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ASTIN Bulletin

Volume **37** (1), 2007

Cai, J. & Tan, K. S. *Optimal retention for a stop-loss reinsurance under the VaR and CTE risk measures.* 93-112. We propose practical solutions for the determination of optimal retentions in a stop-loss reinsurance. We develop two new optimization criteria for deriving the optimal retentions by, respectively, minimizing the value-at-risk (VaR) and the conditional tail expectation (CTE) of the total risks of an insurer. We establish necessary and sufficient conditions for the existence of the optimal retentions for two risk models: individual risk model and collective risk model. The resulting optimal solution of our optimization criterion has several important characteristics: (i) the optimal retention has a very simple analytic form; (ii) the optimal retention depends only on the assumed loss distribution and the reinsurer's safety loading factor; (iii) the CTE criterion is more applicable than the VaR criterion in the sense that the optimal condition for the former is less restrictive than the latter; (iv) if optimal solutions exist, then both VaR- and CTE-based optimization criteria yield the same optimal retentions. In terms of applications, we extend the results to the individual risk models with dependent risks and use multivariate phase type distribution, multivariate Pareto distribution and multivariate Bernoulli distribution to illustrate the effect of dependence on optimal retentions. We also use the compound Poisson distribution and the compound negative binomial distribution to illustrate the optimal retentions in a collective risk model.

De Jong, P. & Marshall, C. *Mortality projection based on the Wang transform.* 149-161. A new method for analysing and projecting mortality is proposed and examined. The method takes observed time series of survival probabilities, finds the corresponding z-scores in the standard normal distribution and forecasts the z-scores. The z-scores appear to follow a common simple linear progression in time and hence forecasting is straightforward. Analysis on the z-score scale offers useful insights into the way mortality evolves over time. The method and extensions are applied to Australian female mortality data to derive projections to the year 2100 in both survival probabilities and expectations of life.

Emms, P. *Dynamic pricing of general insurance in a competitive market.* 1-34. A model for general insurance pricing is developed which represents a stochastic generalisation of the discrete model proposed by Taylor (1986). This model determines the insurance premium based both on the breakeven premium and the competing premiums offered by the rest of the insurance market. The optimal premium is determined using stochastic optimal control theory for two objective functions in order to examine how the optimal premium strategy changes with the insurer's objective. Each of these problems can be formulated in terms of a multi-dimensional Bellman equation. In the first problem the optimal insurance premium is calculated when the insurer maximises its expected terminal wealth. In the second, the premium is found if the insurer maximises the expected total discounted utility of wealth where the utility function is nonlinear in the wealth. The solution to both these problems is built-up from simpler optimisation problems. For the terminal wealth problem with constant loss-ratio the optimal premium strategy can be found analytically. For the total wealth

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problem the optimal relative premium is found to increase with the insurer's risk aversion which leads to reduced market exposure and lower overall wealth generation.

Ferraz Cordeiro, I. M. *Some notes on the average duration of an income protection claim.* 133-148. Cordeiro (2002a) has presented a multiple state model for Income Protection (formerly known as Permanent Health Insurance) which enables us to analyse claims by cause of disability. In that paper average claim durations conditioned on recovery have been calculated. Since, when an Income Protection claim is reported, the insurance company never knows whether it will end in recovery, in death or in expiry, to analyse only average claim durations conditioned on recovery could be misleading, specially for the people responsible for the claims control process. The main purpose of this paper is to calculate average claim durations conditioned on death and average claim durations not conditioned on any particular mode of claim termination. We calculate these claim durations for different deferred periods, causes of disability and ages at the beginning of sickness and we analyse the results obtained.

Johnston, M. *Extension of the capital asset pricing model to non-normal dependence structures.* 35-52. The Capital Asset Pricing Model arises in an economy where agents have exponential utility functions and aggregate consumption is normally distributed, and gives the prices of assets with payoffs which are jointly normal with consumption. Such assets have normal marginal distributions and have dependence with consumption characterised by a normal copula. Wang has derived a transform which extends the CAPM by allowing pricing of assets in such an economy which have non-normal marginal distributions but still are normal copula with consumption. Here we set out the stochastic discount factors corresponding to this version of the CAPM and to Wang's transform, and show how to calculate stochastic discount factors and hence asset prices for assets whose dependence with consumption is non-normal. We show that the impact of dependency structure on asset prices is significant.

Larsen, C. R. *An individual claims reserving model.* 113-132. Traditional Chain Ladder models are based on a few cells in an upper triangle and often give inaccurate projections of the reserve. Traditional stochastic models are based on the same few summaries and in addition are based on the often unrealistic assumption of independence between the aggregate incremental values. In this paper a set of stochastic models with weaker assumptions based on the individual claims development are described. These models can include information about settlement and can handle seasonal effects, changes in mix of business and claim types as well as changes in mix of claim size. It is demonstrated how the distribution of the process can be specified and especially how the distribution of the reserve can be determined. The method is illustrated with an example.

Niemiec, M. *Bonus-malus systems as Markov set-chains.* 53-65. The objective of this paper is to present an analysis of a bonus-malus system (BMS) within the framework of the theory of ergodic Markov set-chains. It is shown that this type of Markov chains enables the evaluation of BMS, even in steady-state, under the assumption that transition probabilities change in a definite range. We introduce a model that allows the determination of the consequences of changes in the claim frequency of a policyholder. In a numerical example we examine the BMS employed by one of the Polish insurance companies.

Riesner, M. *Locally risk-minimizing hedging of insurance payment streams.* 67-91. For the martingale case Föllmer and Sondermann (1986) introduced a unique admissible risk-minimizing hedging strategy for any square-integrable contingent claim H. Schweizer (1991) developed their theory further to the semimartingale case introducing the notion of local risk-minimization. Møller (2001) extended the theory of Föllmer and Sondermann (1986) to hedge general payment processes occurring mainly in insurance. We expand local risk-minimization to the theory of hedging general payment processes and derive such a hedging

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strategy for general unit-linked life insurance contracts in a general Lévy process financial market.

ZIMBIDIS, A., FRANGOS, N. E. & PANTELOUS, A. *Modeling earthquake risk via extreme value theory and pricing the respective catastrophe bonds.* 163-183. The aim of the paper is twofold. Firstly, to analyze the historical data of the earthquakes in the boarder area of Greece and then to produce a reliable model for the risk dynamics of the magnitude of the earthquakes, using advanced techniques from the Extreme Value Theory. Secondly, to discuss briefly the relevant theory of incomplete markets and price earthquake catastrophe bonds, combining the model found for the earthquake risk and an appropriate model for the interest rate dynamics in an incomplete market framework. The paper ends by providing some numerical results using Monte Carlo simulation techniques and stochastic iterative equations.

ASTIN BULLETIN

Volume **37** (2), 2007

ALBRECHER, H., HARTINGER, J. & THONHAUSER, S. *On exact solutions for dividend strategies of threshold and linear barrier type in a Sparre Anderson model.* 203-233. For the classical Cramér-Lundberg risk model, a dividend strategy of threshold type has recently been suggested in the literature. This strategy consists of paying out part of the premium income as dividends to shareholders whenever the free surplus is above a given threshold level. In contrast to the well-known horizontal barrier strategy, the threshold strategy can lead to a positive infinite horizon survival probability, with reduced profit in terms of dividend payments. In this paper we extend several of these results to a Sparre Andersen model with generalized Erlang(n)-distributed interclaim times. Furthermore, we compare the performance of the threshold strategy to a linear dividend barrier model. In particular, (partial) integro-differential equations for the corresponding ruin probabilities and expected discounted dividend payments are provided for both models and explicitly solved for $n = 2$ and exponentially distributed claim amounts. Finally, the explicit solutions are used to identify parameter sets for which one strategy outperforms the other and vice versa.

ALFA, A. & DREKIC, S. *Algorithmic analysis of the Sparre Anderson model in discrete time.* 293-317. In this paper, we show that the delayed Sparre Andersen insurance risk model in discrete time can be analyzed as a doubly infinite Markov chain. We then describe how matrix analytic methods can be used to establish a computational procedure for calculating the probability distributions associated with fundamental ruin-related quantities of interest, such as the time of ruin, the surplus immediately prior to ruin, and the deficit at ruin. Special cases of the model, namely the ordinary and stationary Sparre Andersen models, are considered in several numerical examples.

BUHLMANN, H. *The history of ASTIN: invited lecture at the 50 years anniversary of ASTIN.* 191-202.

COURTOIS, C. & DENUIT, M. *Local moment matching and S-convex extrema.* 387-404. The paper is devoted to the local moment matching method and its links with the discrete version of the *s*-convex extremal distributions. It is well-known that the local moment matching method can produce some negative masses. Connecting the local moment matching method to the discrete *s*-convex extrema gives an explicit criterion that explains why (and says when) the local moment matching method gives some negative mass.

DAHL, M. *A discrete-time model for reinvestment risk in bond markets.* 235-264. In this paper

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we propose a discrete-time model with fixed maximum time to maturity of traded bonds. At each trading time, a bond matures and a new bond is introduced in the market, such that the number of traded bonds is constant. The entry price of the newly issued bond depends on the prices of the bonds already traded and a stochastic term independent of the existing bond prices. Hence, we obtain a bond market model for the reinvestment risk, which is present in practice, when hedging long term contracts. In order to determine optimal hedging strategies we consider the criteria of super-replication and risk-minimization.

DEGEN, M., EMBRECHTS, P. & LAMBRIGGER, D. D. *The quantitative modeling of operational risk between G-and-H and EVT.* 265-291. Operational risk has become an important risk component in the banking and insurance world. The availability of (few) reasonable data sets has given some authors the opportunity to analyze operational risk data and to propose different models for quantification. As proposed in Dutta and Perry [12], the parametric g-and-h distribution has recently emerged as an interesting candidate. In our paper, we discuss some fundamental properties of the g-and-h distribution and their link to extreme value theory (EVT). We show that for the g-and-h distribution, convergence of the excess distribution to the generalized Pareto distribution (GPD) is extremely slow and therefore quantile estimation using EVT may lead to inaccurate results if data are well modeled by a g-and-h distribution. We further discuss the subadditivity property of Value-at-Risk (VaR) for g-and-h random variables and show that for reasonable g and h parameter values, superadditivity may appear when estimating high quantiles. Finally, we look at the g-and-h distribution in the one-claim-causes-ruin paradigm.

ESPINOSA, C. & MACDONALD, A. S. *A correction for ascertainment bias in estimating rates of onset of highly penetrant genetic disorders.* 429-452. Estimation of rates of onset of rare, late-onset dominantly inherited genetic disorders is complicated by: (a) probable ascertainment bias resulting from the 'recruitment' of strongly affected families into studies; and (b) inability to identify the true 'at risk' population of mutation carriers. To deal with the latter, Gui & Macdonald proposed a non-parametric (Nelson-Aalen) estimate $\hat{}(x)$ of a simple function (x) of the rate of onset at age x. The function (x) had a finite bound, which was an increasing function of the probability p that a child of an affected parent inherits the mutation and s the life-time penetrance. However if $\hat{}(x)$ exceeds this bound, it explodes to infinity, and this can happen at quite low ages. We show that such 'failure' may in fact be a useful measure of ascertainment bias. Gui & Macdonald assumed that $p = 1/2$ and $s = 1$, but ascertainment bias means that $p > 1/2$ and s??1 in the sample. The maximum attained by $\hat{}(x)$ allows us to estimate a range for the product ps, and therefore the degree of ascertainment bias that may be present, leading to bias-corrected estimates of rates of onset. However, we find that even classical independent censoring, prior to ascertainment, can introduce new bias. We apply these results to early-onset Alzheimer's disease associated with mutations in the Presenilin-1 gene.

GENEST, C. & NESLEHOVA, J. *A primer on copulas for count data.* 475-515. The authors review various facts about copulas linking discrete distributions. They show how the possibility of ties that results from atoms in the probability distribution invalidates various familiar relations that lie at the root of copula theory in the continuous case. They highlight some of the dangers and limitations of an undiscriminating transposition of modeling and inference practices from the continuous setting into the discrete one.

JOSHI, M. S. & LIESCH, L. *Effective implementation of generic market models.* 453-473. A number of standard market models are studied. For each one, algorithms of computational complexity equal to the number of rates times the number of factors to carry out the computations for each step is introduced. Two new classes of market models are developed and it is shown for them that similar results hold.

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KIM, J. H. T. & HARDY, M. R. *Quantifying and correcting the bias in estimated risk measures.* 365-386. In this paper we explore the bias in the estimation of the Value at Risk and Conditional Tail Expectation risk measures using Monte Carlo simulation. We assess the use of bootstrap techniques to correct the bias for a number of different examples. In the case of the Conditional Tail Expectation, we show that application of the exact bootstrap can improve estimates, and we develop a practical guideline for assessing when to use the exact bootstrap.

LO, C. H., FUNG, W. K. & ZHU, Z. Y. *Structural parameter estimation using generalized estimating equations for regression credibility models.* 323-343. A generalized estimating equations (GEE) approach is developed to estimate structural parameters of a regression credibility model with independent or moving average errors. A comprehensive account is given to illustrate how GEE estimators are worked out within an extended Hachemeister (1975) framework. Evidenced by results of simulation studies, the proposed GEE estimators appear to outperform those given by Hachemeister, and have led to a remarkable improvement in accuracy of the credibility estimators so constructed.

SCHMIDT, K. D. *A note on a recent paper by Zaks, Frostig and Levikson.* 319-321. In the present paper we give a short proof of a result of Zaks, Frostig and Levikson [2006] on the solution of an optimization problem which is related to the problem of optimal pricing of a heterogeneous portfolio.

TAYLOR, G. C. *Credibility, hypothesis testing and regression software.* 517-535. It has been known since Zehnwirth (1977) that a scalar credibility coefficient is closely related to the *F*-statistic of an analysis of variance between and within risk clauses. The *F*-statistic may also be viewed as testing a certain regression structure, associated with credibility framework, against the null hypothesis of a simpler structure. This viewpoint is extended to multi-dimensional credibility frameworks in which the credibility coefficient is a matrix (Sections 3 and 4), and to hierarchical regression credibility frameworks (Section 6). In each case the credibility coefficient is expressed in terms of the *F*-statistic that tests the significance of a defined regression structure against a simpler one. Section 5 points out how the computation may be implemented in certain cases by means of regression software.

VENTER, G. G. *Generalized linear models beyond the exponential family with loss reserve applications.* 345-364. The formulation of generalized linear models in Klugman, Panjer and Willmot (2004) is a bit more general than is often seen, in that the residuals are not restricted to following a member of the exponential family. Some of the distributions this allows have potentially useful applications. The cost is that there is no longer a single form for the likelihood function, so each has to be fit directly. Here the use of loss distributions (frequency, severity and aggregate) in generalized linear models is addressed, along with a few other possibilities.

VILAR ZANON, J. L. & LOZANO-COLOMER, C. *On Pareto conjugate priors and their application to large claims reinsurance premium calculation.* 405-428. This paper addresses the Bayesian estimation of the shape parameter of Pareto distributions, and its application to premium calculation of large claims excess of loss (XL) reinsurance contracts. It studies the use of the generalized inverse Gaussian (GIG) as a Pareto prior conjugate, a family that contains as a particular case the gamma distribution. An exact credibility formula is deduced allowing the calculation of individual reinsurance premiums. These are premiums suited to the excesses history of a sole portfolio. A family of predictive distributions for the excesses is derived. We apply our exact credibility model to a sample of excesses arisen in ten Spanish portfolios of liability motor insurance from year 1992 to year 2001.

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Australian Actuarial Journal

Volume **12** (1), 2006

Fitzherbert, R. *Paradigms, research and recognition of the actuarial profession.* 103-185. This paper is concerned with the role of research within the actuarial profession as a foundation for its future, recognising the desire to become more recognised in the broader financial services industry. To sustain itself, the profession needs to achieve and maintain effective ownership of relevant paradigms in practice areas within the domain of actuarial science. Without this, individuals may be recognised in these fields, but the profession will not. The concepts of paradigm and exemplar, as enunciated by Thomas Kuhn are important to this discussion, without necessarily endorsing Kuhn's view of the history of science as an appropriate model for the actuarial profession. There have been many pronouncements about the future of the profession, its role in the community and the importance of research. However the existence of a formal structure for research and other formalities such as a code of conduct do not guarantee the future of the profession. This depends on its paradigms, their soundness, relevance and effective ownership by the profession. While University based research, the efforts of volunteers and ARCA may contribute towards achieving these ends, the profession may need to take a lead in orienting this research towards the development of its own paradigms. Most of the infrastructure required is already in place: it is the focus and leadership from the profession that needs more thought. Key Words: Research, Paradigms, Actuarial Profession.

Stevenson, M. A. *2006 Presidential Address: The evolution of the Profession.* 1-58. The purpose of this paper is to show how calculations can be performed for multiple state models using mathematical software. We illustrate not only how to calculate probabilities under a multiple state model, but also how to calculate premiums and reserves.

Australian Actuarial Journal

Volume **12** (2), 2006

Dickson, D. C. M. *Premiums and reserves for life insurance products.* 259-79.

Leung, E. *A multiple state model for pricing and reserving private long term care insurance contracts in Australia.* 187-247. We seek to develop a model for pricing LTC insurance contracts in Australia using the disability prevalence rates contained in the 1998 Australian Bureau of Statistics (ABS) Survey of Disability, Ageing and Carers. We perform premium and reserve calculations by applying generalisations of Thiele's differential equation for a multiple state model within a Markov framework. Several sets of results are presented that both capture a varying range of possible scenarios and demonstrate the flexibility of the

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model. Keywords: Long term care; Disability; Multiple State Model; Private Insurance; Markov Process; Thiele's Differential Equation.

AUSTRALIAN ACTUARIAL JOURNAL

Volume **12** (3), 2006

STOTT, P. *External peer review: A value-added approach.* 281-318 319-366 (discussion) This paper investigates the value-added benefit that can result from External Peer Review of a primary actuary's work. In Part B, some principles are discussed, based on merging the traditional concept of peer review (as employed by many consulting firms) with the newer requirement of the Institute for External Peer Review as covered by Professional Standard PS 100. In Part C, the various regulations and professional standards that govern External Peer Review and actuarial audit are examined, with a view to identifying how far the scope of an External Peer Review or audit brief can legitimately be extended. In Part D, some practical situations are discussed that illustrate the value-added benefit of such an approach to peer review. The paper concludes by suggesting some principles for developing the scope of the reviewing actuary's brief so as to maximise the cost-benefit equation for the primary actuary. Keywords: Actuarial audit, external peer review, independence, peer review.

TAYLOR, G. C. *APRA general insurance risk margins.* 367-397. It is common for actuaries to estimate percentile-based risk margins on the assumption of a log normal distribution of liability, together with an estimate of coefficient of variation ('CoV'). This can yield seemingly anomalous results with percentage risk margin decreasing as CoV increases. The mathematics of this type of risk margin is explored. An APRA risk margin is the maximum of this type and a multiple of CoV. Such risk margins are studied in a more general setting than APRA's, with both percentile p and CoV-multiple k free. The APRA risk margins form a special case within this setting. Particular attention is paid to risk margin transition points, values of the log normal dispersion parameter at which the risk margin changes from one form to the other as that parameter increases. For given values of p and k, the existence, uniqueness and location of transition points is investigated. The direction of change of a transition point in a presence of increasing p or k is also investigated. Various numerical examples are given. Keywords: APRA, risk margin, risk margin transition point.

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AUSTRALIAN ACTUARIAL JOURNAL

Volume **12** (4), 2006

CHANDRA, V. & SHERRIS, M. *Capital management and frictional costs in insurance.* 399-447. In this paper we develop a model of an insurer incorporating frictional costs of capital and assess and illustrate an optimal capital management strategy. Frictional costs of capital include the additional taxation on profits of shareholders from an insurer's business over and above those from direct equity investment in financial assets, transaction costs in raising equity capital, moral hazard and adverse selection costs from underwriting insurance risks, agency costs such as management perquisites, as well as the costs of financial distress and insolvency including legal costs and loss of new business opportunities. These costs are deadweight losses to equity investors in an insurer and need to be minimised in order to maximise shareholder returns. Frictional costs of capital do not include the expected return to shareholders, normally

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regarded as the nominal cost of capital. Fair pricing taking into account risk and optimal capital provides a fair expected rate of return to shareholders. A trade-off exists between the frictional costs of the solvent insurer and the contingent financial distress costs of the insolvent insurer. Higher levels of capital lower expected financial distress costs but increase other frictional costs such as an additional taxation, agency, moral hazard and adverse selection costs. By minimising total expected frictional costs, the model determines the optimal trade-off and the optimal level of insurer capital. The model includes adjustment costs of raising and shedding capital. The paper has implications for the long run sustainability of insurers. The efficient management of the frictional costs of capital should be a focus of the risk management strategy of an insurer and is essential for the long run survival of an insurer.

Li, J. *Comparison of stochastic reserving models.* 489-569. In this paper, we compare and contrast several existing stochastic reserving methods under the new Australian prudential regulatory framework. These methods include Bayesian estimation with Markov chain Monte Carlo (MCMC) simulation, the chain ladder method with bootstrapping, generalised linear models (GLMs) with bootstrapping, the Kalman filter on state-space models, the Mack model, and the stochastic chain ladder method. With regard to the qualitative aspects, we investigate the methods' underlying structures, assumptions, and estimation mechanics. In particular, we devise our own structure and estimation mechanics for the stochastic chain ladder method, derive some new approximation formulae for both GLMs and the stochastic chain ladder method, and derive the covariance matrices for the Kalman filter and state-space models adopted. We find that the methods have different levels of flexibility and are suitable to different situations in practice. With regard to the quantitative aspects, we apply the methods considered to a particular claims data set. We then analyse the estimates of the expected outstanding claims liability and the risk margin for each accident year and for total. We find that the risk margin estimate of each accident year and the aggregate risk margin estimate vary considerably for different methods. Keywords: outstanding claims liability, uncertainty, risk margin, 75th percentile, coefficient of variation, model structure, Bayesian, MCMC, chain ladder, bootstrapping, GLM, Kalman filter, state-space model, Mack model, stochastic chain ladder.

Ooi, H. *A comparison of random forests and generalised linear models for general insurance modelling.* 449-487. Random forests (RF) is a statistical modelling algorithm designed by Breiman (2001a). We compare the performance of RF and generalised linear models (GLMs) on several datasets, both real and simulated. The results indicate that the characteristics of the data can have a substantial influence on the relative performance of the two algorithms. In general, RF does as well as or better than GLMs in terms of predictive accuracy, but the degree of superiority varies: RF does best when underlying relationships are complex, and the level of noise is not too high. Disadvantage of RF include its internal complexity and the fact that it is a 'black box' (although tools do exist for probing the structure of the model, such as variable importance plots). We discuss ways of dealing with this, such as a second modelling stage aimed at simplifying the outputs from the RF, along with other model usage and implementation issues. Keywords: Data mining, general insurance, regression, statistical modelling.

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Australian Actuarial Journal

Volume **13** (1), 2007

Institute of Actuaries of Australia Superannuation Tax Reform Task Force. *Tax-free superannuation benefits: a future revenue problem?* 689-699. Questions have been raised by Institute members and others as to the financial consequences of the Government's proposal to remove taxes on benefits paid to those over age 60. Based on work by our Task Force, the cost of this change may be less significant than many might anticipate. The revenue from these taxes is currently less than $500m or 0.05% of GDP, and is estimated to grow to 0.33% of GDP in 2040. By contrast, contributions tax revenues are currently about $5bn or 0.5% of GDP. This paper: explores reasons why revenue from benefits tax is relatively small; discusses some of the problems of taxing benefits instead of contributions; and discusses the issue of whether benefits tax is a solution to the ageing population's revenue needs. Please note that, on the subject of equity or fairness, the paper identifies some issues but does not attempt to follow them through in any way. The essential purpose of the paper is to explain the results of the Task Force's analysis of the long term financial consequences of the proposed removal of benefits taxes. Our primary observations are that: Few retirees pay benefits taxes under the existing system; Tax revenue on benefits is small and would have remained small under the existing system; To tax benefits instead of contributions would reduce revenue indefinitely; and Superannuation taxes were unlikely ever to support ageing population.

Li, J. *Variance of the present value of a pension.* 701-718. Under GN 465, a 'high degree of probability' that a superannuation fund will be able to pay its defined benefit pensions should be interpreted as a probability of at least 70%. GN 465 states that a complete analysis for computing the probability involves a projection of certain factors including inflation, investment returns, expenses, and mortality. Leung (2002) derives an approximation formula to calculate the variance of the present value of a pension, in which mortality risk is allowed for. This paper is an extension of Leung (2002), in which we have derived some formulae to accommodate both investment risk and mortality risk. Two examples are provided to demonstrate the use of this formulae. The proofs of the formulae are set out in the appendix. Keywords: Pension, variance, 70th percentile, annuity, mortality risk, investment risk, geometric Brownian motion.

Rowley, F. *Realising the vision: actuaries strategy and risk: Presidential address.* 573-624 discussion, 625-685.

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Australian Actuarial Journal

Volume **13** (2), 2007

Asher, A. *Mean reversion in investment markets: The implications for investors and regulators.* 721-770. This paper is particularly concerned with mean reversion in investment markets and its implications for investment market regulation. It is now well established that equity markets reflect a varying risk premium. It also seems that they and other investment markets are not necessarily always efficient and can sometimes move to extreme levels. Investors who rely on fundamental analysis of individual assets and asset classes can profit from such movements. Uninformed investors, on the other hand, can not only lose money by inadequate diversification and excessive trading, but also by being panicked into buying overpriced or

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selling underpriced assets. This leads on to a consideration of other errors, identified by recent research, to which uninformed investors may be prone. Most important would appear to be the failure of superannuation members to adapt their investment strategy over their lifetimes. It is suggested that official and industry regulators should take behavioural finance insights into account in enforcing disclosure, and by encouraging a more thorough approach to the monitoring of investment performance. The pressure on uninformed and nervous investors to panic might be reduced by the publication of a consensus portfolio to act as a benchmark. Keywords: Superannuation; choice; mean reversion; behavioural finance.

Institute of Actuaries of Australia Life Risk Insurance Committee. *Report (without tables) on the Disability Income Experience Investigation for the years 1998-01.* 771-877. This paper has been prepared for issue to, and discussion by, Members of the Institute of Actuaries of Australia (Institute). The Institute Council wishes it to be understood that opinions put forward herein are not necessarily those of the Institute and the Council is not responsible for those opinions. A copy of the full report (with tables) can be purchased directly from the Institute.

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Geneva Risk and Insurance Review

Volume **32** (1), 2007

Braun, H. & Koeniger, W. *On the role of market insurance in a dynamic model.* 61-90. Durables like cars or houses are a substantial component in the balance sheets of households. These durables are exposed to risk and can be insured in the market. We build a dynamic model in which agents have three possibilities to cope with the risk exposure of the durable stock: (i) purchase of market insurance, (ii) buffer-stock saving of the riskless asset, or (iii) adjustment of the durable stock. We calibrate our model to the US economy and find a small role for market insurance.

Glaser, M. & Weber, M. *Overconfidence and trading volume.* 1-36. Theoretical models predict that overconfident investors will trade more than rational investors. We directly test this hypothesis by correlating individual overconfidence scores with several measures of trading volume of individual investors. Approximately 3,000 online broker investors were asked to answer an internet questionnaire which was designed to measure various facets of overconfidence (miscalibration, volatility estimates, better than average effect). The measures of trading volume were calculated by the trades of 215 individual investors who answered the questionnaire. We find that investors who think that they are above average in terms of investment skills or past performance (but who did not have above average performance in the past) trade more. Measures of miscalibration are, contrary to theory, unrelated to measures of trading volume. This result is striking as theoretical models that incorporate overconfident investors mainly motivate this assumption by the calibration literature and model overconfidence as underestimation of the variance of signals. In connection with other recent findings, we conclude that the usual way of motivating and modeling overconfidence which is mainly based on the calibration literature has to be treated with caution. Moreover, our way of empirically evaluating behavioral finance models — the correlation of economic and

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psychological variables and the combination of psychometric measures of judgment biases (such as overconfidence scores) and field data — seems to be a promising way to better understand which psychological phenomena actually drive economic behavior.

Hofmann, A. *Internalizing externalities of loss prevention through insurance monopoly: an analysis of interdependent risks.* 91-111. When risks are interdependent, an agent's decision to self-protect affects the loss probabilities faced by others. Due to these externalities, economic agents invest too little in prevention relative to the socially efficient level by ignoring marginal external costs or benefits conferred on others. This paper analyzes an insurance market with externalities of loss prevention. It is shown in a model with heterogenous agents and imperfect information that a monopolistic insurer can achieve the social optimum by engaging in premium discrimination. An insurance monopoly reduces not only costs of risk selection, but may also play an important social role in loss prevention.

Palmon, O. & Spivak, A. *Adverse selection and the market for annuities.* 37-59. Adverse selection is often blamed for the malfunctioning of the annuities market. We simulate the impact of adverse selection on the consumption allocation of annuitants under alternative parameter values, and explore the resulting welfare implications. We show that, for most parameter values, the welfare losses associated with equilibriums that are subject to adverse selection correspond to a loss of wealth of around one percent in a first-best equilibrium. These losses are smaller than the corresponding losses associated with equilibriums with no access to an annuity market by an order of magnitude of ten. The existence of substitutes for annuities such as a bequest motive or a social security system intensifies the adverse selection but reduces its welfare impact.

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Campana, A. *On Tail Value-at-Risk for sums of non-independent random variables with a generalized Pareto distribution.* 169-180. Recently in actuarial literature several authors have derived lower and upper bounds in the sense of convex order for sums of random variables with given marginal distributions and unknown dependency structure. In this paper, we derive convex bounds for sums of non-independent and identically distributed random variables when marginal distributions are mixture models. In particular, we examine some well-known risk measures and we find approximations for Tail Value-at-Risk of the sums considered when marginal distributions are generalized Pareto distributions. By numerical examples we illustrate the goodness of the presented approximations.

Huang, R. J. & Tzeng, L. Y. *Insurer's insolvency risk and tax deductions for the individual's net losses.* 129-145. Using the representative agent approach as in Kaplow (*Am. Econ. Rev.*, **82**:1013-1017, 1992b), this paper shows that providing tax deductions for the individual's net losses is socially optimal when the insurer faces the risk of insolvency. We further show that the government should adopt a higher tax deduction rate for net losses when the insurer is insolvent than when the insurer is solvent. Thus, tax deductions for net losses could be used to provide an insurance for individuals against the insurer's risk of insolvency. These findings could also be used to explain why a government provides supplementary public insurance or government relief. Finally, we discuss that, if the individuals are heterogeneous in terms of loss severity, loss probability, or income level, providing a tax deduction for the individual's net losses may not always achieve a Pareto improvement, and cross subsidization should be taken into consideration.

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Posey, L. L. & Yavas, A. *Screening equilibria in experimental markets.* 147-167. We conduct an experimental test of a screening model of an insurance market with asymmetric information. We first conduct three sessions in which the proportion of high risk buyers is such that a separating equilibrium should exist. We then conduct three more sessions in which the only change we make is decreasing the proportion of high risks such that the equilibrium is now a pooling equilibrium. In both treatments, the observed behavior converges to the equilibrium prediction.

Romaniuk, K. *The optimal asset allocation of the main types of pension funds: a unified framework.* 113-128. The existing literature deals with the optimal investment strategy of defined benefit (DB) or defined contribution (DC) pension plans. This article's objective is to compare the optimal policies of different types of pension plans. This is done by first defining an original framework, which is based on the distinction between the nature of the guarantee — which can be internal or external — offered by or to a pension fund. This framework allows to establish links between optimization programs of DC, DB and targeted money purchase schemes. The case of an internal guarantee appears as a standard portfolio insurer's problem. The second kind of guarantee, not analyzed in the literature yet with regard to the resulting optimal policy, is characterized by the existence of an option in the final wealth definition. Four funds are present in the internal guarantee optimal allocation: the speculative component, the preference independent guarantee- and contribution-hedge terms and the preference dependent state variable-hedge fund. The external guarantee program, solved with an original method using the principles of standard options theory, yields an optimal policy incorporating the delta of the option embodied in the final wealth definition. The conclusion is that the resulting optimal portfolio policy becomes riskier.

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Insurance: Mathematics & Economics

Volume **41** (1), 2007

Asimit, A. V. & Jones, B. L. *Extreme behavior of bivariate elliptical distributions.* 53-61. This paper exploits a stochastic representation of bivariate elliptical distributions in order to obtain asymptotic results which are determined by the tail behavior of the generator. Under certain specified assumptions, we present the limiting distribution of componentwise maxima, the limiting upper copula, and a bivariate version of the classical peaks over threshold result.

Avanzi, B., Gerber, H. U. & Shiu, E. S. W. *Optimal dividends in the dual model.* 111-123. The optimal dividend problem proposed by de Finetti [1957, Transactions of the XVth International Congress of Actuaries, Vol. 2. pp. 433-443] is to find the dividend-payment strategy that maximizes the expected discounted value of dividends which are paid to the shareholders until the company is ruined or bankrupt. In this paper, it is assumed that the surplus or shareholders' equity is a Lévy process which is skip-free downwards; such a model might be appropriate for a company that specializes in inventions and discoveries. In this model, the optimal strategy is a barrier strategy. Hence the problem is to determine b*, the optimal level of the dividend barrier. A key tool is the method of Laplace transforms. A variety of numerical examples are provided. It is also shown that if the initial surplus is b*, the expectation of the discounted dividends until ruin is the present value of a perpetuity with the payment rate being the drift of the surplus process.

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Ayuso, M. & Santolino, M. *Predicting automobile claims bodily injury severity with sequential ordered logit models.* 71-83. Despite the large cost of bodily injury (BI) claims in motor insurance, relatively little research has been done in this area. Many companies estimate (and therefore reserve) bodily injury compensation directly from initial medical reports. This practice may underestimate the final cost, because the severity is often assessed during the recovery period. Since the evaluation of this severity is often only qualitative, in this paper we apply an ordered multiple choice model at different moments in the life of a claim reported to an insurance company. We assume that the information available to the insurer does not flow continuously, because it is obtained at different stages. Using a real data set, we show that the application of sequential ordered logit models leads to a significant improvement in the prediction of the BI severity level, compared to the subjective classification that is used in practice. We also show that these results could improve the insurer's reserves notably.

Bayraktar, E. & Young, V. R. *Minimizing the probability of lifetime ruin under borrowing constraints.* 196-221. We determine the optimal investment strategy of an individual who targets a given rate of consumption and who seeks to minimize the probability of going bankrupt before she dies, also known as lifetime ruin. We impose two types of borrowing constraints: First, we do not allow the individual to borrow money to invest in the risky asset nor to sell the risky asset short. However, the latter is not a real restriction because in the unconstrained case, the individual does not sell the risky asset short. Second, we allow the individual to borrow money but only at a rate that is higher than the rate earned on the riskless asset. We consider two forms of the consumption function: (1) The individual consumes at a constant (real) dollar rate, and (2) the individual consumes a constant proportion of her wealth. The first is arguably more realistic, but the second is closely connected with Merton's model of optimal consumption and investment under power utility. We demonstrate that connection in this paper, as well as include a numerical example to illustrate our results.

Bratiychuk, M. S. & Derfla, D. *On a modification of the classical risk process.* 156-162. In this paper, we present the classical risk process with two-step premium function. This means that the gross risk premium rate changes if the insurer's surplus reaches a certain threshold level. The formula for the infinite-time ruin probability is obtained. The asymptotic behaviour of the ruin probability in the case where the claim size distribution has a light tail is considered as well.

Chadjiconstantinidis, S. & Politis, K. *Two-sided bounds for the distribution of the deficit at ruin in the renewal risk model.* 41-52. We obtain lower and upper bounds for the severity of ruin in the renewal (Sparre Andersen) model of risk theory. We present two types of bounds: (i) bounds applicable generally; and (ii) exponential bounds for the case where the adjustment coefficient of the risk process exists. Many of these bounds are obtained using existing bounds and the integral equation for the severity of ruin.

Date, P., Mamon, R. & Wang, I.-C. *Valuation of cash flows under random rates of interest: A linear algebraic approach.* 84-95. This paper reformulates the classical problem of cash flow valuation under stochastic discount factors into a system of linear equations with random perturbations. Using convergence results, a sequence of uniform approximations is developed. The new formulation leads to a general framework for deriving approximate statistics of cash flows for a broad class of models of stochastic interest rate process. We show applications of the proposed method by pricing default-free and defaultable cash flows. The methodology developed in this paper is applicable to a variety of uncertain cash flow analysis problems.

Filipovic, D. & Kupper, M. *Monotone and cash-invariant convex functions and hulls.* 1-16.

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This paper provides some useful results for convex risk measures. In fact, we consider convex functions on a locally convex vector space E which are monotone with respect to the preference relation implied by some convex cone and invariant with respect to some numeraire ('cash'). As a main result, for any function f, we find the greatest closed convex monotone and cash-invariant function majorized by f. We then apply our results to some well-known risk measures and problems arising in connection with insurance regulation.

GUPTA, A. & LI, Z. *Integrating optimal annuity planning with consumption — investment selections in retirement planning.* 96-110. Annuities can be effective tools in managing longevity risk in retirement planning. This paper develops a framework that merges annuity purchase decisions with consumption — investment selections in retirement planning. After introducing a pricing and a benefit payment model for an annuity, we construct a multi-period wealth evolution model. An optimization problem is formulated with an objective of maximizing lifetime utility of consumption and wealth. Optimal decisions are determined as a trade off between consumption and investment among an annuity, a risky and a risk-free asset. Computational results are provided to illustrate the practical implications of the framework.

HAINAUT, D. & DEVOLDER, P. *Management of a pension fund under mortality and financial risks.* 134-155. The purpose of this article is to analyze the dividend policy and the asset allocation of a pension fund. We consider a financial market composed of three assets: cash, stocks and a rolling bond. Interest rates are driven by Vasicek's model whereas the mortality of the insured population is modelled by a Poisson process. We determine investment and dividend policies maximizing the utility of dividends and of terminal surplus under a budget constraint. In particular, solutions are developed for CRRA and CARA utility functions. The methodology is based both on the Cox and Huang's approach and on the dynamic programming principle.

JANG, J.-W. *Jump diffusion processes and their applications in insurance and finance.* 62-70. For insurance risks, jump processes such as homogeneous/non-homogeneous compound Poisson processes and compound Cox processes have been used to model aggregate losses. If we consider the economic assumption of a positive interest to aggregate losses, Lévy processes have proven to be useful. Also in financial modelling, it has been observed that diffusion models are not robust enough to capture the appearance of jumps in underlying asset prices and interest rates. As a result, jump diffusion processes, which are, simply speaking, combinations of compound Poisson processes with Brownian motion, have gained popularity for modelling in insurance and finance. In this paper, considering a jump diffusion process, we obtain the explicit expression of the joint Laplace transform of the distribution of a jump diffusion process and its integrated process, assuming that jump size follows the mixture of two exponential distributions, which is a special case of phase-type distributions. Based on this Laplace transform, we derive the moments of the aggregate accumulated claim amounts of insurance risk. For a financial application, we concern non-defaultable zero-coupon bond pricing. We also provide several numerical examples for the moments of aggregate accumulated claims and default-free zero-coupon bond prices.

LI, J., LIU, Z. & TANG, Q. *On the ruin probabilities of a bidimensional perturbed risk model.* 185-195. We follow some recent works to study the ruin probabilities of a bidimensional perturbed insurance risk model. For the case of light-tailed claims, using the martingale technique we obtain for the infinite-time ruin probability a Lundberg-type upper bound, which captures certain information of dependence between the two marginal surplus processes. For the case of heavy-tailed claims, we derive for the finite-time ruin probability an explicit asymptotic estimate.

THONHAUSER, S. & ALBRECHER, H. *Dividend maximization under consideration of the time value*

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of ruin. 163-184. In the Cramér–Lundberg model and its diffusion approximation, it is a classical problem to find the optimal dividend payment strategy that maximizes the expected value of the discounted dividend payments until ruin. One often raised disadvantage of this approach is the fact that such a strategy does not take the lifetime of the controlled process into account. In this paper we introduce a value function which considers both expected dividends and the time value of ruin. For both the diffusion model and the Cramér–Lundberg model with exponential claim sizes, the problem is solved and in either case the optimal strategy is identified, which for unbounded dividend intensity is a barrier strategy and for bounded dividend intensity is of threshold type.

Willmot, G. E. *On the discounted penalty function in the renewal risk model with general interclaim times.* 17-31. The defective renewal equation satisfied by the Gerber–Shiu discounted penalty function in the renewal risk model with arbitrary interclaim times is analyzed. The ladder height distribution is shown to be a mixture of residual lifetime claim severity distributions, which results in an invariance property satisfied by a large class of claim amount models. The class of exponential claim size distributions is considered, and the Laplace transform of the (discounted) defective density of the surplus immediately prior to ruin is obtained. The mixed Erlang claim size class is also examined. The simplified defective renewal equation which results when the penalty function only involves the deficit is used to obtain moments of the discounted deficit.

Xiao, Y. & Guo, J. *The compound binomial risk model with time-correlated claims.* 124-133. In this paper, we consider the compound binomial risk model with the time-correlated claims. It is assumed that every main claim will produce a by-claim but the occurrence of the by-claim may be delayed. We obtain the recursive formula of the joint distribution of the surplus immediately prior to ruin and deficit at ruin. Furthermore, the ruin probability is given by means of ruin probability and the deficit at ruin of the classical compound binomial risk model. Finally, we derive an upper bound for the ruin probability.

Zhang, Z., Yuen, K. C. & Li, W. K. *A time-series risk model with constant interest for dependent classes of business.* 32-40. In this paper, we propose a discrete-time model with dependent classes of business using a time-series approach. Specifically, premiums and claims of all classes are supposed to satisfy a multivariate first-order autoregressive time-series model. A constant interest rate is also included in the model. A Lundberg-type inequality for the ruin probability is deduced. We also give an example with constant premiums and two classes of claims for which an expression as well as an exponential bound for the ruin probability is given. A simulation study is provided to help understanding the model.

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Ahn, S. & Badescu, A. L. *On the analysis of the Gerber–Shiu discounted penalty function for risk processes with Markovian arrivals.* 234-249. In this paper, we consider an insurance risk model governed by a Markovian arrival claim process and by phase-type distributed claim amounts, which also allows for claim sizes to be correlated with the inter-claim times. A defective renewal equation of matrix form is derived for the Gerber–Shiu discounted penalty function and solved using matrix analytic methods. The use of the busy period distribution for the canonical fluid flow model is a key factor in our analysis, allowing us to obtain an explicit form of the Gerber–Shiu discounted penalty function avoiding thus the use of Lundberg's fundamental equation roots. As a special case, we derive the triple Laplace transform of the time to ruin, surplus prior to ruin, and deficit at ruin in explicit form, further

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obtaining the discounted joint and marginal moments of the surplus prior to ruin and the deficit at ruin.

ASIMIT, A. V. & JONES, B. L. *Extreme behavior of multivariate phase-type distributions.* 223-233. This paper investigates the limiting distributions of the componentwise maxima and minima of suitably normalized iid multivariate phase-type random vectors. In the case of maxima, a large parametric class of multivariate extreme value (MEV) distributions is obtained. The flexibility of this new class is exemplified in the bivariate setup. For minima, it is shown that the dependence structure of the Marshall–Olkin class arises in the limit.

JONES, B. L. & ZITIKIS, R. *Risk measures, distortion parameters, and their empirical estimation.* 279-297. Risk measures are of considerable current interest. Among other uses, they allow an insurer to calculate a risk-loaded premium for a random loss. However, the premium principle in use by the insurer may be, at least in part, based on considerations other than risk. It is then important to quantify the degree to which the premium compensates the insurer for the risk associated with the loss. This can be done by choosing a suitable risk measure and solving for the parameter that leads to the insurer's premium. When the loss distribution is unknown, this becomes a statistical estimation problem. In this paper, we investigate the nonparametric estimation of the parameter associated with a distortion-based risk measure. It is assumed that the premium principle is known, but no information is assumed about the loss distribution, and therefore empirical estimators are used. We explore the asymptotic properties of the resulting estimator of the risk measure parameter in general and for three well-known risk measures in particular: the proportional hazards transform, the Wang transform, and the conditional tail expectation.

KOSTADINOVA, R. *Optimal investment for insurers when the stock price follows an exponential Lévy process.* 250-263. We consider a stochastic model for the wealth of an insurance company which has the possibility to invest into a risky and a riskless asset under a constant mix strategy. The total claim amount is modeled by a compound Poisson process and the price of the risky asset follows a general exponential Lévy process. We investigate the resulting reserve process and the corresponding discounted net loss process. This opens up a way to measure the risk of a negative outcome of the reserve process in a stationary way. We provide an approximation of the optimal investment strategy which maximizes the expected wealth of the insurance company under a risk constraint on the Value-at-Risk. We conclude with some examples.

LEE, J.-P. & YU, M.-T. *Valuation of catastrophe reinsurance with catastrophe bonds.* 264-278. This study develops a contingent-claim framework for valuing a reinsurance contract and examines how a reinsurance company can increase the value of a reinsurance contract and reduce its default risk by issuing catastrophe (CAT) bonds. The results also show how the changes in contract values and default risk premium are related to basis risk, trigger level, catastrophe risk, interest rate risk, and the reinsurer's capital position.

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ANNAERT, J., DEELSTRA, G., HEYMAN, D. & VANMAELE, M. *Risk management of a bond portfolio using options.* 299-316. In this paper, we elaborate a formula for determining the optimal strike price for a bond put option, used to hedge a position in a bond. This strike price is optimal in the sense that it minimizes, for a given budget, either Value-at-Risk or Tail Value-at-Risk. Formulas are derived for both zero-coupon and coupon bonds, which can also

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be understood as a portfolio of bonds. These formulas are valid for any short rate model that implies an affine term structure model and in particular that implies a lognormal distribution of future zero-coupon bond prices. As an application, we focus on the Hull–White one-factor model, which is calibrated to a set of cap prices. We illustrate our procedure by hedging a Belgian government bond, and take into account the possibility of divergence between theoretical option prices and real option prices. This paper can be seen as an extension of the work of Ahn and co-workers [Ahn, D., Boudoukh, J., Richardson, M., Whitelaw, R., 1999. Optimal risk management using options. J. Financ. 54, 359-375], who consider the same problem for an investment in a share.

Cheung, K. C. *Optimal allocation of policy limits and deductibles.* 382-391. In this paper, we study the problems of optimal allocation of policy limits and deductibles. Several objective functions are considered: maximizing the expected utility of wealth assuming the losses are independent, minimizing the expected total retained loss and maximizing the expected utility of wealth when the dependence structure is unknown. Orderings of the optimal allocations are obtained.

Gupta, A. & Li, L. *Integrating long-term care insurance purchase decisions with saving and investment for retirement.* 362-381. Risk related to long-term care (LTC) is high for the elderly. Planning for LTC is now regarded as the 'third leg' of retirement planning. In this paper, planning for LTC is integrated with saving and investment decisions for an integrated approach to retirement planning. Optimal LTC insurance purchase decisions are obtained by developing a trade-off between post-retirement LTC costs and LTC insurance premiums paid and coverage received. Integrating insurance purchase with wealth evolution, consisting of saving and investment decisions, allows addressing affordability issues. Two-way branching models are used for the stochastic health events and asset returns. The problem, formulated as a nonlinearly constrained mixed-integer optimization problem, is solved using a heuristic. Sensitivity analyses are performed for initial health and wealth status. Some important aspects of an individual's behavioral preferences are also addressed in this framework to provide more robust decision support.

Kaishev, V. K., Dimitrova, D. S. & HAberman, S. *Modelling the joint distribution of competing risks survival times using copula functions.* 339-361. The problem of modelling the joint distribution of survival times in a competing risks model, using copula functions, is considered. In order to evaluate this joint distribution and the related overall survival function, a system of non-linear differential equations is solved, which relates the crude and net survival functions of the modelled competing risks, through the copula. A similar approach to modelling dependent multiple decrements was applied by Carriere [Carriere, J., 1994. Dependent decrement theory. Transactions, Society of Actuaries XLVI, 45-65] who used a Gaussian copula applied to an incomplete double-decrement model which makes it difficult to calculate any actuarial functions and draw relevant conclusions. Here, we extend this methodology by studying the effect of complete and partial elimination of up to four competing risks on the overall survival function, the life expectancy and life annuity values. We further investigate how different choices of the copula function affect the resulting joint distribution of survival times and in particular the actuarial functions which are of importance in pricing life insurance and annuity products. For illustrative purposes, we have used a real data set and used extrapolation to prepare a complete multiple-decrement model up to age 120. Extensive numerical results illustrate the sensitivity of the model with respect to the choice of copula and its parameter(s).

Kijima, M. & Wong, T. *Pricing of Ratchet equity-indexed annuities under stochastic interest rates.* 317-338. We consider the valuation of simple and compound Ratchet equity-indexed annuities (EIAs) in the presence of stochastic interest rates. We assume that the equity index

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follows a geometric Brownian motion and the short rate follows the extended Vasicek model. Under a given forward measure, we obtain an explicit multivariate normal characterization for multiple log-returns on the equity index. Using such a characterization, closed-form price formulas are derived for both simple and compound Ratchet EIAs. An efficient Monte Carlo simulation scheme is also established to overcome the computational difficulties resulting from the evaluation of high-dimensional multivariate normal cumulative distribution functions (CDFs) embedded in the price formulas as well as the consideration of additional complex contract features. Finally, numerical results are provided to illustrate the computational efficiency of our simulation scheme and the effects of various model and contract parameters on pricing.

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AASE, K. K. *Equilibrium in marine mutual insurance markets with convex operating costs.* 239-268. The article analyzes the possibility of reaching an equilibrium in a market of marine mutual insurance syndicates, called Protection and Indemnity Clubs, or P&I Clubs for short, displaying economies of scale. Our analysis rationalizes some empirically documented findings, and points out an interesting future scenario. We find an equilibrium in a market of mutual marine insurers, in which some smaller clubs, having operating costs above average, may grow larger relative to the other clubs in order to become more cost effective, and where medium to larger cost-efficient clubs may stay unchanged or some even downsize relative to the others. Some of the very large clubs suffering from diseconomies of scale may have a motive to further increase relative to the other clubs. According to observations, most clubs have, during the last decade, expanded significantly in size measured by gross tonnage of entered ships, some clubs have merged, but very few seem to have decreased their underwriting activity, in particular none of the really large ones. The analysis points to the following future scenario: The small and the medium to large clubs converge in size, while there is a possibility for some very large clubs to be present as well.

BROCKETT, P. L. & GOLDEN, L. L. *Biological and psychobehavioral correlates of credit scores and automobile insurance losses: toward an explication of why credit scoring works.* 23-63. The most important new development in the past two decades in the personal lines of insurance may well be the use of an individual's credit history as a classification and rating variable to predict losses. However, in spite of its obvious success as an underwriting tool, and the clear actuarial substantiation of a strong association between credit score and insured losses over multiple methods and multiple studies, the use of credit scoring is under attack because there is not an understanding of why there is an association. Through a detailed literature review concerning the biological, psychological, and behavioral attributes of risky automobile drivers and insured losses, and a similar review of the biological, psychological, and behavioral attributes of financial risk takers, we delineate that basic chemical and psychobehavioral characteristics (e.g., a sensation-seeking personality type) are common to individuals exhibiting both higher insured automobile loss costs and poorer credit scores, and thus provide a connection which can be used to understand why credit scoring works. Credit scoring can give information distinct from standard actuarial variables concerning an individual's biopsychological makeup, which then yields useful underwriting information about how they will react in creating risk of insured automobile losses.

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DENUIT, M., DEVOLDER, P. & GODERNIAUX, A.-C. *Securitization of longevity risk: pricing survivor bonds with Wang transform in the Lee-Carter framework*. 87-113. Longevity risk is a major issue for insurers and pension funds, especially in the selling of annuity products. In that respect, securitization of this risk could offer great opportunities for hedging. This article proposes to design survivor bonds which could be issued directly by insurers. In order to guaranty some transparency in the product, the survivor bond is based on a public mortality index. The classical Lee-Carter model for mortality forecasting is used to price a risky coupon survivor bond based on this index.

FRIESEN, G. *On the lack of participating policy usage by stock insurance companies.* 185-206. Stock insurers can reduce or eliminate agency conflicts between policyholders and stockholders by issuing participating insurance. Despite this benefit, most stock companies don't offer participating contracts. This study explains why. We study an equilibrium with both stock and mutual insurers in which stockholders set premiums to provide a fair expected return on their investment, and with a policyholder who chooses the insurance contract that maximizes her expected utility. We demonstrate that stockholders cannot profitably offer fully participating contracts, but can profitably offer partially participating insurance. However, when the policyholder participation fraction is high, the fair-return premium is so large that the policyholder always prefers fully participating insurance from the mutual company. Policies with lower levels of policyholder participation are optimal for policyholders with relatively high risk aversion, though such policies are usually prohibited by insurance legislation. Thus, the reason stock insurers rarely issue participating contracts isn't because the potential benefits are small or unimportant. Rather, profitability or regulatory constraints simply prevent stock insurers from exercising those benefits in equilibrium.

GRACE, M. F. & PHILLIPS, R. D. *The allocation of governmental regulatory authority: federalism and the case of insurance regulation.* 207-238. We investigate the incentives states have to provide insurance regulatory services in an efficient manner. Regulation of the insurance industry in the United States is unique, as it is conducted primarily at the state level whereas the majority of insurance sales are interstate. Consistent with predictions from the federalism literature, we find evidence of trans-state externalities, as states with small domestic insurance markets are less efficient producers of insurance regulation and appear to allow states that choose to expend the greatest resources to regulate for them. In addition, states with more profitable domestic insurers are shown to export greater levels of regulation, suggesting extraterritorial regulation may erect modest barriers to entry. We find evidence of increasing economies of scale in the production of insurance regulation after controlling for these regulatory externalities.

HAU, A. *Insurance, bond covenants, and under- or over-investment with risky asset reconstitution.* 3-22. Traditional theory predicts that the shareholders of a limited liability company financed partly by bonds may underinvest by not replacing damaged company assets. It also precludes the possibility of overinvestment. By relaxing the restrictive assumption maintained under traditional theory, namely, that the effects of reconstituting damaged assets are nonstochastic, this article shows that both over and underinvestment are possible. It is shown that these moral hazard problems can be mitigated by incorporating appropriate insurance requirements into bond covenants. Moreover, it is shown that the insurance requirements for alleviating underinvestment and overinvestment are quite different. Particularly, for underinvestment, the required insurance only needs to make the bonds riskless in the best asset reconstitution states of the loss states in which the company value falls short of the promised bond repayment; however, for overinvestment, the required insurance should make the bonds totally riskless. The difference in insurance requirements is especially important when insurance is actuarially unfavorable such that more-than-required insurance is always undesirable.

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Lee, K. *Wealth, income, and optimal insurance.* 175-184. This article considers the decision to purchase insurance against possible losses of a property or wealth. The decision involves a standard economic trade-off between the benefit of protection against loss and the cost of insurance premium. The premium is paid out of the income and decreases the consumption of other goods and services, rather than out of wealth and decreases the property or wealth. The demand for insurance depends mainly on the income and preferences. As a result, unlike in the standard model, a fair premium is neither necessary nor sufficient for the optimality of full coverage insurance. Rather, the individuals with higher incomes purchase full coverage insurance even at unfair prices of insurance while the individuals with lower income purchase partial coverage insurance at a fair price.

Lin, Y. & Grace, M. F. *Household life cycle protection: life insurance holdings, financial vulnerability, and portfolio implications.* 141-173. Using the Survey of Consumer Finances, we examine the life cycle demand for different types of life insurance. Specifically, we test for the consumer's aversion to income volatility resulting from the death of a household's wage-earner through the purchase of life insurance. We first develop a financial vulnerability index to control for the risk to the household. We then examine the life cycle demand for life insurance using several definitions of life insurance. We find, in contrast to previous research, that there is a relationship between financial vulnerability and the amount of term life or total life insurance purchased. In addition, we find older consumers use less life insurance to protect a certain level of financial vulnerability than younger consumers. Secondly, our study provides evidence that life insurance demand is jointly determined as part of a household's portfolio. Finally, we consider the impact of family members' nonmonetary contribution on the household's life cycle protection decision. Our results provide some evidence that households take into account the value of nonmonetary contribution in their insurance purchase.

Pauly, M. V. & Herring, B. *The demand for health insurance in the group setting: can you always get what you want?* 115-140. To what extent do health benefits obtained in the employment-based setting reflect individual preferences? We examine this question by comparing the relationship between person-level characteristics and the plans they obtain in a group setting to the relationship observed in the individual insurance market, using data from the 1996-1997 and 1998-1999 Community Tracking Study's Household Surveys. We also examine the effect of unions on group choice. Our structural models of the demand for insurance indicate that plans obtained in the group setting often reflect underlying individual preferences for insurance, but we consistently observe significantly different effects of ethnicity and unionization.

Viswanathan, K. S., Lemaire, J., Withers, K., Armstrong, K., Baumritter, A., Hershey, J. C., Pauly, M. V. & Asch, D. A. *Adverse selection in term life insurance purchasing due to the BRCA1/2 genetic test and elastic demand.* 65-86. Consumer groups fear that the use of genetic testing information in insurance underwriting might lead to the creation of an underclass of individuals who cannot obtain insurance; thus, these groups want to ban insurance companies from accessing genetic test results. Insurers contend that such a ban might lead to adverse selection that could threaten their financial solvency. To investigate the potential effect of adverse selection in a term life insurance market, a discrete-time, discrete-state, Markov chain is used to track the evolution of twelve closed cohorts of women, differentiated by family history of breast and ovarian cancer and age at issue of a 20-year annually renewable term life insurance policy. The insurance demand behavior of these women is tracked, incorporating elastic demand for insurance. During the 20-year period, women may get tested for BRCA1/2 mutations. Each year, the insurer calculates the expected premiums and expected future benefit payouts which determine the following year's premium schedule. At the end of each policy year, women can change their life insurance benefit,

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influenced by their testing status and premium changes. Adverse selection could result from (i) differentiated benefits following test results; (ii) differentiated lapse rates according to test results; and (iii) differentiated reactions to price increases. It is concluded that with realistic estimates of behavioral parameters, adverse selection could be a manageable problem for insurers.

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BOYER, M. M. *Resistance (to fraud) is futile.* 461-492. This article studies a static principal-agent model of insurance fraud using a costly state verification approach. In an economy where there are two types of agents, the Truths, who always report the true state of the world, and the Dares, who dare misreport the true state of the world, I show that no separating contract exists. Furthermore, if the proportion of Dares is large enough, then the pooling contract, the amount of fraud and the number of agents found to have committed fraud are independent of the Dares' exact proportion in the economy. Finally, I show that investment in prevention can be useless if the proportion of Dares is large enough, which means that investing in prevention becomes a waste of resources. This last result holds when the proportion of Dares is large. When their proportion is small, investing in prevention reduces fraud.

BREWER III, E., CARSON, J. M., ELYASIANI, E., MANSUR, I. & SCOTT, W. L. *Interest rate risk and equity values of life insurance companies: a GARCH-M model.* 401-423. The importance of managerial decisions related to interest-sensitive cash flows has received considerable attention in the insurance literature. Consistent with the interest-sensitive nature of insurer assets and liabilities, empirical research has shown that insurer insolvency is significantly related to interest rate volatility. We investigate the interest rate sensitivity of monthly stock returns of life insurers based on a generalized autoregressive conditionally heteroskedastic in the mean (GARCH-M) model. We examine three different portfolios (equally weighted, risk-based, and size-based) with binary variables to explicitly account for varying interest rate strategies adopted by the Federal Reserve System. Results based on data for the period 1975 through 2000 indicate that life insurer equity values are sensitive to long-term interest rates and that interest sensitivity varies across subperiods and across risk-based and size-based portfolios. The results complement insolvency research that links insurer financial performance to changes in interest rates.

COLE, C. R., LEE, R. B. & MCCULLOUGH, K. A. *A test of the eclectic paradigm: evidence from the U.S. reinsurance market.* 493-522. This study provides a test of the eclectic paradigm with data from U.S. reinsurers. The U.S. reinsurance industry provides a unique setting to test the eclectic paradigm due to the extensive data available on U.S. reinsurers and the well-developed literature related to reinsurance. The ability to test the hypotheses related to the eclectic paradigm in a service industry and incorporate industry-specific factors adds to the eclectic paradigm literature which has traditionally focused primarily on manufacturing firms. In addition, the application of the eclectic paradigm to the reinsurance industry provides an empirical framework that combines several prior streams of literature which examine the reinsurer's decision to internationalize. The current study includes firm-specific factors, country-specific factors of the international markets, and factors related to the U.S. reinsurance industry. This article finds support for traditional factors impacting globalization such as host market size, loss experience, and competitiveness as well as reinsurer's ability to expand based on available capacity. Understanding the importance of firm-, country-, and industry-specific factors is key for managers, as analyzing these issues in isolation may lead to

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an incomplete picture of the factors impacting the internationalization decision, hindering managers' ability to make decisions that are in the best interest of the firm. With the continued interdependence of the world reinsurance marketplace, as well as the recent expansion of the European Union, internationalization issues are of critical importance not only to U.S. insurers, reinsurers, and regulators, but also to their global counterparts.

Coleman, T. F., Kim, Y., Li, Y. & Patron, M. *Robustly hedging variable annuities with guarantees under jump and volatility risks.* 347-376. Recent variable annuities offer participation in the equity market and attractive protection against downside movements. Accurately quantifying this additional equity market risk and robustly hedging options embedded in the guarantees of variable annuities are new challenges for insurance companies. Due to sensitivities of the benefits to tails of the account value distribution, a simple Black–Scholes model is inadequate in preventing excessive liabilities. A model which realistically describes the real world price dynamics over a long time horizon is essential for the risk management of the variable annuities. In this article, both jump risk and volatility risk are considered for risk management of lookback options embedded in guarantees with a ratchet feature. We evaluate relative performances of delta hedging and dynamic discrete risk minimization hedging strategies. Using the underlying as the hedging instrument, we show that, under a Black–Scholes model, local risk minimization hedging can be significantly better than delta hedging. In addition, we compare risk minimization hedging using the underlying with that of using standard options. We demonstrate that, under a Merton's jump diffusion model, hedging using standard options is superior to hedging using the underlying in terms of the risk reduction. Finally, we consider a market model for volatility risks in which the at-the-money implied volatility is a state variable. We compute risk minimization hedging by modeling at-the-money Black–Scholes implied volatility explicitly; the hedging effectiveness is evaluated, however, under a joint model for the underlying price and implied volatility. Our computational results suggest that, when implied volatility risk is suitably modeled, risk minimization hedging using standard options, compared to hedging using the underlying, can potentially be more effective in risk reduction under both jump and volatility risks.

Froot, K. A. *Risk management, capital budgeting, and capital structure policy for insurers and reinsurers.* 273-299. This article builds on Froot and Stein in developing a framework for analyzing the risk allocation, capital budgeting, and capital structure decisions facing insurers and reinsurers. The model incorporates three key features: (i) value-maximizing insurers and reinsurers face product-market as well as capital-market imperfections that give rise to well-founded concerns with risk management and capital allocation; (ii) some, but not all, of the risks they face can be frictionlessly hedged in the capital market; and (iii) the distribution of their cash flows may be asymmetric, which alters the demand for underwriting and hedging. We show these features result in a three-factor model that determines the optimal pricing and allocation of risk and capital structure of the firm. This approach allows us to integrate these features into: (i) the pricing of risky investment, underwriting, reinsurance, and hedging; and (ii) the allocation of risk across all of these opportunities, and the optimal amount of surplus capital held by the firm.

Golden, L. L., Wang, M. & Yang, C. *Handling weather related risks through the financial markets: considerations of credit risk, basis risk, and hedging.* 319-346. The profits of many businesses are strongly affected by weather related events, and insurance against weather related risks (acts of God) has been a traditional domain for transfer of (certain) of these risks. Recent innovations in the capital market have now provided financial instruments to transfer and hedge some of these risks. Unlike insurance solutions, however, using these financial derivative instruments creates a situation in which the return to the purchaser of the instrument is no longer perfectly correlated with the loss experienced. Such a mismatch creates new risks which must be examined and evaluated as part of ascertaining cost effective risk

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management plans. Two newly engendered risks, basis risk (the risk created by the fact that the return from the financial derivative is a function of weather at a prespecified geographical location which may not be identical to the location of the firm) and credit risk (the risk that the counterparty to the derivative contract may not perform), are analyzed in this article. Using custom tailored derivatives from the over the counter market can decrease basis risk, but increases credit risk. Using standardized exchange traded derivatives decreases credit risk but increases basis risk. Here also the effectiveness of using hedging methods involving forwards and futures having linear payoffs (linear hedging) and methods using derivatives having nonlinear payoffs such as those involving options (nonlinear hedging) for the purpose of hedging basis risk are examined jointly with credit risk.

GRUNDL, H. & SCHMEISER, H. *Capital allocation for insurance companies — what good is it?* 301-317. In their 2001 Journal of Risk and Insurance article, Stewart C. Myers and James A. Read Jr. propose to use a specific capital allocation method for pricing insurance contracts. We show that in their model framework no capital allocation to lines of business is needed for pricing insurance contracts. In the case of having to cover frictional costs, the suggested allocation method may even lead to inappropriate insurance prices. Beside the purpose of pricing insurance contracts, capital allocation methods proposed in the literature and used in insurance practice are typically intended to help derive capital budgeting decisions in insurance companies, such as expanding or contracting lines of business. We also show that net present value analyses provide better capital budgeting decisions than capital allocation in general.

LI, C.-S., LIU, C.-C. & YEH, J.-H. *The incentive effects of increasing per-claim deductible contracts in automobile insurance.* 441-459. A new rating system of automobile insurance for vehicle damage in Taiwan was launched in 1996, introducing a deductible that increases with the number of claims. In this article, we provide a theoretical rationale for the existence of an increasing per-claim deductible system and show that the new system is most likely an optimal choice for those insured who tend to have lower claims probability when incentives are present. Using a unique dynamic data set, we are able to conduct a natural experiment to examine the incentive effects (both positive and negative) by looking at the change in claim tendency before and after switching between two deductible plans: an increasing per-claim deductible and a zero deductible. Our results provide direct evidence of the effects of deductible structures on claim behavior.

PINQUET, J., AYUSO, M. & GUILLEN, M. *Selection bias and auditing policies for insurance claims.* 425-440. Selection bias results from a discrepancy between the range of estimation of a statistical model and its range of application. This is the case for fraud risk models, which are estimated on audited claims but applied on incoming claims in the design of auditing strategies. Now audited claims are a minority within the parent sample since they are chosen after a severe selection performed by claims adjusters. This article presents a statistical approach that counteracts selection bias without using a random auditing strategy. A two-equation model on audit and fraud (a bivariate probit model with censoring) is estimated on a sample of claims where the experts are left free to take the audit decision. The expected overestimation of fraud risk derived from a single-equation model is corrected. Results are close to those obtained with a random auditing strategy, at the expense of some instability with respect to the regression components set. Then we compare auditing policies derived from the different approaches.

SHARPE, I. G. & STADNIK, A. *Financial distress in Australian general insurers.* 377-399. We develop and test a statistical model to identify Australian general insurers experiencing financial distress over the 1999-2001 period. Using a logit model and two measures of financial distress we are able to predict, with reasonable confidence, the insurers more likely to

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be distressed. They are generally small and have low return on assets and cession ratios. Relative to holdings of liquid assets they have high levels of property and reinsurance assets, and low levels of equity holdings. They also write more overseas business, and less motor insurance and long-tailed insurance lines, relative to fire and household insurance.

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Baranoff, E. G., Sager, T. W. & Papadopoulos, S. *Capital and risk revisited: a structural equation model approach for life insurers.* 653-681. The role of risk in the capital structure decision of firms is a vast topic in finance. Commonly, models of the interrelationship between risk and capital enumerate as many risk factors as possible by appropriate proxies, with the goal of detailing their individual effects. In this study of the life insurance industry for 1994 through 2000, we take a broader, holistic view of enterprise risk, identifying two groups of insurer risk factors that arise from the major activities of life insurers: investing and underwriting. We call the group of risk factors associated with investing asset risk, and the group associated with underwriting product risk. After specifying other important determinants of capital structure as controls, we allow all other risk factors to find expression in residual error. Within this framework, our focus is to compare two candidate measures for the role of proxy for asset-related risks. One measure, called regulatory asset risk (RAR), derives from the regulatory tradition of concern with solvency and is related to the $C-1$ component of risk-based capital. The other measure, called opportunity asset risk (OAR), is motivated by traditional finance concerns with market risk and reflects volatility of returns. Product-related risks are proxied by underwriting exposures in different product lines. We employ structural equation modeling (SEM), which uses longitudinal factor analysis. SEM is an innovative technique for such studies, in dealing effectively with multiple structural equations, autocorrelated panel data, unobserved underlying factors, and other issues that are not simultaneously addressed in other methodologies. We find that RAR and OAR are not equivalent proxies for asset risks. Although overlapping to some extent, each illuminates different aspects of the asset risk-capital interrelationship. In particular, RAR does not seem to affect the capital structure decision of small firms, although OAR does. We interpret this to suggest that small firms as a whole are not as sensitive in their capital decisions to the proxy of regulatory concerns as to the proxy of market opportunity. This contrasts with large insurers, for whom both RAR and OAR have significant effects on capital that comport with the finite risk hypothesis. More detailed analysis suggests that the lack of effect of RAR for small insurers may result from RAR's proxying some factors that induce finite risk for part of the small insurer sample, and other factors that favor the excessive risk hypothesis.

Butler, R. J. *JRI, JF and the internet: coauthors, new authors and empirical research.* 713-737. This article examines how the Internet has changed the work of academic researchers and addresses the question of how expanded Internet usage has affected Journal of Risk and Insurance (JRI) and Journal of Finance (JF) articles, including the shift to empirical research, joint authorship, and new authorship. Internet availability significantly increased joint authorship overall (more for JF than for JRI), shifting upwards a strong secular trend toward working with other researchers. Another big impact of the Internet has been to increase the number of new authors (more for JRI than for JF).

Hoy, M. & Witt, J. *Welfare effects of banning genetic information in the life insurance market: the case of BRCA1/2 genes.* 523-546. We investigate whether regulations that ban insurance companies from access to individuals' genetic tests are likely to lead to substantial adverse selection costs for the specific example of the so-called breast cancer (BRCA1/2) genes. Using

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a data set including economic, demographic, and relevant family background information to simulate the market for 10-year term life insurance, we find generally only modest adverse selection costs associated with such a regulatory ban. However, for family background groups that are at high risk for carrying one of these genes, the efficiency cost of adverse selection may be significant should the test become widely adopted.

KLING, A. & GATZERT, N. *Analysis of participating life insurance contracts: a unification approach.* 547-570. Fair pricing of embedded options in life insurance contracts is usually conducted by using risk-neutral valuation. This pricing framework assumes a perfect hedging strategy, which insurance companies can hardly pursue in practice. In this article, we extend the risk-neutral valuation concept with a risk measurement approach. We accomplish this by first calibrating contract parameters that lead to the same market value using risk-neutral valuation. We then measure the resulting risk assuming that insurers do not follow perfect hedging strategies. As the relevant risk measure, we use lower partial moments, comparing shortfall probability, expected shortfall, and downside variance. We show that even when contracts have the same market value, the insurance company's risk can vary widely, a finding that allows us to identify key risk drivers for participating life insurance contracts.

KLING, A., RICHTER, A. & RUSS, J. *The impact of surplus distributio on the risk exposure of with profit life insurance policies including interest rate guarantees.* 571-589. This article analyzes the numerical impact of different surplus distribution mechanisms on the risk exposure of a life insurance company selling with profit life insurance policies with a cliquet-style interest rate guarantee. Three representative companies are considered, each using a different type of surplus distribution: a mechanism, where the guaranteed interest rate also applies to surplus that has been credited in the past, a slightly less restrictive type in which a guaranteed rate of interest of 0 percent applies to past surplus, and a third mechanism that allows for the company to use former surplus in order to compensate for underperformance in "bad" years. Although at the outset all contracts offer the same guaranteed benefit at maturity, a distribution mechanism of the third type yields preferable results with respect to the considered risk measure. In particular, throughout the analysis, our representative company 3 faces ceteris paribus a significantly lower shortfall risk than the other two companies. Offering "strong" guarantees puts companies at a significant competitive disadvantage relative to insurers providing only the third type of surplus distribution mechanism.

LAI, G. C., MCNAMARA, M. J. & JENG, V. *Efficiency and demutualisation: evidence from the US life insurance industry in the 1980s and 1990s.* 683-711. This article examines the efficiency changes of U.S. life insurers before and after demutualization in the 1980s and 1990s. We use two frontier approaches (the value-added approach and the financial intermediary approach) to measure the efficiency changes. In addition, we use Malmquist indices to investigate the efficiency and productivity change of converted life insurers over time. The results using the value-added approach indicate that demutualized life insurers improve their efficiency before demutualization. On the other hand, the evidence using the financial intermediary approach shows the efficiency of the demutualized life insurers relative to mutual control insurers deteriorates before demutualization and improves after conversion. The difference in the results between the two approaches is due to the fact that the financial intermediary approach considers financial conditions. The results of both approaches suggest that there is no efficiency improvement after demutualization relative to stock control insurers. There is, however, efficiency improvement relative to mutual control insurers when the financial intermediary approach is used.

LI, D., MOSHIRIAN, F., WEE, T. & NGUYEN, P. *The demand for life insurance in OECD countries.* 637-652. This article examines the determinants of life insurance consumption in

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OECD countries. Consistent with previous results, we find a significant positive income elasticity of life insurance demand. Demand also increases with the number of dependents and level of education, and decreases with life expectancy and social security expenditure. The country's level of financial development and its insurance market's degree of competition appear to stimulate life insurance sales, whereas high inflation and real interest rates tend to decrease consumption. Overall, life insurance demand is better explained when the product market and socioeconomic factors are jointly considered. In addition, the use of GMM estimates helps reconcile our findings with previous puzzling results based on inconsistent OLS estimates given heteroscedasticity problems in the data.

POTTIER, S. W. *The determinants of private debt holdings: evidence from the life insurance industry*. 591-612. Life insurers hold the majority of private debt. Lenders in the private debt market must have the ability to evaluate the credit quality of borrowers and to perform ongoing risk monitoring. The purpose of this study is to examine the determinants of private debt holdings in the life insurance industry. The results suggest that larger insurers, insurers with higher financial quality, mutual insurers, publicly traded insurers, insurers facing stringent regulation, and insurers with greater cash holdings are more prevalent lenders in the private debt market.

ZHU, Y. *One-period model of individual consumption, life insurance, and investment decisions*. 613-636. This article studies individuals' optimal decisions on consumption, life insurance, and stock purchases in a one-period framework. With exponential utility functions, individuals' life insurance and stock purchases are independent of each other; life insurance purchases are affected only by individuals' future income, bequest intensity, risk attitude, survival probability, and the insurance risk premium; stock purchases are affected only by individuals' risk attitude, the risk-free rate of return, the stock return, and stock volatility. With power utility functions, life insurance and stock purchases are positively related with each other and are affected by all the factors.

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COWELL, R. G., VERRALL, R. J. & YOON, Y. K. *Modeling operational risk with Bayesian networks*. 795-827. Bayesian networks is an emerging tool for a wide range of risk management applications, one of which is the modeling of operational risk. This comes at a time when changes in the supervision of financial institutions have resulted in increased scrutiny on the risk management of banks and insurance companies, thus giving the industry an impetus to measure and manage operational risk. The more established methods for risk quantification are linear models such as time series models, econometric models, empirical actuarial models, and extreme value theory. Due to data limitations and complex interaction between operational risk variables, various nonlinear methods have been proposed, one of which is the focus of this article: Bayesian networks. Using an idealized example of a fictitious on line business, we construct a Bayesian network that models various risk factors and their combination into an overall loss distribution. Using this model, we show how established Bayesian network methodology can be applied to: (1) form posterior marginal distributions of variables based on evidence, (2) simulate scenarios, (3) update the parameters of the model using data, and (4) quantify in real-time how well the model predictions compare to actual data. A specific example of Bayesian networks application to operational risk in an insurance setting is then suggested.

FIELDS, L. P., FRASER, D. R. & KOLARI, J. W. *Is bancassurance a viable model for financial*

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firms? 777-794. The bancassurance (i.e., bank and insurance company combinations) model for financial firm architecture has been widely used in Europe and recently has been adopted by U.S. financial firms. We provide evidence regarding the viability of bancassurance combinations for U.S. and non-U.S. mergers between 1997 and 2002. We find positive gains and no significant risk shifts for shareholders of bidding firms, and that higher CEO stock ownership results in less positive gains for shareholders. These and other results suggest that bancassurance firms are viable entities that may play an important role in the future evolution of the U.S. financial system.

HUANG, R. J. & TZENG, L. Y. *Optimal tax deductions for net losses under private insurance with an upper limit.* 883-893. Kaplow (1992b) shows that governments should not provide a tax deduction for net losses when a private insurance contract is available. However, his findings rest on the assumption that the private insurance is proportional coverage. We find that Kaplow's conclusions may not hold when the private insurance contract contains an upper limit. The findings of our article show that Kaplow's conclusions are sensitive to the assumption that the insurance contract is available in the private market.

JIN, H. J. *Heavy-tailed behavior of commodity price distribution and optimal hedging demand.* 863-881. This study explores the importance of imposing a correct distributional hypothesis in a risk management strategy, by comparing hedge ratios under the restrictive normality assumption to those under the generalized stable distribution. Concepts are illustrated for the case of a representative Pennsylvania dairy farm manager who purchases corn as a feed input. The results show that time processes of corn prices and basis risk in five Pennsylvania regions do not correspond to the normal distribution, and they more correctly correspond to one of the stable distribution set. The estimated hedge ratios under the stable distribution are typically larger than those under the normal distribution. The difference would be a bias from imposing a wrong distributional assumption.

KER, A. & ERGUN, A. T. *On the revelation of private information in the U.S. Crop Insurance Program.* 761-776. The crop insurance program is a prominent facet of U.S. farm policy. The participation of private insurance companies as intermediaries is justified on the basis of efficiency gains. These gains may arise from either decreased transaction costs through better established delivery channels and/or the revelation of private information. We find empirical evidence suggesting that private information is revealed by insurance companies via their reinsurance decisions. However, it is unlikely that such information will be incorporated into subsequent premium rates by the government.

LIGON, J. A. & THISTLE, P. D. *The organizational structure of insurance companies: the role of heterogeneous risks and guaranty funds.* 851-862. We examine a market with observably heterogeneous risks and a government sponsored guaranty fund and consider whether it is optimal to form a single insurer or separate insurers for each consumer type. Given the economic environment, pooling never dominates the formation of separate insurance companies. This result provides an incentive for the phenomenon of insurance fleets.

LIU, J. W. & BROWNE, M. J. *First-best equilibrium in insurance markets With transaction costs and heterogeneity.* 739-760. We investigate extensions of the classic Rothschild and Stiglitz (1976) (RS) model of adverse selection under asymmetric information. In RS, low-risk customers are worse off owing to an externality created by high-risk buyers in the market. We find critical changes in insurance buyers' behavior under the joint assumptions of transaction costs and buyer heterogeneity with respect to either risk aversion or wealth. Combining transaction costs and heterogeneity, we find a separating equilibrium in which neither high-risk nor low-risk individuals are penalized due to information asymmetry.

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Regan, L. & Hur, Y. *On the corporate demand for insurance: the case of Korean nonfinancial firms.* 829-850. Several theories have been developed to explain the motives for corporate insurance purchases, but there are few empirical tests of these theories. Furthermore, the empirical results are not consistent across studies, suggesting the need for further research. This study uses accounting data for 433 publicly listed nonfinancial firms in Korea to test the determinants of insurance demand for the period 1990 through 2001. Our results support the theory that firm size, tax considerations, and firm ownership are important determinants of insurance demand. Firms that are members of chaebols demand more insurance than unaffiliated firms, all else equal. Contrary to theory, our results also indicate that firms that have higher debt-to-equity ratios demand less insurance than less leveraged firms, and that firms that have greater liquidity demand more insurance. This might be related to the overall high debt levels of firms in the period leading up to the Korean financial crisis in 1997, but that investigation is beyond the scope of this study.

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Dufresne, D. *Stochastic life annuities.* 136-157. This paper gives analytic approximations for the distribution of a stochastic life annuity. It is assumed that returns follow a geometric Brownian motion. The distribution of the stochastic annuity may be used to answer questions such as "What is the probability that an amount F is sufficient to fund a pension with annual amount y to a pensioner aged x?". The main idea is to approximate the future lifetime distribution with a combination of exponentials, and then apply a known formula (due to Marc Yor) related to the integral of geometric Brownian motion. The approximations are very accurate in the cases studied.

Frees, E. W. *James C Hickman: an actuary who made a difference.* 1-16.

Gavrilova, N. S. & Gavrilov, L. A. *Search for predictors of exceptional human longevity: Using computerized genealogies and Internet resources for human longevity study.* 49-67. This paper explores new opportunities provided by the ongoing revolution in information technology, computer science, and Internet expansion for studies of exceptional human longevity. To this aim, the detailed family data for 991 alleged centenarians born between 1875 and 1899 in the United States were extracted from publicly available computerized family histories of 75 million individuals available at the Rootsweb site. To validate the age of the centenarians, these records were linked first to the Social Security Administration Death Master File records (for death date validation) and then to the records of the U.S. censuses for 1900, 1910, and 1920 (for birth date validation). The results of this cross-validation study demonstrated that computerized genealogies may serve as a useful starting point for developing a reliable family-linked scientific database on exceptional human longevity. The resulting database on centenarians with validated ages was used in the study of the predictors of exceptional human longevity, including familial factors and early-life living conditions. The comparison of households where children (future centenarians) were raised (using data obtained through linkage of genealogies to early U.S. censuses) with control households drawn from the Integrated Public Use Microdata Series for the 1900 U.S. census suggests that a farm background (farm ownership by parents in particular) and childhood residence in the Western region of the United States may be predictive for subsequent survival to age 100.

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These findings are consistent with the hypothesis that lower burden of sickness during childhood (expressed as lower child mortality in families of farm owners and families living in the West) may have far-reaching consequences for survival to extreme old ages. Analysis of familial factors suggests that there may be a link between exceptional longevity and a person's birth order. It was found that first-born daughters are three times more likely to survive to age 100, compared to later-born daughters of higher birth orders (7). First-born sons are twice more likely to become centenarians compared to sons having birth order between four and six. Further within-family comparison of centenarians with their siblings found that the protective effect of being first-born is driven mostly by the young maternal age at the person's birth (being born to a mother younger than 25 years). Being born to a young mother is an important within-family predictor of human longevity, and even at age 75 it is still important to be born to young mother to survive to 100 years.

Gutierrez, C. & MacDonald, A. S. *Adult polycystic kidney disease and insurance: A case study in genetic heterogeneity.* 90-118. Adult Polycystic Kidney Disease (APKD) is a single-gene autosomal dominant genetic disorder leading to end-stage renal disease (ESRD, meaning kidney failure). It is associated with mutations in either of two genes, APKD1 and APKD2, and although diagnosis is still mostly by ultrasonography rather than DNA-based tests, this may change in the future. Recent studies have shown that the rates of onset of ESRD associated with APKD1 mutations are much greater than those associated with APKD2 mutations, a form of genetic heterogeneity that differs from, for example, familial breast cancer. In this paper we model the the impact of mutations in APKD1 or APKD2 on critical illness insurance, extending the work of Gutierrez and Macdonald (2003), which was based on studies predating DNA-based tests. We then extend the model to life insurance and show that the financial impact is strongly dependent on the availability of treatment (dialysis and transplant), but that if it is available, extra premiums for life insurance are modest. We show that genetic heterogeneity introduces a novel problem, because carrying an APKD2 mutation is less risky than having a family history of APKD. Thus, in jurisdictions where family history may be used in under underwriting but genetic tests may not, it may be illegal to use knowledge that benefits the applicant.

Landsman, Z. M. & Sherris, M. *An actuarial premium pricing model for nonnormal insurance and financial risks in incomplete markets.* 119-135. A model for pricing insurance and financial risks, based on recent developments in actuarial premium principles with elliptical distributions, is developed for application to incomplete markets and heavy-tailed distributions. The pricing model involves an application of a generalized variance premium principle from insurance pricing to the pricing of a portfolio of nontraded risks relative to a portfolio of traded risks. This pricing model for a portfolio of insurance or financial risks reflects preferences for features of the distributions other than mean and variance, including kurtosis. The model reduces to the Capital Asset Pricing Model for multinormal portfolios and to a form of the CAPM in the case where the traded and nontraded risks have the same elliptical distribution.

Li, S.-H. & Chan, W.-S. *The Lee-Carter model for forecasting mortality, revisited.* 68-89. Interrupting phenomena are commonly encountered in time-series data analysis with the study of mortality trends being no exception. Nevertheless, previous demographic forecasts have paid little attention to the existence of such phenomena. In this study we use mortality data from Canada and the United States to perform time-series outlier analysis on the key component of the Lee-Carter model: the mortality. We begin by employing a systematic outlier detection process to ascertain the timing, magnitude, and persistence of any outliers present in historical trends of the mortality index. We then try to match the identified outliers with important events that could possibly justify the vacillations in human mortality levels. At the same time, we adjust the effect of the outliers for model reestimation. The empirical

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results indicate that the outlier adjusted model could achieve better fits and more efficient forecasts of variables such as the central rates of death and the life expectancies at birth. Finally, we conclude our study with possible extensions on the valuations of life annuities and the probabilistic distribution of the highest attained age, incorporating the effect of mortality improvement portrayed by the revised model.

MacDonald, B.-J. & Cairns, A. J. G. *The impact of DC pension systems on population dynamics.* 17-48. This study investigates the risk inherent in defined contribution (DC) pension plans on an individual and aggregate basis, based on U.S. data. Our aim is to gain insight into the consequences of a DC pension scheme becoming the predominant pillar of retirement income for an entire society. Using the stochastic simulated output of a DC flexible age-of-retirement model, we first determine the optimal investment strategies. We then examine the demographic retirement dynamics of an entire population of DC pension plan participants. We observe that even for the most risk-averse plan members there is a high level of uncertainty in an individual's age at retirement. At the aggregate population level, we find that this uncertainty does not get dampened to any great extent by a diversification effect. Instead, the central role played by the market in determining retirement dates results in significant variation in the dependency ratio (the ratio of retirees to workers) over time. In addition, an attempt to ameliorate the outcome by introducing additional realistic features in the DC population modeling did little to dampen this volatility, which suggests that countries dominated by DC schemes of this type may, over time, be exposed to significant risk in the size of its labor force.

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Albrecher, H. & Hartinger, J. *A risk model with multilayer dividend strategy.* 43-64. In recent years various dividend payment strategies for the classical collective risk model have been studied in great detail. In this paper we consider both the dividend payment intensity and the premium intensity to be step functions depending on the current surplus level. Algorithmic schemes for the determination of explicit expressions for the Gerber-Shiu discounted penalty function and the expected discounted dividend payments are derived. This enables the analytical investigation of dividend payment strategies that, in addition to having a sufficiently large expected value of discounted dividend payments, also take the solvency of the portfolio into account. Since the number of layers is arbitrary, it also can be viewed as an approximation to a continuous surplus-dependent dividend payment strategy. A recursive approach with respect to the number of layers is developed that to a certain extent allows one to improve upon computational disadvantages of related calculation techniques that have been proposed for specific cases of this model in the literature. The tractability of the approach is illustrated numerically for a risk model with our layers and an exponential claim size distribution.

Bellini, F. & Caperdoni, C. *Coherent distortion risk measures and higher-order stochastic dominances.* 35-42. We show that the only coherent distortion risk measure that is consistent with respect to 3-convex order and hence with stochastic dominance of order 3 is the expected value, thus generalizing previous results of Hurlimann and solving a problem posed by Yamai and Yoshiba.

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Cossette, H. & Delwarde, A. *Pension plan valuation and mortality projection: A case study with mortality data.* 1-34. It is now well documented that human mortality globally declined during the course of the twentieth century. These mortality improvements pose a challenge for pricing and reserving in life insurance and for the management of public pension regimes. Assuming a further continuation of the stable pace of mortality decline, a Poisson log-bilinear projection model is applied to population mortality data to forecast future death rates. Then a relational model embedded in a Poisson regression approach is used to merge a dynamic mortality table based on data of a large population (in this case the Canadian province of Quebec) to mortality data of a given pension plan (here the Regie des Rentes du Quebec) to create another dynamic mortality table, which can be used to make any assessments on the total costs of the pension plan. We provide at the end numerical examples that illustrate the impact of mortality improvements on a pension plan.

Kornya, P. S. *On approximating the individual risk model.* 77-98. Error bounds are developed for Kornya-Presman-type approximations to the individual risk model. In particular, error bounds are given for the compound Poisson approximation, with the Poisson parameter equal to the expected number of claims. The approximations considered are a modification by Hipp of an approximation originally developed by Kornya, as well as Kornya's original approximation. The error bounds are similar in concept to Hipp's original error bounds using concentration-functions, as refined by Cekanavicius, Roos, and others. Computation of the bounds, however, is considerably simplified. In particular, concentration function type bounds called width-norm bounds are calculated directly from the values of the approximation, avoiding completely the need for calculating a special auxiliary compound Poisson distribution. Two examples are given. Depending on the portfolio parameters, the width-norm error bounds may or may not be sharper than the Hipp-Roos error bounds. In any event, it is recommended that the simpler width norm calculation, possibly together with an increase in the order of the approximation, be considered in practical applications if the goal is to achieve a specified accuracy with the least amount of computation. For large portfolios, where the maximum claim on any one policy is relatively small compared to the expected aggregate claims, the width-norm error bounds compare quite favorably with error bounds developed by De Pril and by Dhaene.

Li, S. & Lu, Y. *Moments of the dividend payments and related problems in a Markov-modulated risk model.* 65-76. In this paper we derive some results on the dividend payments prior to ruin in a Markov modulated risk process in which the rate for the Poisson claim arrival process and the distribution of the claim sizes vary in time depending on the state of an underlying (external) Markov jump process $\{J(t); t_0\}$. The main feature of the model is the flexibility in modeling the arrival process in the sense that periods with very frequent arrivals and periods with very few arrivals may alternate, and that the states of $\{J(t); t_0\}$ could describe, for example, epidemic types in health insurance or weather conditions in car insurance. A system of integro-differential equations with boundary conditions satisfied by the nth moment of the present value of the total dividends prior to ruin, given the initial environment state, is derived and solved. We show that the probabilities that the surplus process attains a dividend barrier from the initial surplus without first falling below zero and the Laplace transforms of the time that the surplus process first hits a barrier without ruin occurring can be expressed in terms of the solution of the above-mentioned system of integro-differential equations. In the two-state model, explicit results are obtained when both claim amounts are exponentially distributed.

Lu, Y. & Tsai, C. C.-L. *The expected discounted penalty at ruin for a Markov-modulated risk process perturbed by diffusion.* 136-152. A Markov-modulated risk process perturbed by diffusion is considered in this paper. In the model the frequencies and distributions of the claims and the variances of the Wiener process are influenced by an external Markovian environment process with a finite number of states. This model is motivated by the flexibility

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in modeling the claim arrival process, allowing that periods with very frequent arrivals and ones with very few arrivals may alternate. Given the initial surplus and the initial environment state, systems of integro-differential equations for the expected discounted penalty functions at ruin caused by a claim and oscillation are established, respectively; a generalized Lundberg's equation is also obtained. In the two-state model, the expected discounted penalty functions at ruin due to a claim and oscillation are derived when both claim amount distributions are from the rational family. As an illustration, the explicit results are obtained for the ruin probability when claim sizes are exponentially distributed. A numerical example also is given for the case that two classes of claims are Erlang(2) distributed and of a mixture of two exponentials.

Willmot, G. E. & Woo, J.-K. *On the class of Erlang mixtures with risk theoretic applications.* 99-118. A wide variety of distributions are shown to be of mixed-Erlang type. Useful computational formulas result for many quantities of interest in a risk-theoretic context when the claim size distribution is an Erlang mixture. In particular, the aggregate claims distribution and related quantities such as stop-loss moments are discussed, as well as ruin-theoretic quantities including infinite time ruin probabilities and the distribution of the deficit at ruin. A very useful application of the results is the computation of finite-time ruin probabilities, with numerical examples given. Finally, extensions of the results to more general gamma mixtures are briefly examined.

Wu, R., Lu, Y. & Fang, Y. *On the Gerber-Shiu discounted penalty function for the ordinary renewal risk model with constant interest.* 119-135. In this paper we study the Gerber-Shiu discounted penalty function for the ordinary renewal risk model modified by the constant interest on the surplus. Explicit answers are expressed by an infinite series, and a relational formula for some important joint density functions is derived. Applications of the results to the compound Poisson model are given. Finally, a lower bound and an upper bound for the ultimate ruin probability are derived.

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North American Actuarial Journal

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Cox, S. H. & Lin, Y. *Natural hedging of life and annuity mortality risks.* 1-15. The values of life insurance and annuity liabilities move in opposite directions in response to a change in the underlying mortality. Natural hedging utilizes this to stabilize aggregate liability cash flows. We find empirical evidence that suggests that annuity writing insurers who have more balanced business in life and annuity risks also tend to charge lower premiums than otherwise similar insurers. This indicates that insurers who have a natural hedge have a competitive advantage. In addition, we show how a mortality swap might be used to provide the benefits of natural hedging.

Dornheim, H. & Brazauskas, V. *Robust and efficient methods for credibility: when claims are approximately gamma-distributed.* 138-158. As is well known in actuarial practice, excess claims (outliers) have a disturbing effect on the ratemaking process. To obtain better estimators of premiums, which are based on credibility theory, Künsch and Gisler and Reinhard suggested using robust methods. The estimators proposed by these authors are indeed resistant to outliers and serve as an excellent example of how useful robust models can be for insurance pricing. In this article we further refine these procedures by reducing the

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degree of heuristic arguments they involve. Specifically we develop a class of robust estimators for the credibility premium when claims are approximately gamma-distributed and thoroughly study their robustness-efficiency trade-offs in large and small samples. Under specific datagenerating scenarios, this approach yields quantitative indices of estimators' strength and weakness, and it allows the actuary (who is typically equipped with information beyond the statistical model) to choose a procedure from a full menu of possibilities. Practical performance of our methods is illustrated under several simulated scenarios and by employing expert judgment.

GERBER, H. U. & YANG, H. *Absolute ruin probabilities in a jump diffusion risk model with investment.* 159-169. This article considers the compound Poisson insurance risk model perturbed by diffusion with investment. We assume that the insurance company can invest its surplus in both a risky asset and the risk-free asset according to a fixed proportion. If the surplus is negative, a constant debit interest rate is applied. The absolute ruin probability function satisfies a certain integro-differential equation. In various special cases, closed-form solutions are obtained, and numerical illustrations are provided.

GODA, G. S. & RAMSAY, C. M. *Determining the optimum guarantee period for a one-life retirement annuity.* 100-112. We consider a risk averse retiree from a defined contribution plan who decides to purchase a onelife annuity with a guarantee period. Given the retiree has a bequest motive, we focus on the problem of determining the optimum length of the guarantee period. Assuming the retiree's bequest function is proportional to his or her utility function, we determine necessary and/or sufficient conditions under which the retiree would choose an annuity with (i) no guarantee period, (ii) the maximum guarantee period, or (iii) an intermediate guarantee period.

POWERS, M. R. *Using aumann-shapley values to allocate insurance risk: the case of inhomogeneous losses.* 113-127. The problem of allocating responsibility for risk among members of a portfolio arises in a variety of financial and risk-management contexts. Examples are particularly prominent in the insurance sector, where actuaries have long sought methods for distributing capital (net worth) across a number of distinct exposure units or accounts according to their relative contributions to the total "risk" of an insurer's portfolio. Although substantial work has been done on this problem, no satisfactory solution has yet been presented for the case of inhomogeneous loss distributions — that is, losses $X_(x)FX_$ such that $FX_t_(x)_FtX_(x)$ for some t_0. The purpose of this article is to show that the value-assignment method of nonatomic cooperative games proposed in 1974 by Aumann and Shapley may be used to solve risk-allocation problems involving losses of this type. This technique is illustrated by providing analytical solutions for a useful class of multivariatenormal loss distributions.

REN, J. *The discounted joint distribution of the surplus prior to ruin and the deficit at ruin in a spare andersen model.* 128-137. In this article, we consider the risk model with phase-type interclaim times. We first derive a simple matrix-form expression for the discounted joint density of the surplus prior to ruin and the deficit at ruin when the initial surplus is zero. Then we express the discounted joint density in terms of certain expected discounted penalty functions when the initial surplus is greater than zero. This result generalizes that in Gerber and Shiu (1997).

ROSENBERG, M. A., FREES, E. W., SUN, J., JOHNSON JR, P. H. & ROBINSON, J. M. *Predictive modeling with longitudinal data: a case study of wisconsin nursing homes.* 54-69. The recent development and availability of sophisticated computer software has facilitated the use of predictive modeling by actuaries and other financial analysts. Predictive modeling has been used for several applications in both the health and property and casualty sectors. Often these applications employ extensions of industry-specific techniques and do not make full use of

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information contained in the data. In contrast, we employ fundamental statistical methods for predictive modeling that can be used in a variety of disciplines. As demonstrated in this article, this methodology permits a disciplined approach to model building, including model development and validation phases. This article is intended as a tutorial for the analyst interested in using predictive modeling by making the process more transparent. This article illustrates the predictive modeling process using State of Wisconsin nursing home cost reports. We examine utilization of approximately 400 nursing homes from 1989 to 2001. Because the data vary both in the cross section and over time, we employ longitudinal models. This article demonstrates many of the common difficulties that analysts face in analyzing longitudinal health care data, as well as techniques for addressing these difficulties. We find that longitudinal methods, which use historical trend information, significantly outperform regression models that do not take advantage of historical trends.

STALLARD, E. *Trajectories of disability and mortality among the U.S. elderly population: evidence from the 1984-1999 nltcs.* 16-53. This article employs a longitudinal form of the Grade of Membership (GoM) model to specify and estimate a multivariate model of the trajectories of morbidity, disability, and mortality among longitudinally followed elderly respondents to the National Long-Term Care Survey (NLTCS) of 1984, 1989, 1994, and 1999. A distinct trajectory was constructed for each individual respondent to the survey. The trajectories described the progressive declines over time in physical and cognitive functioning among a nationally representative sample of the U.S. elderly population. The model was structured to represent simultaneously the essential features of the fixed frailty model of Vaupel, Manton, and Stallard and Strehler and Mildvan's model of linearly declining vitality. Unlike those models, however, the longitudinal GoM model was designed for easy and direct application to existing longitudinal data sets. The measurement space in the NLTCS application included from one to four sets of repeated measures for each survey respondent on 95 independent variables characterizing the nature and intensity of limitations in activities of daily living (ADLs), instrumental activities of daily living (IADLs), physical functioning, and cognitive functioning, as well as indicators of behavioral characteristics, medical conditions, subjective health, age, race, sex, institutional status, and survival status. The application showed that the model can be fitted to existing data and that the results were interpretable as generalizations of fixed frailty with linearly declining vitality.

TAYLOR, G. C. & MCGUIRE, G. *A synchronous bootstrap to account for dependencies between lines of business in the estimation of loss reserve prediction error.* 70-88. In this article we consider the situation in which an insurer requires a loss reserve, together with the estimated prediction error, in respect of a number of stochastically dependent lines of business, individually and in aggregate. We suppose that generalized linear models are used to estimate each of the individual loss reserves, and that bootstrapping is used to estimate prediction errors. Specialized forms of the bootstrap, referred to as synchronous bootstraps, are constructed to capture the dependencies. Numerical examples are given in which loss reserve forecasts and their prediction errors are obtained for individual lines of business and in aggregate.

WANG, S. *Normalized exponential tilting: pricing and measuring multivariate risks.* 89-99. This article discusses methods of risk-neutralizing multivariate probability distributions by applying exponential tilting to the joint probability density function with respect to a set of reference risks. To ensure consistent interpretations of the exponential tilting parameters, a normalization procedure is performed on the reference risks via percentile mapping to standard normal variables. The article establishes links between normalized exponential tilting and multivariate probability distortions. It provides efficient methods for computing risk-neutralized multivariate probability distributions, and it gives illustrative examples in pricing contingent claims on multiple risks.

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Booth, P. M. & Morrison, A. D. *Regulatory competition and life insurance solvency regulation in the European Union and United States.* 23-41. The economic reasons for life insurance regulation have not been well developed in the finance literature. In this paper we discuss some justifications that have been advanced for regulation and argue that they are not persuasive. The most rigorous arguments in favor of the regulation of life insurance companies are as follows. First, regulation can prevent the adverse affects of information asymmetries in markets for illiquid contracts. Second, regulation can be used to ensure that insurers commit to contracts. In the case of life insurers these contracts may be incomplete, and it may be difficult to determine the terms of the contracts objectively; this is particularly so with U.K. with-profit contracts, for example. These justifications for regulation, combined with a public choice analysis of regulation, lead us to conclude that regulation should be voluntary and provided by competing private and government agencies. Finally we propose a method of moving toward such a regulatory framework starting from the current regulatory institutions in the United States and the European Union (EU). An approach based on the "mutual recognition" concept used, at least in theory, in the EU would provide an approximation to the regulatory approach we believe can be justified by economic principles.

Boucher, J.-P., Denuit, M. & Guillen, M. *Risk classification for claim counts: a comparative analysis of various zero-inflated mixed Poisson and hurdle models.* 110-131. This paper presents and compares different risk classification models for the annual number of claims reported to the insurer. Generalized heterogeneous, zero-inflated, hurdle, and compound frequency models are applied to a sample of an automobile portfolio of a major company operating in Spain. A statistical comparison between models is performed with the help of various specification tests (Score and Hausman tests for nested models, Vuong test or information criteria for nonnested ones). Interesting results about claiming behavior are obtained.

Boyle, P. P. & Liew, S. S. *Asset allocation with hedge funds on the menu.* 1-22. Hedge funds have become an increasingly important asset class in recent years. This paper discusses the asset allocation decision of an investor who is considering investing in hedge funds. We develop a simple procedure that may help in making this decision when the assets consist of a core equity portfolio, the risk-free asset, and a hedge fund. A regime-switching framework is used to model the joint returns of the hedge fund and the equity market. We use monthly intervals so that the regimes can change only at most once a month. Within each regime the returns on the two risky assets are bivariate lognormal with constant parameters. These parameters are estimated from the empirical data. We show how to determine the optimal allocation of an investor, such as a pension plan, to hedge fund assets. Our procedure is based on the maximization of expected utility, and we use different horizons. We restrict the admissible strategies to buy-andhold strategies, so we do not allow for portfolio balancing. We illustrate the procedure with examples. We find that bias in the hedge fund expected return has an important impact on the results. We note that some hedge fund strategies have substantial left-tail risk to which investors may be very averse. This type of risk aversion is not adequately captured by the standard expected utility model, but it could be added as a constraint.

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DUNHAM, L. M. & FRIESEN, G. *An empirical examination of jump risk in U.S. equity and bond markets.* 76-91. Actuaries manage risk, and asset price volatility is the most fundamental parameter in models of risk management. This study utilizes recent advances in econometric theory to decompose total asset price volatility into a smooth, continuous component and a discrete (jump) component. We analyze a data set that consists of high-frequency tick-by-tick data for all stocks in the S&P 100 Index, as well as similar futures contract data on three U.S. equity indexes and three U.S. Treasury securities during the period 1999-2005. We find that discrete jumps contribute between 15% and 25% of total asset risk for all equity index futures, and between 45% and 75% of total risk for Treasury bond futures. Jumps occur roughly once every five trading days for equity index futures, and slightly more frequently for Treasury bond futures. For the S&P 100 component stocks, on days when a jump occurs, the absolute jump is between 80% and 90% of the total absolute return for that day. We also demonstrate that, in the cross section of individual stocks, the average jump beta is significantly lower than the average continuous beta. Cross-correlations within the bond and stock markets are significantly higher on days when jumps occur, but stockbond correlations are relatively constant regardless of whether or not a jump occurs. We conclude with a discussion of the implications of our findings for risk management.

LE ROUX, M. *A long term model of the dynamics of the S&P500 implied volatility surface.* 61-75. In this paper we present an econometric model of implied volatilities of S&P500 index options. First, we model the dynamics the CBOE VIX index as a proxy for the general level of implied volatilities. We then describe a parametric model of the implied volatility surface for options with a term of up to two years. We show that almost all of the variation in the implied volatility surface can be explained by the VIX index and one or two other uncorrelated factors. Finally, we present a model of the dynamics of these factors.

LIN, X. S. & LIU, X. *Markov aging process and phase-type law of mortality.* 92-109. In this article, we propose a finite-state Markov process with one absorbing state to model human mortality. A health index called physiological age is introduced and modeled by the Markov process. Under this model the time of death follows a phase-type distribution. The model possesses many desirable analytical properties useful for mortality analysis. Closed-form expressions are available for many quantities of interest including the conditional survival probabilities of the time of death and the actuarial present values of the whole life insurance and annuity. The heterogeneity or frailty effect of a cohort can be expressed explicitly. The model is also able to explain some stylized facts of observed mortality data. We fit the model to some Swedish population cohort data and life tables compiled by the U.S. Social Security Administration. The fitting results are very satisfactory.

MILIDONIS, A. & WANG, S. *Estimation of distress costs associated with downgrades using regime-switching models.* 42-60. We use a unique dataset of bond downgrades from a niche rating company that has been found to be reacting faster to publicly available information than its competitors. Using regime-switching models we propose risk measures to quantify stock return disturbances (distress costs) associated with the timing of downgrades. These risk measures are based on the Capital Asset Pricing Model (CAPM) and use the estimated parameters of the regime-switching models. We observe a noticeable switch from a low-volatility to a high-volatility regime one day before the day of downgrades. On average the volatility in stock returns triples around the time of downgrades, and the stock return process remains in the high-volatility regime for about three days. Using our proposed risk measure we find that stock returns are associated with distress costs of about 22*d% (where "d" is the daily market price of risk) over a window of 10 days before and after downgrades. These costs can be further separated between bond-rating companies that are designated by the SEC as nationally recognized to rate debt and those that are not.

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Bauerle, N. & Kotter, M. *Markov-modulated diffusion risk models.* 34-52. In this paper we consider Markov-modulated diffusion risk reserve processes. Using diffusion approximation we show the relation to classical Markov-modulated risk reserve processes. In particular we derive a representation for the adjustment coefficient and prove some comparison results. Among others we show that increasing the volatility of the diffusion increases the probability of ruin.

Denuit, M. & Frostig, E. *Association and heterogeneity of insured lifetimes in the Lee–Carter framework.* 1-19. This paper is devoted to the study of some unexpected consequences of the Lee–Carter model for mortality projection. The fact that survival probabilities are governed by a stochastic process induces some positive dependence between insured lifetimes (namely, association). This, in turn, has an impact on solvency capital (as measured by distortion risk measures, for instance). Failing to take this dependence into account, by assuming falsely that the lifetimes are independent, leads to systematic underestimations of the risk capital. The heterogeneity between the policy benefits and the insured lifetimes is also studied (with the help of majorisation, Schur-increasingness and a frailty model).

Holtan, J. *Pragmatic insurance option pricing.* 53-70. This paper deals with theoretical and practical pricing of non-life insurance contracts within a financial option pricing context. The market-based assumption approach of the option context fits well into the practical nature of non-life insurance pricing and valuation. The fundamental characteristics of most insurance markets, such as the apparent variation in insurer price offers for the same risk in the same market, support the need for a market based approach. The paper outlines insurance and option pricing in a parallel setup. First it takes a complete market approach, focusing on dynamic hedging, no-arbitrage and risk-neutral martingale valuation principles within insurance and options. Secondly it takes an incomplete market view by introducing supply and demand effects via purchasing preferences in the market. Finally the paper discusses market-based insurance price models, parameter estimation techniques and international best practice of insurance pricing. The general purpose of the paper is to describe and unite the headlines of the more or less common insurance and option pricing theory, and hence increase the pragmatic understanding of this theory from a business point of view.

Scollnik, D. P. M. *On composite lognormal-Pareto models.* 20-33. Recently, Cooray & Ananda (2005) proposed a composite lognormal-Pareto model for use with loss payments data of the sort arising in the actuarial and insurance industries. Their model is based on a lognormal density up to an unknown threshold value and a two-parameter Pareto density thereafter. Here we identify and discuss limitations of this composite lognormal-Pareto model which are likely to severely curtail its potential for practical application to real world data sets. In addition, we present two different composite models based on lognormal and Pareto models in order to address these concerns. The performance of all three composite models is discussed and compared in the context of an example based upon a well-known fire insurance data set.

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Buchwalder, M., Buhlmann, H., Merz, M. & Wuthrich, M. V. *Valuation portfolio in non-life insurance.* 108-125. The purpose of this paper is the construction of the Valuation Portfolio (VaPo) for a non-life insurance company. The VaPo represents the obligations of the insurer for the whole period of his insurance contracts. These obligations are not simply measured by a one-dimensional figure (as standard for reserves in practice), but are expressed as a portfolio of financial instruments. Hence, the actuarial reserves become multidimensional. The financial instruments in the VaPo are a properly chosen basis to represent the future cashflows resulting from the insurance contracts. In this setup, financial and technical risks are clearly separated. The financial fluctuations derive from the basis elements, the technical fluctuations are covered by an increased number of basis elements (VaPo protected against technical risks). We show how this protection can be calculated in the case of a non-life insurance company.

Grandits, P., Hubalek, F., Schachermayer, W. & Zigo, M. *Optimal expected exponential utility of dividend payments in a Brownian risk model.* 73-107.

Ronkainen, V., Koskinen, L. & Berglund, R. *Topical modelling issues in Solvency II.* 135-146. The main reasons for giving European insurance companies the option to apply internal models for calculating the main solvency requirement within the Solvency II framework is to enhance better risk management in the firms, and to provide the opportunity to derive a more accurate risk-oriented capital requirement than the standard Solvency Capital Requirement (SCR) could provide. The possibility to use internal models within pillar 1 basically means freedom to calculate the solvency requirement using some other formula and even principles than those given by the standard formula. This freedom is more limited with partial models. This paper gives a brief introduction and update to the Solvency II project, reviews and discusses some topical aspects of internal models from the supervisory point of view, and points out some relating results of the Quantitative Impact Studies carried out, thus far, in the EU by CEIOPS.

Sandstrom, A. *Solvency II: calibration for skewness.* 126-134. The standard formula for the calculation of the capital requirement within the EU's Solvency II project will be modular based. Each capital charge from the modules will be calculated consistent with the overall capital charge, i.e. with the same risk measure, the same confidence level and time horizon. If any of the underlying probability distributions are skewed, then the model must be calibrated for that to retain the consistency. This paper proposes and discusses one way of calibrating for skewness. The main objective of the paper is to show, by two simple examples, the effect of not calibrating for skewness if some of the underlying distributions are skew.

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Badescu, A. L., Drekic, S. & Landriault, D. *Analysis of a threshold dividend strategy for a MAP risk model.* 227-247. We consider a class of Markovian risk models in which the insurer collects premiums at rate $c1(c2)$ whenever the surplus level is below (above) a constant threshold level b. We derive the Laplace-Stieltjes transform (LST) of the distribution of the time to ruin as well as the LST (with respect to time) of the joint distribution of the time to ruin, the surplus prior to ruin, and the deficit at ruin. By interpreting that the insurer pays dividends continuously at rate $c1 - c2$ whenever the surplus level is above b, we also derive the

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expected discounted value of total dividend payments made prior to ruin. Our results are obtained by making use of an existing connection which links an insurer's surplus process to an embedded fluid flow process.

BADESCU, A. L., DREKIC, S. & LANDRIAULT, D. *On the analysis of a multi-threshold Markovian risk model.* 248-260. We consider a class of Markovian risk models perturbed by a multiple threshold dividend strategy in which the insurer collects premiums at rate ci whenever the surplus level resides in the i-th surplus layer, $i = 1, 2, n + 1$ where $n <??$. We derive the Laplace-Stieltjes transform (LST) of the distribution of the time to ruin as well as the discounted joint density of the surplus prior to ruin and the deficit at ruin. By interpreting that the insurer, whose gross premium rate is c, pays dividends continuously at rate $di = c - ci$ whenever the surplus level resides in the i-th surplus layer, we also derive the expected discounted value of total dividend payments made prior to ruin. Our results are obtained via a recursive approach which makes use of an existing connection, linking an insurer's surplus process to an embedded fluid flow process.

BUCH-KROMANN, T., ENGLUND, M., GUSTAFSSON, J., NIELSEN, J. P. & THURING, F. *Non-parametric estimation of operational risk losses adjusted for under-reporting.* 293-304. Not all claims are reported when a database for financial operational risk is created. The probability of reporting increases with the size of the operational risk loss, and converges towards one for big losses. Losses in operational risk have different causes, and usually follow a wide variety of distributional shapes. Therefore, a method for modelling operational risk based on one or two parametric models is deemed to fail. In this paper, we introduce a semi-parametric method for modelling operational risk that is capable of taking under-reporting into account and being guided by prior knowledge of the distributional shape.

CHIRAGIEV, A. & LANDSMAN, Z. M. *Multivariate Pareto portfolios: TCE-based capital allocation and divided differences.* 261-280. Determination of risk capital is a subject of active interest to researchers, regulators of financial institutions, and commercial vendors of financial products and services. Recently, there has been growing concentration among the insurance companies and regulators on the use of tail conditional expectation (TCE) as measure of risk. The present study examines the TCE-based portfolio allocation for multivariate dependent Pareto risks. This family is broadly popular in actuarial sciences, mostly because of modeling heavy-tailed dependent losses. We show that the tool of divided differences, actually important in numerical analysis and polynomial's approximations, is quite convenient in the problem of capital asset allocation.

HELLER, G. Z., STASINOPOULOS, D. M., RIGBY, R. A. & DE JONG, P. *Mean and dispersion modelling for policy claims costs.* 281-292. A model for the statistical analysis of the total amount of insurance paid out on a policy is developed and applied. The model simultaneously deals with the number of claims (zero or more) and the amount of each claim. The number of claims is from a Poisson-based discrete distribution. Individual claim sizes are from a continuous right skewed distribution. The resulting distribution of total claim size is a mixed discrete-continuous model, with positive probability of a zero claim. The means and dispersions of the claim frequency and claim size distribution are modeled in terms of risk factors. The model is applied to a car insurance data set.

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Asher, A. *Pension benefit design: flexibility and the integration of insurance over the life cycle.* 73-115. It is suggested that South African retirement schemes ought to be designed around the financial life cycle and the risks faced by the families of members at various stages of the cycle. This paper reviews what we know about the life cycle and the non-investment risks: principally death, disability, dismissal and divorce. Providing for death and disability within schemes would allow for an offset of these costs against that of retirement, for less in the way of underwriting and for economies of scope. It would also allow for the elimination of those statutory and private schemes that give partial cover for accidental causes of death and disability. The paper also criticises insurance arrangements that conflate the heterogeneous causes of disability. It then considers arguments for making scheme membership and various elements of design a legislative requirement. Against the common view, it is suggested that a relatively low level of saving should be required, but that life and disability cover ought to be compulsory as should annuitisation at retirement.

Dorrington, R. E. & Tootla, S. *South African annuitant standard mortality tables 1996-2000.* 161-184. This paper describes the data and the processes used to produce the first standard tables of mortality of South African immediate annuitants. A parametric curve was fitted to the data from the normal retirement ages up to age 85. Below the normal retirement ages the rates increasingly reflected the impact of higher mortality due to ill-health retirements and so the curve was blended into that of the most recent standard table of life-assured mortality (SA85-90). Above age 85 the estimates were thought to be unreliable and the extrapolation of the curve fit to the younger ages did not allow for the expected fall in the rate of increase in the rates with age. Thus rates above this age were estimated using a relationship proposed by Coale and Kisker. It was not possible to produce select rates or to decide on a trend in these rates over time.

Govender, P., Kambaran, N., Patchett, N., Ruddle, A., Torr, G. & Van Zyl, N. *Poverty and inequality in South Africa and the world.* 117-160. This article begins with a discussion of various definitions and concepts of poverty and inequality. It then distinguishes between objective and subjective concepts of poverty, temporary versus chronic poverty, and absolute versus relative poverty. The concept of inequality is discussed and compared with that of poverty. Specific measures of poverty and inequality are considered next. The measurement of poverty requires the choice of a welfare measure, a benchmark welfare level for identifying those in poverty (a poverty line), and the selection of one or more appropriate poverty indicators. The mathematically desirable features of a poverty or inequality measure are discussed, and the most commonly used measures are described. Some of the special considerations that arise when measuring poverty and inequality at the world level are then investigated, and this is followed by a discussion of the datasets available for producing these. Finally, actual estimates of poverty and inequality in South Africa and the world are examined,with a particular focus on trying to assess the trend in recent years. It seems fairly certain that the proportion of people in the world living in absolute poverty has declined significantly and consistently over the last few decades, and this trend is continuing. There is less agreement about trends in inequality. Progress against poverty has been very uneven across regions: there have been dramatic declines in Asia, but the situation in Africa has worsened. There is an ongoing debate about poverty and inequality trends in South Africa.

Johnson, L. F. & Dorweiler, P. *The potential effect of an HIV/AIDS vaccine in South Africa.* 49-72. This paper presents a model for assessing the potential effect of an HIV/AIDS vaccine in South Africa, and for calculating the amount of vaccine that would be required. A number of different hypothetical vaccine profiles and vaccine distribution strategies are

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considered. Results suggest that a sterilising vaccine could reduce the HIV incidence between 2015 and 2025 by up to 50%, while a disease-modifying vaccine would be unlikely to reduce HIV incidence by more than a third. The effect on AIDS mortality over the same period would be substantially smaller, and it is unlikely that any preventive vaccine would reduce AIDS mortality by more than 10% between 2015 and 2025.

SLATTERY, P. G. & KEMP, H. J. *Options for the development of the education and professional qualification of South African actuaries.* 1-47. This paper investigates the various education and qualification systems available around the world for actuaries, and analyses which actuarial associations rely on their own examinations, those of other bodies, or those of universities. Particular attention is given to the Australian system, which in several ways parallels the South African situation. The paper outlines the pros and possible cons of a local education and qualification system for the actuarial profession in South Africa. Various options currently available to the Actuarial Society of South Africa relating to a local education and qualification system are discussed. Following the withdrawal of the localised final examinations by the Faculty and Institute of Actuaries at the end of 2006, the maintenance of the current system is not an option. Key issues that will need to be addressed if changes are to be made to the South African actuarial education system are highlighted.

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