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ASTIN Bulletin

Volume **33** (2), 2003

Aase, K. K. & Persson, S.-A. *New econ for life actuaries.* 117-122. In an editorial in ASTIN Bulletin, Hans Bühlmann (2002) suggests it is time to change the teaching of the life insurance theory towards the real life challenges of that industry. The following note is a response to this editorial. In Bergen we have partially taught the NUMAT, or the NUMeraire based Actuarial Teaching since the beginning of the 90s at the Norwegian School of Economics and Business Administration (NHH). In this short note we point out that there may be some practical problems when these principles are to be implemented.

Albrecht, T. *Interest rate changes and the value of a non-life insurance company.* 347-364. How does a change in the risk-free interest-rate affect the value of a non-life insurance company or portfolio? Risk managers typically argue that there should be little impact as long as assets and liabilities are properly matched. However, the risk-management perspective focuses on existing assets and liabilities, while neglecting the value of future business potential. This paper argues that interest rate changes can have a significant impact on the appraisal value of a non-life insurance company, even if assets and liabilities are matched. This impact can be positive as well as negative, depending on the underlying parameters. Relevant parameters include reserving intensity, combined ratio, business growth rate, asset allocation, risk-capital relative to premium income and the correlation between interest-rate and technical insurance results.

Boyle, P. P. & Hardy, M. R. *Guaranteed annuity options.* 125-152. Under a guaranteed annuity option, an insurer guarantees to convert a policyholder's accumulated funds to a life annuity at a fixed rate when the policy matures. If the annuity rates provided under the guarantee are more beneficial to the policyholder than the prevailing rates in the market the insurer has to make up the difference. Such guarantees are common in many US tax sheltered insurance products. These guarantees were popular in UK retirement savings contracts issued in the 1970s and 1980s when long-term interest rates were high. At that time, the options were very far out of the money and insurance companies had apparently assumed that the interest rates would remain high and thus that the guarantees would never become active. In the 1990s, as long term interest rates began to fall, the value of these guarantees rose. Because of the way the guarantee was written, two other factors influenced the cost of these guarantees. First, strong stock market performance meant that the amounts to which the guarantee applied increased significantly. Second, the mortality assumption implicit in the guarantee did not anticipate the improvement in mortality which actually occurred.
The emerging liabilities under these guarantees threatened the solvency of some companies and led to the closure of Equitable Life (UK) to new business. In this paper we explore the pricing and risk management of these guarantees.

Brazauskas, V. & Serfling, R. *Favorable estimators for fitting Pareto models: a study using goodness-of-fit measures with actual data.* 365-381. Several recent papers treated robust and efficient estimation of tail index parameters for (equivalent) Pareto and truncated exponential

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models, for large and small samples. New robust estimators of 'generalized median' (GM) and 'trimmed mean' (T) type were introduced and shown to provide more favorable trade-offs between efficiency and robustness than several well-established estimators, including those corresponding to methods of maximum likelihood, quantiles, percentile matching. Here we investigate performance of the above mentioned estimators on real data and establish - via the use of goodness-of-fit measures - that favorable theoretical properties of the GM and T type estimators translate into excellent practical performance. Further, we arrive at guidelines for Pareto model diagnostics, testing, and selection of particular robust estimators in practice. Model fits provided by the estimators are ranked and compared on the basis of the Kolmogorov-Smirnov, Cramér-von Mises, and Anderson-Darling statistics.

Bühlmann, H. & Platen, E. *A discrete time benchmark approach for insurance and finance.* 153-172. This paper proposes a consistent approach to discrete time valuation in insurance and finance. This approach uses the growth optimal portfolio as reference unit or benchmark. When used as benchmark, it is shown that all benchmarked price processes are supermartingales. Benchmarked fair price processes are characterized by martingales. No measure transformation is needed for the fair pricing of insurance policies and derivatives. The standard actuarial pricing rule is obtained as a particular case of fair pricing when the contingent claim is independent from the growth optimal portfolio.

De Jong, G. F. & Wielhouwer, J. L. *The valuation and hedging of variable rate savings accounts.* 383-397. Variable rate savings accounts have two main features. The interest rate paid on the account is variable and deposits can be invested and withdrawn at any time. However, customer behaviour is not fully rational and withdrawals of balances are often performed with a delay. This paper focuses on measuring the interest rate risk of variable rate savings accounts on a value basis (duration) and analyses the problem how to hedge these accounts. In order to model the embedded options and the customer behaviour we implement a partial adjustment specification. The interest rate policy of the bank is described in an error-correction model.

Goovaerts, M. J., Kaas, R., Dhaene, J. & Tang, Q. *A unified approach to generate risk measures.* 173-191. The paper derives many existing risk measures and premium principles by minimizing a Markov bound for the tail probability. Our approach involves two exogenous functions $v(S)$ and $\phi(S, \pi)$ and another exogenous parameter $\alpha \leq 1$. Minimizing a general Markov bound leads to the following unifying equation:

$$\mathrm{E}[\phi(S, \pi)] = \alpha \mathrm{E}[v(S)].$$

For any random variable, the risk measure π is the solution to the unifying equation. By varying the functions ϕ and v, the paper derives the mean value principle, the zero-utility premium principle, the Swiss premium principle, Tail VaR, Yaari's dual theory of risk, mixture of Esscher principles and more. The paper also discusses combining two risks with super-additive properties and sub-additive properties. In addition, we recall some of the important characterization theorems of these risk measures.

Hipp, C. & Vogt, M. *Optimal dynamic XL reinsurance.* 193-207. We consider a risk process modelled as a compound Poisson process. We find the optimal dynamic unlimited excess of loss reinsurance strategy to minimize infinite time ruin probability and prove the existence of a smooth solution of the corresponding Hamilton-Jacobi-Bellman equation as well as a verification theorem. Numerical examples with exponential, shifted exponential, and Pareto claims are given.

Lindskog, F. & McNeil, A. J. *Common Poisson shock models: applications to insurance and*

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credit risk modelling. 209-238. The idea of using common Poisson shock processes to model dependent event frequencies is well known in the reliability literature. In this paper we examine these models in the context of insurance loss modelling and credit risk modelling. To do this we set up a very common shock framework for losses of a number of different types that allows for both dependence in loss frequencies across types and dependence in loss severities. Our aims are three-fold: to demonstrate that the common shock model is a very natural way approaching the modelling of dependent losses in an insurance or risk management context; to provide a summary of some analytical results concerning the nature of the dependence implied by the common shock specification; to examine the aggregate loss distribution that results from the model and its sensitivity to the specification of the model parameters.

MATA, A. J. *Asymptotic dependence of reinsurance aggregate claim amounts.* 239-263. In this paper we study the asymptotic behaviour of the joint distribution of reinsurance aggregate claim amounts for large values of the retention level under various dependence assumptions. We prove that, under dependence assumptions, for large values of the retention level the ratio between the joint distribution of the aggregate losses and the product of the marginal distributions converges to a constant value that only depends on the frequency parameters.

NIELSEN, J. P. & SPERLICH, S. *Prediction of stock returns: a new way to look at it.* 399-417. While the traditional R^2 value is useful to evaluate the quality of a fit, it does not work when it comes to evaluating the predictive power of estimated financial models in finite samples. In this paper we introduce a validated R_V^2 value useful for prediction. Based on data from the Danish stock market, using this measure we find that the dividend-price ratio has predictive power. The best horizon for prediction seems to be four years. On a one year horizon, we find that while inflation and interest rate do not add to the predictive power of the dividend-price ratio then last year's excess stock return does.

NORBERG, R. *The Markov chain market.* 265-287. We consider a financial market driven by a continuous time homogeneous Markov chain. Conditions for the absence of arbitrage and for completeness are spelled out, non-arbitrage pricing of derivatives is discussed, and details are worked out for some cases. Closed form expressions are obtained for interest rate derivatives. Computations typically amount to solving a set of first order partial differential equations. An excursion into risk minimization in the incomplete case illustrates the matrix techniques that are instrumental in the model.

OWADALLY, M. I. *Pension funding and the actuarial assumption concerning investment returns.* 289-312. An assumption concerning the long-term rate of return on assets is made by actuaries when they value defined-benefit pension plans. There is a distinction between this assumption and the discount rate used to value the pension liabilities, as the value placed on liabilities does not depend on asset allocation in the pension fund. The more conservative the investment return assumption is, the larger planned initial contributions are, and the faster benefits are funded. A conservative investment return assumption, however, also leads to long-term surpluses in the plan, as is shown for two practical actuarial funding methods. Long-term deficits result from an optimistic assumption. Neither outcome is desirable as, in the long term, pension plan assets should be accumulated to meet the pension liabilities valued at a suitable discount rate. A third method is devised that avoids such persistent surpluses and deficits regardless of conservatism or optimism in the assumed investment return.

PITREBOIS, S., DENUIT, M. & WALHIN, J. F. *Setting a bonus-malus scale in the presence of other rating factors: Taylor's work revisited.* 419-436. In this paper we propose an analytic analogue to the simulation procedure described in Taylor (1997). We apply the formulas to a Belgian data set and discuss the interaction between a priori and a posteriori ratemakings.

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TAYLOR, G. C. *Chain ladder bias.* 313-330. The chain ladder forecast of outstanding losses is well known to be unbiased under suitable assumptions. According to these assumptions, claim payments in any cell of a payment triangle are dependent on those from preceding development years of the same accident year. If all cells are assumed stochastically independent, the forecast is no longer unbiased. Section 5 shows that, under rather general assumptions, it is biased upward. This result is linked to earlier work on some stochastic versions of the chain ladder.

WUTHRICH, M. V. *Claims reserving using Tweedie's compound Poisson model.* 331-346. We consider the problem of claims reserving and estimating run-off triangles. We generalize the gamma cell distributions model which leads to Tweedie's compound Poisson model. Choosing a suitable parametrization, we estimate the parameters of our model within the framework of generalized linear models (see Jørgensen-de-Souza (2), and Smyth-Jørgensen (8)). We show that these methods lead to reasonable estimates of the outstanding loss liabilities.

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AUSTRALIAN ACTUARIAL JOURNAL

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ELLIS, G. *The actuary as an expert witness: Discussion.* 291-325; discussion: 327-47. Judges and juries frequently rely on the evidence of expert witnesses. Actuaries who are requested to prepare a report and/or give evidence should be aware of what courts expect of them. This paper outlines recent developments in relation to expert evidence and provides some guidance for those involved in this field.

INSTITUTE OF ACTUARIES OF AUSTRALIA, AGEING AUSTRALIA TASKFORCE. *Submission to the Senate Select Committee on Superannuation Inquiry into Planning for Retirement.* 415-433. In May 2003, the Institute of Actuaries of Australia made a submission to the Senate Select Committee on Superannuation Inquiry into Planning for Retirement which covers the continuing relevance of the concept of a fixed retirement age and work to retirement transition issues.

INSTITUTE OF ACTUARIES OF AUSTRALIA, ENERGY AND ENVIRONMENT COMMITTEE. *Submission on greenhouse gas issues within Australia's electricity industry.* 351-408. In March 2003, the Institute of Actuaries of Australia made a submission to the Commonwealth Department of Prime Minister and Cabinet comprising a letter responding to the recommendations of COAG's energy market review (December 2002) and a discussion paper by R. Cumpston and A. Burge.

INSTITUTE OF ACTUARIES OF AUSTRALIA, HEALTH PRACTICE COMMITTEE. *Submission to the Senate Community Affairs Legislation Committee regarding the Health Legislation Amendment (Private Health Insurance Reform) Bill 2003.* 409-413.

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INSTITUTE OF ACTUARIES OF AUSTRALIA, SUPERANNUATION AND EMPLOYEE BENEFITS PRACTICE COMMITTEE. *Submission on tax limits on employer contributions to defined benefit superannuation funds.* 435-443. In May 2003, the Institute of Actuaries of Australia wrote to Senator Helen Coonan, Assistant Treasurer and Minister for Revenue for the Commonwealth Government, to bring to the Government's attention the implications of the current limits on tax deductibility of contributions to defined benefit superannuation funds for employers.

SATO, M., DICKSON, D. C. M. & FITZHERBERT, R. M. *Initial capital and margins required to secure a Japanese life insurance policy portfolio under variable interest rates.* 251-89. Keywords: interest rate risk, Japanese life insurance, HJM modelling, yield curve, zero interest rates, ruin probability.

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INSURANCE: MATHEMATICS & ECONOMICS

Volume **33** (3), 2003

CARDOSO, R. M. R. & WATERS, H. R. *Recursive calculation of finite time ruin probabilities under interest force.* 659-676. In this paper, we consider a classical insurance surplus process affected by a constant interest force. We present numerical algorithms for the calculation of finite time ruin probabilities using a discrete time Markov chain to approximate the risk process. Based on this method, upper and lower bounds are also obtained.

DAHAN, M., FROSTIG, E. & LANGBERG, N. A. *Analysis of heterogeneous endowment policies portfolios under fractional approximations.* 567-584. In this paper we consider heterogeneous portfolios of endowment insurance policies with a 12 months maturation time. We apply majorization order, Schur functions, and fractional approximations to study the effects of statistical heterogeneity on the premium, on the death benefit and on the survival benefit of the endowment contract. We obtain upper and lower bounds for the premium and the benefits, and under the power approximation we derive some monotone properties of the premium and the benefits.

DE KOK, T. G. *Ruin probabilities with compounding assets for discrete time finite horizon problems, independent period claim sizes and general premium structure.* 645-658. In this paper, we present fast and accurate approximations for the probability of ruin over a finite number of periods, assuming inhomogeneous independent claim size distributions and arbitrary premium income in subsequent periods. We develop exact recursive expressions for the non-ruin probabilities in subsequent periods. These recursive expressions provide the basis for a computationally efficient recursive approximation scheme based on two-moment gamma distribution fits. An extensive simulation experiment showed the accuracy of the approximations for values of the horizon up to 20. Having shown the validity of the approximations, we applied them to gain insight into two non-stationary investment problems.

DEBICKA, J. *Moments of the cash value of future payment streams arising from life insurance contracts.* 533-550. A model for the cash value of a stream of future payments arising from an insurance contract, where the interest rate and future-lifetime are random, is studied. A matrix form for formulas for the first two moments of the cash value of the stream of future payments for a portfolio of policies is derived. Numerical illustrations for the rate of interest modeled by a Wiener and an Ornstein–Uhlenbeck process are provided.

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GRASSELLI, M. *A stability result for the HARA class with stochastic interest rates.* 611-627. We study an investment problem where the interest rates follow the Cox–Ingersoll–Ross dynamics. The optimal investment strategy is obtained in explicit form under the hypotheses that financial markets are complete and that the utility functions belong to the HARA, exponential and logarithmic classes. We show that the solution for the HARA utility is stable when the parameters vary in a suitable way: more precisely, we find that the optimal investment strategy corresponding to the HARA function converges almost surely to the one corresponding to the exponential and logarithmic utility functions.

HUANG, X., SONG, L. & LIANG, Y. *Semiparametric credibility ratemaking using a piecewise linear prior.* 585-593. A practical estimate on the credibility formula is presented, where a piecewise linear function is taken as the approximation of the prior distribution and applied to the credibility theory. The convergence of the approximation is analyzed. Simulation results for the lognormal–lognormal mixture show the effectiveness of the proposed estimate on the credibility.

LEE, H. *Pricing equity-indexed annuities with path-dependent options.* 677-690. Equity-linked products such as equity-indexed annuities (EIAs) provide their customers with the greater of either the return linked to the underlying index or the minimum guaranteed return. The current volatile equity market increases the costs of options embedded in these products, and decreases the participation rates. This paper proposes four types of EIAs embedded with path-dependent options in order to increase participation rates. It also derives the joint distribution function of terminal time value and running maximum of Brownian motion. With the method of Esscher transforms, explicit pricing formulas for these proposed products and a floating-strike lookback option are derived.

LIN, X. S., WILLMOT, G. E. & DREKIC, S. *The classical risk model with a constant dividend barrier: analysis of the Gerber–Shiu discounted penalty function.* 551-566. The classical compound Poisson risk model is considered in the presence of a constant dividend barrier. An integro-differential equation for the Gerber–Shiu discounted penalty function is derived and solved. The solution is a linear combination of the Gerber–Shiu function with no barrier and the solution of the associated homogeneous integro-differential equation. This latter function is proportional to the product of an exponential function and a compound geometric distribution function. The results are then used to find the Laplace transform of the time to ruin, the distribution of the surplus before ruin, and moments of the deficit at ruin. The special cases where the claim size distribution is exponential and a mixture of two exponentials are considered in some detail. The integro-differential equation is then extended to the stationary renewal risk model.

LINDSET, S. *Pricing of multi-period rate of return guarantees.* 629-644. The basis for this paper is the pricing of multi-period rate of return guarantees. These guarantees can typically be found in life insurance and pension contracts. We derive closed form solutions, expressed by the cumulative multivariate normal probability distribution, for multi-period rate of return guarantees on both a money market account and a stock. The guarantees of Hipp (1996), Persson and Aase (1997), and Miltersen and Persson (1999) are special cases of our results.

MOORE, K. S. & YOUNG, V. R. *Pricing equity-linked pure endowments via the principle of equivalent utility.* 497-516. We consider a pure endowment contract whose life contingent payout is linked to the performance of a risky stock or index. Because of the additional mortality risk, the market is incomplete; thus, a fundamental assumption of the Black–Scholes theory is violated. We price this contract via the principle of equivalent utility and demonstrate that, under the assumption of exponential utility, the indifference price solves a nonlinear Black–Scholes equation; the nonlinear term reflects the mortality risk and exponential

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risk preferences in our model. We discuss qualitative and quantitative properties of the premium, including analytical upper and lower bounds.

SUNDT, B. *Some recursions for moments of compound distributions.* 487-496. In the present paper, we deduce some recursions for compound distributions. To introduce our technique of deduction, we start with a recursion developed by De Pril (1986) for univariate distributions when the counting distribution belongs to the Panjer class. We then extend this recursion to some wider classes of counting distributions. Finally, we extend the recursions to the case with multivariate severity distribution.

SUNDT, B. *Some recursions for moments of n-fold convolutions.* 479-486. In the present paper, we deduce some recursions for *n*-fold convolutions both in the univariate and the multivariate case. Some special cases are commented upon, and we discuss rescaling and use that in connection with characterisation of the normal and multinormal distributions.

TANSKANEN, A. J. & LUKKARINEN, J. *Fair valuation of path-dependent participating life insurance contracts.* 595-609. Fair valuation of insurance contracts, and of options embedded in them, is an important, incompletely understood issue. With the coming IAS insurance contract standard, the valuation of liabilities in life insurance is due to a drastic change. We present a computationally tractable model for fair valuation of participating life insurance contracts with given, almost arbitrary bonus policies. Unlike traditional valuation methods, our model captures several essential features of participating life insurance contracts, such as fair values of interest rate guarantees and of various bonus policies. In the model, fair value of life insurance contracts is understood as the arbitrage free price in the presence of liquid markets for liabilities. In addition to numerical results, the model gives solutions in closed form.

VALDEZ, E. A. & CHERNIH, A. *Wang's capital allocation formula for elliptically contoured distributions.* 517-532. There is a growing interest among insurance companies to be able not only to compute total company capital requirements but also to allocate this total capital across its various business units. Wang [2002] recently recommended allocating the total cost of capital of an insurance company based on the idea of 'exponential tilting'. Under the assumption that the risks or losses follow a multivariate normal distribution, the resulting allocation formula will be a function of the variance–covariance structure. We extend Wang's idea into a larger class of multivariate risks called 'elliptically contoured' multivariate distributions, of which the multivariate normal is a special case. In addition, this paper develops three criteria of what constitutes a 'fair allocation' between lines of business of an insurance company: no undercut, symmetry, and consistency. We prove that the covariance-based allocation principle satisfies the requirements of a fair allocation. Because the resulting allocation reduces to the covariance-based principle, it follows that Wang's allocation formula is also considered fair.

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INSURANCE: MATHEMATICS & ECONOMICS

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BATTOCCHIO, P. & MENONCIN, F. *Optimal pension management in a stochastic framework.* 79-95. We consider a stochastic model for a defined-contribution pension fund in continuous time. In particular, we focus on the portfolio problem of a fund manager who wants to maximize the expected utility of his terminal wealth in a complete financial market with stochastic interest

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rate. The fund manager must cope with two background risks: the salary risk and the inflation risk. We find a closed form solution for the asset allocation problem and so we are able to analyze in detail the behavior of the optimal portfolio with respect to salary and inflation. Finally, a numerical simulation is presented..

DEELSTRA, G., LIINEV, J. & VANMAELE, M. *Pricing of arithmetic basket options by conditioning.* 55-77. Determining the price of a basket option is not a trivial task, because there is no explicit analytical expression available for the distribution of the weighted sum of prices of the assets in the basket. However, by using a conditioning variable, this price can be decomposed in two parts, one of which can be computed exactly. For the remaining part we first derive a lower and an upper bound based on comonotonicity, and another upper bound equal to that lower bound plus an error term.
Secondly, we derive an approximation by applying some moment matching method.

DICKSON, D. C. M. & DREKIC, S. *The joint distribution of the surplus prior to ruin and the deficit at ruin in some Sparre Andersen models.* 97-107. For the Sparre Andersen risk model, we derive a general expression for $h(u, x, y)$, the joint density function of the surplus prior to ruin and the deficit at ruin when the initial surplus is u. This density function is expressed in terms of the corresponding density function when the initial surplus is 0. We apply a known result for $h(0, x, y)$ in the situation when inter-claim times follow a generalised Erlang distribution to derive expressions for $h(u, x, y)$ when individual claims have a phase-type(m) distribution, $m \in Z^+$. We also consider the case when inter-claim times follow a phase-type(2) distribution and derive an expression for $h(0, x, y)$.

DREKIC, S., STAFFORD, J. E. & WILLMOT, G. E. *Symbolic calculation of the moments of the time of ruin.* 109-120. Lin and Willmot [IME 27] derived a set of defective renewal difference equations involving the moments of the time of ruin in the classical insurance risk model. In principal, this allows for evaluation of these moments. Even with their result, however, it becomes apparent that obtaining even the first two moments is complicated due to the recursive nature of the relation and sheer volume of algebra. To combat these difficulties and obtain higher order moments, we explore the use of symbolic computation as a tool to automate the algebraic detail. In particular, we present a *Mathematica* program that algebraically calculates the moments of the time of ruin.

KUNKLER, M. *Modelling zeros in stochastic reserving models.* 23-35. This paper presents a mixture model to extend stochastic reserving models for incremental loss data triangles, which should be noted to include zero. Stochastic reserving models are usually applied to incremental loss data triangles. Most models, due to their underlying assumptions, place restrictions on the number of incremental claims that can be zero and/or negative. These assumptions, in practice, might not be satisfied. From the nature of the claims reserving problem, it is expected that a higher proportion of zeros would be observed in the later stages of the incremental loss data triangle. In reinsurance, zero claims are also frequently observed in incremental loss data triangles for excess layers.

PITSELIS, G. *A seemingly unrelated regression model in a credibility framework.* 37-54. There are various formulations for the randomly varying behavior of regression coefficients, which can be applied to credibility estimation. In this paper two different credibility estimation models are proposed, the credibility model of seemingly unrelated regressions (SUR) with fixed coefficients and of SUR model with random coefficients. For each model, unbiased credibility estimators are established, asymptotic optimality is proved and an application to real data is presented.

STEPHENS, D. A., CROWDER, M. J. & DELLAPORTAS, P. *Quantification of automobile insurance*

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liability: a Bayesian failure time approach. 1-21. We propose a new modelling approach to the prediction of outstanding claims of an insurance company. For given claim amounts and counts that have occurred in previous years, we use a three-stage hierarchical model in which the number of claims made per year, the settlement process in each year and the claim settlement amounts are modelled in turn. We provide implementation details and illustrations with real automobile insurance data.

Sun, L. & Yang, H. *On the joint distributions of surplus immediately before ruin and the deficit at ruin for Erlang(2) risk processes.* 121-125. In this note, we present some results for the joint distributions of the surplus immediately before and after ruin under a risk process in which the claim inter-arrival distribution is an Erlang(2) distribution.

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Journal of Risk and Insurance

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Brockett, P. L., Chang, R. E., Rousseau, J. J., Semple, J. H. & Yang, C. *A comparison of HMO efficiencies as a function of provider autonomy.* 1-19. Current debates in the insurance and public policy literatures over health care financing and cost control measures continue to focus on managed care and HMOs. The lower utilization rates found in HMOs (compared to traditional fee-for-service indemnity plans) have generally been attributed to the organization's incentive to eliminate all unnecessary medical services. As a consequence HMOs are often considered to be a more efficient arrangement for delivering health care. However, it is important to make a distinction between utilization and efficiency (the ratio of outcomes to resources). Few studies have investigated the effect that HMO arrangements would have on the actual efficiency of health care delivery. Because greater control over provider autonomy appears to be a recurrent theme in the literature on reform, it is important to investigate the effects these restrictions have already had within the HMO market. In this article, the efficiencies of two major classes of HMO arrangements are compared using 'game-theoretic' data envelopment analysis (DEA) models. While other studies confirm that absolute costs to insurance firms and sponsoring companies are lowered using HMOs, our empirical findings suggest that, within this framework, efficiency generally becomes worse when provider autonomy is restricted. This should give new fuel to the insurance companies providing fee-for-service (FFS) indemnification plans in their marketplace contentions.

Ennsfellner, K. C., Lewis, D. & Anderson, R. I. *Production efficiency in the Austrian insurance industry: a Bayesian examination.* 135-159. This paper examines the developments in the production efficiency of the Austrian insurance market for the period 1994-1999 using firm-specific data on life/health and non-life insurers obtained from the Austrian insurance regulatory authority. The article uses a Bayesian stochastic frontier to obtain aggregate and firm-specific estimates of production efficiency across insurer types and time. The study provides strong evidence that the process of deregulation had positive effects on the production efficiency of Austrian insurers. The life/health and non-life firms showed similar patterns of development in that they were less efficient during the years 1994-1996 and significantly more efficient in 1997-1999. If the Austrian experience is representative, similar benefits from deregulation may be expected for the Central and Eastern European countries that prepare for the accession to the European Union.

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KAPUR, K. *The impact of the health insurance market on small firm employment.* 63-90. Small firms that offer health insurance to their employees may face variable premiums if they hire employees with high expected health costs. To avoid expensive premium variability, small firms may attempt to maintain a workforce with low expected health costs. This results in employment distortions. I examine the magnitude of these employment distortions using the 1987 National Medical Expenditure Survey and the 1996 Medical Expenditure Panel Survey. Based on the underwriting behavior of insurance companies in 1988, I classify medical conditions into three categories: conditions that led to denial of coverage; conditions that led to exclusion restrictions; and, conditions that led to higher premiums. In 1987, I find that insured small firms were less likely to employ workers with families that had conditions that led to higher premiums than insured large firms. However, in 1996, possibly due to the passage of small group health insurance reforms that restrict insurers' ability to exclude or deny coverage, insured small firms were less likely to employ workers with denial conditions compared to insured large firms. These results suggest that the pattern of employment distortions in insured small firms is consistent with the evolving small group health insurance market.

KETSCHE, P. G. *An analysis of the effect of tax policy on health insurance purchases by risk group.* 91-113. There is an extensive body of literature dealing with the welfare loss associated with generous levels of health insurance as a function of the tax subsidy. The theoretical discussion in this study considers the effect of the tax subsidy on pooling within plans, and suggests the hypotheses that the tax subsidy will have a disproportionately positive effect on the likelihood that a high-risk worker will be eligible for and participate in employment-based coverage, while the effect of the tax subsidy on plan generosity will be greatest for low-risk employees. If coverage of high-risk individuals enhances social welfare, this result may offset, at least in part, the welfare loss associated with generous plans. Data from the 1987 National Medical Expenditure Survey are used to test these hypotheses. The results provide evidence that the subsidy works to expand risk pools in the employment-based health insurance market.

KOÇ, Ç. *The effects of uncertainty on the demand for health insurance.* 41-61. This article analyzes the effects of uncertainty and increases in risk aversion on the demand for health insurance using a theoretical model that highlights the interdependence between insurance and health care demand decisions. Two types of uncertainty faced by the individuals are examined. The first one is the uncertainty in the consumer's pretreatment health and the second is the uncertainty surrounding the productivity of health care. Comparative statics results are reported indicating the impact on the demand for insurance of shifts in the distributions of pretreatment health and productivity of health care in the form of first-order stochastic dominance, Rothschild–Stiglitz mean-preserving spreads, and second-order stochastic dominance. The demand for insurance increases in response to a Rothschild–Stiglitz increase in risk in the distribution of the pretreatment health provided that the health production function is in a special class and the price elasticity of health care is nondecreasing in the pretreatment health. Provided also that the demand for health care is own-price inelastic, the same conclusion is obtained when the uncertainty is about the productivity of health care.

NEKBY, L. *Pure versus mutual health insurance: evidence from Swedish historical data.* 115-134. Using data from voluntary Swedish health insurance societies 1902-1910, this article analyzes the coexistence of pure and mutual insurance societies where pure societies are characterized by charging ex ante premiums only while mutuals in addition charge ex post assessments. On average, mutual insurance societies are found to be larger and to offer greater insurance coverage per member. Pure insurance societies have, on average, higher insurance coverage per day, greater mean levels of moral hazard controls, a higher mean number of policy categories, and greater longevity.

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Polsky, D. & Nicholson, S. *Why are managed care plans less expensive: risk selection, utilization or reimbursement?* 21-40. This article develops a new method of decomposing the cost difference between HMO and non-HMO plans into observed risk selection, unobserved risk selection, utilization differences, and differences in provider reimbursement rates. We implement this method using a large national sample of employer-sponsored health insurance enrollees from the Community Tracking Study Household Survey. We find no evidence that HMO plans attract a disproportionate share of low-risk enrollees; the US$188 difference between HMO and non-HMO medical expenditures per enrollee can be explained by the relatively low provider reimbursement rates paid by HMO plans. This indicates there may be little need for employers to risk adjust insurance premiums or otherwise restrict employee choice of plan types.

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Kaluszka, M. *Mean-variance optimal reinsurance arrangements.* 28-41. Reinsurance reduces the risk but it also reduces the potential profit. The aim of the paper is to derive optimal, from the cedent's point of view, reinsurance arrangements balancing the risk measured by variance and expected profits under various mean-variance premium principles of the reinsurer. We find that quota share, excess of loss or combinations of excess or loss with quota share are the optimal rules according to a fixed expected gain of the cedent.

Lillo, R. E. & Semeraro, P. *Stochastic bounds for discrete-time claim processes with correlated risks.* 1-13. The purpose of this paper is to derive bounds on the marginal distributions of a discrete-time claim process $\mathbf{S}$ with correlated claims. These bounds are based on stochastic comparison in convex order and in Laplace transform order of the process $\mathbf{S}$ with two corresponding processes $\hat{\mathbf{S}}$ and $\tilde{\mathbf{S}}$ having, respectively, uncorrelated and weakly correlated claims. The relevance of these comparisons is due to the simple structure of the processes $\hat{\mathbf{S}}$ and $\tilde{\mathbf{S}}$, which are nothing else than a random walk and a mixed random walk. The paper also contains the proof of the closure under mixture property of some dependence orders, like supermodular and PQD, and some applications of the main results.

Mancini, C. *Estimation of the characteristics of the jumps of a general Poisson-diffusion model.* 42-52. We consider a filtered probability space with a standard Brownian motion W, a simple Poisson process N with constant intensity $\lambda > 0$, and we consider the process Y such that $Y_0 \in \mathbb{R}$ and

$$dY_t = a_t dt + \sigma_t dW_t + \gamma_t dN_t, \quad t > 0, \tag{1}$$

where a, σ are predictable bounded stochastic processes, and γ is a predictable process which is bounded away from zero. A discrete record of $n+1$ observations $\{Y_0, Y_{t_1}, \ldots, Y_{t_{n-1}}, Y_{t_n}\}$ is available, with $t_i = ih$. Using such observations, we construct estimators of $N_{t_i}, i = 1, \ldots, n, \lambda$ and γ_{τ_j}, where τ_j are the instants of jump within $[0, nh]$. They are consistent and asymptotically controlled when the number of observations increases and the step h tends to zero.

Rempala, G. A. & Szatzschneider, K. *Bootstrapping parametric models of mortality.* 53-78. We consider a general problem of modelling a mortality law of a population of failing units with some parametric function. In this setting we define a mortality table of crude rates as a

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statistical estimator with multinomial distribution and show its consistency as well as asymptotic normality. We further derive the statistical properties of parameter estimators in a parametric mortality model based on a weighted square loss function. We use the obtained results to study consistency and appropriateness of the parametric bootstrap method in our setting. We derive the conditions on the assumed parametric mortality law and the loss function, under which the bootstrap is consistent for estimating the model parameters, their standard errors and corresponding confidence intervals. We apply our results to a model of Aggregate US Mortality Table based on a so called mixture of extreme value distributions suggested by Carriere (1992).

ZACKS, S. & LEVIKSON, B. *Claiming strategies and premium levels for bonus malus systems.* 14-27. In this paper we study a bonus malus system (BMS) with deductibles. A bms is characterised by its premium levels and the transition rules among them. An insured is being moved among premium levels according to his/her claim record. Thus, an insured has to find an optimal strategy of submitting claims. Here optimal is in the sense of minimising the total expected present value (epf) costs. Such strategies are found both for finite and infinite horizons. Furthermore, premium levels balancing the cost to the insured and the payoff of the insurer are given. The methods used to analyse the problem are from dynamic programming and Markov chains.

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DREKIC, S., DICKSON, D. C. M., STANFORD, D. A. & WILLMOT, G. E. *On the distribution of the deficit at ruin when claims are phase-type.* 105-120. We consider the distribution of the deficit at ruin in the Sparre Andersen renewal risk model given that ruin occurs. We show that if the individual claim amounts have a phase-type distribution, then there is a simple phase-type representation for the distribution of the deficit. We illustrate the application of this result with several examples.

FLEDELIUS, P., GUILLÉN, M., NIELSEN, J. P. & VOGELIUS, M. *Two-dimensional hazard estimation for longevity analysis.* 133-156. We investigate developments in Danish mortality based on data from 1974-1998 working in a two-dimensional model with chronological time and age as the two dimensions. The analyses are done with non-parametric kernel hazard estimation techniques. The only assumption is that the mortality surface is smooth. Cross-validation is applied for optimal bandwidth selection to ensure the proper amount of smoothing to help distinguishing between random and systematic variation in data. A bootstrap technique is used for construction of pointwise confidence bounds. We study the mortality profiles by slicing up the two-dimensional mortality surface. Furthermore we look at aggregated synthetic population metrics as 'population life expectancy' and 'population survival probability'. For Danish women these metrics indicate decreasing mortality with respect to chronological time. The metrics can not directly be used for prediction purposes. However, we suggest that life insurance companies use the estimation technique and the cross-validation for bandwidth selection when analyzing their portfolio mortality. The non-parametric approach may give valuable information prior to developing more sophisticated prediction models for analysis of economic implications arising from mortality changes.

LINNEMANN, P. *Valuation of participating life insurance liabilities.* 81-104. Surrender and paid-up states are incorporated in the valuation of guaranteed benefits and payments of a level premium paying life insurance policy. We present different valuation methods and examine to

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what extent they avoid capitalizing and releasing future loadings which are associated with the payment of future premiums. We demonstrate how to avoid capital being required in the future to cover valuation strains. The paid-up benefit valuation method is being extended so that it does not require the premium basis to be on the safe-side of the valuation basis. We obtain a unification and integration of the level premium and paid-up valuation principles.

Rong, W. & Li, W. *The probability of ruin in a kind of Cox risk model with variable premium rate.* 121-132. In this paper the probability of ruin is investigated under the influence of a premium rate which varies according to the intensity of claims, and the occurrence of claims is described by a Cox process in the considered risk model. The idea is originally enlightened by Jasiulewicz (2001). We make a slight modification on the model and a generalization on the intensity process. By a 'backward differential argument' and the Markov property of the intensity process we strictly derive the integral equation satisfied by the probability of ruin. Further, we solve the equation when the intensity process is a homogeneous *n*-state Markov process by Laplace transforms. At the end of the paper, an example is given.

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