by Haberman, Ballotta, and Wang (2003) to allow for the default option. The default option is a feature of the design of these policies, which recognizes that the insurance company's liability is limited by the market value of the reference portfolio of assets underlying the policies that have been sold. The valuation approach is based on the classical contingent claim pricing "machinery," underpinned by Monte Carlo techniques for the computation of fair values. The article addresses in particular the issue of a fair contract design for a complex type of participating policy and analyzes in detail the feasible set of policy design parameters that would lead to a fair contract and the trade-offs between these parameters.

COLE, C. R. & MCCULLOUGH, K. A. *A reexamination of the corporate demand for reinsurance.* 169-192. This study examines the effect of the state of the international reinsurance market on the demand for reinsurance by U.S. insurers using data from the years 1993 through 2000. Both the overall demand for reinsurance and the utilization of foreign reinsurance by U.S. insurers are explored. In addition to supporting the findings of prior literature related to the traditional motives for the corporate demand for insurance, evidence indicates that the state of the U.S. reinsurance industry impacts the amount of reinsurance demanded by U.S. insurers. The study also investigates reasons why U.S. insurers utilize a reinsurance program composed of both U.S. and foreign reinsurers. The results indicate that the decision to utilize some percentage of foreign reinsurance is driven primarily by the financial and operational characteristics of the ceding company such as firm size, group affiliation, and organizational form. However, no support is found for the hypothesis that possible differences between the foreign and U.S. reinsurance markets impact the decision to utilize foreign reinsurance.

DOWD, K., BLAKE, D., CAIRNS, A. J. G. & DAWSON, P. *Survivor swaps.* 1-17. A survivor swap (SS) is an agreement to exchange cash flows in the future based on the outcome of at least one survivor index. This article discusses the possible uses of SSs as instruments for managing, hedging, and trading mortality-dependent risks. SSs are especially useful for insurance companies, but also offer other interested parties low beta avenues into the acquisition of mortality risk exposure. The article also investigates vanilla SSs in some detail, and suggests how their premiums and values might be determined in an incomplete market setting.

GRÜNDL, H., POST, T. & SCHULZE, R. N. *To hedge or not to hedge: managing demographic risk*

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in life insurance companies. 19-41. Demographic risk, i.e., the risk that life tables change in a nondeterministic way, is a serious threat to the financial stability of an insurance company having underwritten life insurance and annuity business. The inverse influence of changes in mortality laws on the market value of life insurance and annuity liabilities creates natural hedging opportunities. Within a realistically calibrated shareholder value (SHV) maximization framework, we analyze the implications of demographic risk on the optimal risk management mix (equity capital, asset allocation, and product policy) for a limited liability insurance company operating in a market with insolvency-averse insurance buyers. Our results show that the utilization of natural hedging is optimal only if equity is scarce. Otherwise, hedging can even destroy SHV. A sensitivity analysis shows that a misspecification of demographic risk has severe consequences for both the insurer and the insured. This result highlights the importance of further research in the field of demographic risk.

Moreno, I., Vazquez, F. J. & Watt, R. *Can bonus-malus alleviate insurance fraud?* 123-151. Traditionally, insurance companies attempt to reduce (or even eliminate) fraud via audit strategies under which claims may be investigated at some cost to the insurer, with a penalty imposed upon insureds who are found to report claims fraudulently. However, it is also clear that, in a multiperiod setting, bonus-malus contracts (increases in subsequent premiums whenever a claim is presented) also provide an incentive against fraud. In this article, we consider a model in which, conditional upon the client renewing his contract, the only mechanism used to combat fraud is bonus-malus. In this way, our model provides the opposite pole to the pure audit model. We show that in our simplified setting there exists a bonus-malus contract that will eliminate all fraud in all periods, while guaranteeing nonnegative expected profits to the insurer and participation by the insured. We also consider the dynamics of the solution, the effect of an increase in risk aversion on the solution, and the welfare implications.

Plantin, G. *Does reinsurance need reinsurers?* 153-168. The reinsurance market is the secondary market for insurance risks. It has a very specific organization. Direct insurers rarely trade risks with each other. Rather, they cede part of their primary risks to specialized professional reinsurers who have no primary business. This article offers a model of equilibrium in reinsurance and capital markets in which professional reinsurers arise endogenously. Their role is to monitor primary insurers credibly, so that insurers can raise capital more easily. In equilibrium, the financial structure of primary insurers consists of a mix of reinsurance and outside capital. The comparative statics yield empirical predictions which are broadly in line with a number of stylized facts from the reinsurance market.

Sherris, M. L. *Solvency, capital allocation, and fair rate of return in insurance.* 71-96. In this article, we consider the links between solvency, capital allocation, and fair rate of return in insurance. A method to allocate capital in insurance to lines of business is developed based on an economic definition of solvency and the market value of the insurer balance sheet. Solvency, and its financial impact, is determined by the value of the insolvency exchange option. The allocation of capital is determined using a complete markets' arbitrage-free model and, as a result, has desirable properties, such as the allocated capital "adds up" and is consistent with the economic value of the balance sheet assets and liabilities. A single-period discrete-state model example is used to illustrate the results. The impact of adding lines of business is briefly considered.

Ulm, E. R. *The effect of the real option to transfer on the value of guaranteed minimum death benefits.* 43-69. Variable annuity contracts frequently have many options and option-like features embedded in the contracts. Some are obvious, such as guaranteed minimum death benefits (GMDBs), while others are less obviously option-like. In this article, we consider the effect of the real option to transfer funds between fixed and variable accounts. If a GMDB

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rider is considered in isolation, it is sometimes in the policyholder's interest to transfer to the fixed fund if the fixed fund earns less than the variable fund in a risk-neutral world. On the other hand, the option to transfer will not be used if the entire annuity and rider are considered together.

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BUTLER, R. J., BALDWIN, M. L. & JOHNSON, W. G. *The effects of occupational injuries after returns to work: work absences and losses of on-the-job productivity.* 309-334. We extend the research on postinjury employment by estimating productivity losses for workers with permanent partial disabilities (PPDs) in the first three years after injury. Our method distinguishes between productivity losses attributed to spells of work absence versus reduced earnings during spells of employment. The method is applied to data for 800 Ontario workers with PPDs. The results document large productivity losses persisting at least three years after injury, with different loss patterns for workers returning to stable versus unstable employment. Human capital investments or job accommodations can reduce productivity losses, but the significant determinants of losses differ for the stable versus unstable employment groups.

DOWD, K. & BLAKE, D. *After VaR: the theory, estimation, and insurance applications of quantile-based risk measures.* 193-229. We discuss a number of quantile-based risk measures (QBRMs) that have recently been developed in the financial risk and actuarial/insurance literatures. The measures considered include the Value-at-Risk (VaR), coherent risk measures, spectral risk measures, and distortion risk measures. We discuss and compare the properties of these different measures, and point out that the VaR is seriously flawed. We then discuss how QBRMs can be estimated, and discuss some of the many ways they might be applied to insurance risk problems. These applications are typically very complex, and this complexity means that the most appropriate estimation method will often be some form of stochastic simulation.

HAN, L.-M. & MACMINN, R. *Stock options and the corporate demand for insurance.* 231-260. This article shows that a corporate manager compensated in stock options makes corporate decisions to maximize stock option value. Over-investment is a consequence if risk increases with investment. Facing the choice of hedging corporate risk with forward contracts on a stock market index fund and insuring pure risks the manager will choose the latter. Hedging with forwards reduces weight in both tails of corporate payoff distribution and thus reduces option value. Insuring pure risks reduces the weight in the left tail where the options are out-of-the-money and increases the weight in the right tail where the options are in-the-money; the effect is an increase in the option value. Insurance reduces the over-investment problem but no level of insurance coverage can reduce investment to that which maximizes the shareholder value.

HAU, A. *The liquidity demand for corporate property insurance.* 261-278. This article suggests that liquidity may be an important reason for a corporation to purchase property insurance. A model of a risk-neutral producer facing an endogenously determined risk of property damage under an output contract that penalizes underproduction is formulated to exemplify such a real need of liquidity. Under the output contract, the producer may purchase full unfavorable property insurance even when postloss financing is available. Surprisingly, the conclusion may still hold when the cost of postloss financing equals that of long-term capital, provided that the rate of underproduction penalty is sufficiently high. Similar conclusions apply when

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postloss financing is replaced by planned internal reserve (self-insurance) that may be invested in the short run at an interest rate that is lower than the long-term cost of capital. When the capital market is perfect, however, the holding of planned internal reserve eliminates the purchase of actuarially unfavorable property insurance.

SAITO, K. *Testing for asymmetric information in the automobile insurance market under rate regulation.* 335-356. This article examines whether adverse selection or moral hazard could be induced by rate regulation, which prohibits insurance companies from considering some attributes of drivers in setting premiums. Using an individual data set from a heavily regulated automobile insurance market, we arrived at several conclusions, as follows. First, no evidence of adverse selection or moral hazard is found in general: conditional on all the variables observed by insurer, the null hypothesis of independence between risk and coverage is not rejected at reasonable levels of statistical significance. Second, this result is robust in the sense that it holds under several empirical procedures and different definitions of risk and coverage. Third, we find that unobserved variables do not induce adverse selection: the null hypothesis that consumers in risky regions are more likely to purchase insurance is tested against the alternative and rejected. Our study supports the view that the adverse selection phenomenon exists only to a very limited extent in this market.

SCHLESINGER, H. *Mossin's theorem for upper-limit insurance policies.* 297-301. Although Mossin's Theorem ("full insurance with a fair premium and less-than-full coverage with a proportional premium loading") is well known for the classes of coinsurance contracts and for deductible-insurance contracts, it has not been proven for the class of upper-limit insurance contracts. This article provides a proof for this case.

SEOG, S. H. *Strategic demand for insurance.* 279-295. We focus on the corporate demand for insurance under duopoly. We consider the case in which firms purchase insurance in order to enhance their competitiveness. We show that a higher level of corporate insurance makes a firm more aggressive and its competitor less aggressive in the output market (strategic effect). The optimal coverage of insurance is determined by comparing the strategic effect of insurance and the cost of insurance. The optimal coverage is positive if the strategic effect is greater than the cost of insurance. An interesting implication is that a risk-neutral firm may purchase actuarially unfair insurance. The main strategic effect of insurance comes from the fact that firms purchase insurance before they produce outputs. Insurance makes firms more aggressive due to the limited risk costs of firms.

TIBILETTI, L. *A shortcut way of pricing default risk through zero-utility principle.* 303-308. Pricing the default risk is a hot challenge for every risk manager. The problem is tackled in the framework of the zero-utility principle. According to Pratt (1964), an approximation of the risk premium should be proportional to the Arrow-Pratt absolute risk aversion coefficient and the variance. Is that still true as a default risk is concerned? The answer appears to be negative, because the variance does not look to be an appropriate tool for asymmetrical risk. On the other hand, fear of ruin coefficient and probability of default are proved to be well-tailored tools for a preliminary pricing. Bid and ask price approximations are both elicited and a necessary condition for risk exchange set out.

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Albrecher, H. & Asmussen, S. *Ruin probabilities and aggregate claims distributions for shot noise Cox processes.* 86-110. We consider a risk process *Rt* where the claim arrival process is a superposition of a homogeneous Poisson process and a Cox process with a Poisson shot noise intensity process, capturing the effect of sudden increases of the claim intensity due to external events. The distribution of the aggregate claim size is investigated under these assumptions. For both light-tailed and heavy-tailed claim size distributions, asymptotic estimates for infinite-time and finite-time ruin probabilities are derived. Moreover, we discuss an extension of the model to an adaptive premium rule that is dynamically adjusted according to past claims experience.

Li, S. *The distribution of the dividend payments in the compound Poisson risk model perturbed by diffusion.* 73-85. We consider a diffusion perturbed classical compound Poisson risk model in the presence of a constant dividend barrier. An integro-differential equation with certain boundary conditions for the n-th moment of the discounted dividend payments prior to ruin is derived and solved. Its solution can be expressed in terms of the expected discounted penalty (Gerber-Shiu) functions due to oscillation in the corresponding perturbed risk model without a barrier. When the discount factor δ is zero, we show that all the results can be expressed in terms of the non-ruin probability in the perturbed risk model without a barrier.

Yin, G., Liu, Y. J. & Yang, H. *Bounds of ruin probability for regime-switching models using time scale separation.* 111-127. This paper is concerned with regime-switching insurance risk models. The regime-switching is modeled by a continuous-time Markov chain. Owing to various modeling considerations, the state space is likely to be very large. A two-time-scale formulation is used to reduce the complexity. Under simple conditions, limits of ultimate survival probabilities and ultimate ruin probabilities are obtained. These results reveal that, for example, as a decision maker, one may ignore the detailed variations, and use the limit ultimate ruin probabilities to approximate that of the actual ones. Moreover, the differences of the original and limit ruin probabilities are examined. Error bounds are developed.

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Nadarajah, S. & Kotz, S. *Compound mixed Poisson distributions I.* 141-162. The concept of compound mixed Poisson distributions in actuarial science is used to represent such variables as the total amount of claims or losses payable by an insurer. In this paper, comprehensive collections of approximate forms are derived for the compound mixed Poisson distribution. The calculations involve use of several special functions and their properties. We believe that the results will serve as an important reference in actuarial science.

Nadarajah, S. & Kotz, S. *Compound mixed Poisson distributions II.* 163-181. The concept of compound mixed Poisson distributions in actuarial science is used to represent such variables as the total amount of claims or losses payable by an insurer. This paper provides the second part of the list of approximate forms for the compound mixed Poisson distribution (following up from Nadarajah and Kotz (2006)). The calculations involve use of several special functions and their properties. We believe that the results will serve as an important reference in actuarial science.

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YUEN, K. C. & GUO, J. *Some results on the compound Markov binomial model.* 129-140. This paper considers the compound Markov binomial risk model proposed by Cossette et al. (2003,2004). Two discrete-time renewal (ordinary renewal and delayed renewal) risk processes associated with the compound Markov binomial risk model are analyzed. Based on the associated ordinary renewal process, a defective renewal equation for the conditional Gerber–Shiu expected discounted penalty function is obtained. The relationship between the conditional expected discounted penalty function in the ordinary renewal case and that in the delayed renewal case is then established. From these results, the conditional ultimate probability of ruin as well as the conditional joint distribution of the surplus just prior to ruin and the deficit at ruin are studied. Finally, it is shown that a modified version of the compound Markov binomial risk model is a special case of the discrete-time semi-Markov risk model introduced by Reinhard and Snoussi (2001, 2002).

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