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Insurance: Mathematics & Economics

Volume **32**(2), 2003

Andersson, F. & Skogh, G. *Quality, self-regulation, and competition: the case of insurance.* 267-280. In this paper, insurers' credibility problems explain contracting, co-operation, and regulation in the insurance industry. First, it is noted that cheating by policyholders may be eliminated if the insurer withholds compensation on the basis of detecting careless behaviour with high enough probability. Then, assuming that care taken is imperfectly observable and non-contractible, the problem that insurers may deceive policyholders is addressed. In a repeated game, insurers' building a reputation for being generous can sustain an efficient outcome. Finally, intra-industry co-operation is considered; it is shown that the industry's monitoring care and 'fair' compensation, while sustaining monopolistic pricing, mitigates negative credibility externalities.

Battauz, A. *Quadratic hedging for asset derivatives with discrete stochastic dividends.* 229-243. In this paper we analyze the effect of discrete stochastic dividends on the pricing and hedging of contingent claims, formulating the No Arbitrage condition without requiring the continuity of the implied gain process. We allow the stock jump dependence on an additional random source, still preserving the positivity of the stock value at the ex-dividend date. We characterize all the equivalent martingale measures and analyze the quadratic hedging approaches, as local risk minimizing and mean variance hedging.

Chang, S. C., Tzeng, L. Y. & Miao, J. C. Y. *Pension funding incorporating downside risks.* 217-228. This research extends Haberman and Sung's [IME 15] and Chang's [IME 24] works to study optimal funding strategies through the control mechanism. The paper further generalizes the previous research in three ways. First, downside risks, under-funding risk and over-contributing risk, are included additionally in the risk minimization criterion to obtain the optimal solutions. Second, we allow the weighting factors in the performance criterion to belong to a broader parametric family. Third, the rates of investment returns are assumed to follow the auto-regressive process. The above three generalizations indeed include traditional models as special cases. Furthermore, an actual case is employed to investigate their financial impacts on funding and contribution due to our generalization. The results show that neglecting to recognize the under-funding risk and the over-contribution risk will lead to a significant difference in optimal funding schedule. The weighting factors and the returns of investment also play critical roles in obtaining the optimal strategy.

Cossette, H. & Luong, A. *Generalized least squares estimators for covariance parameters for credibility regression models with moving average errors.* 281-293. Weighted least squares methods are developed for the estimation of variance–covariance parameters of credibility regression models with moving average dependent errors.

The estimators proposed are shown to be useful for constructing empirical Bayes estimators and credibility type estimators. Numerical examples are included to illustrate the proposed methods.

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JOUINI, E. & NAPP, C. *Comonotonic processes.* 255-265. We consider in this paper two Markovian processes X and Y, solutions of a stochastic differential equation with jumps, that are comonotonic, i.e., that are such that for all t, almost surely, X_t is greater in one state of the world than in another if and only if the same is true for Y_t. This notion of comonotonicity can be of great use for finance, insurance and actuarial issues.

We show here that the assumption of comonotonicity imposes strong constraints on the coefficiencts of the diffusion part of X and Y.

MØLLER, T. *Indifference pricing of insurance contracts in a product space model: applications.* 295-315. This paper determines fair premiums and optimal strategies under the financial variance and standard deviation principles of Schweizer [IME 28 (2001b)] for some insurance contracts with financial risk. Examples considered include unit-linked pure endowment contracts and integrated risk management solutions such as stop-loss contracts with barrier and financial stop-loss contracts. In each example we illustrate how the amount of information available to the reinsurer affects premiums and investment strategies. In addition, we determine the simple upper and lower bounds for the fair premiums that were obtained in [Finan. Stochast., in press].

PERRY, D., STADJE, W. & YOSEF, R. *Annuities with controlled random interest rates.* 245-253. We derive the expected values of annuities with random interest rates modelled by a reflected Brownian motion with a switchover at some positive level at which the drift and variance parameters change. The lifetime of the annuity is assumed to be exponentially distributed. The approach can be extended to the case of several switchover levels. We also consider other related models.

POWERS, M. R., VENEZIAN, E. C. & JUCÁ, I. B. *Of happy and helpless regulators: the asymptotics of ruin.* 317-330. We employ a simple single-period ruin probability as a useful tool for studying various asymptotic effects associated with increasing the number of exposure units, n, covered by an insurer. These effects include: the law of large numbers, the roles of capital and underwriting profit loadings, and adverse selection. For a model with known parameters, we find the necessary and sufficient condition for the ruin probability to converge to zero, as well as sufficient conditions for the normal approximation to provide asymptotically accurate comparative statics with respect to n. For a model with parameter-estimation errors, we find that the normal approximation no longer holds in general, and that the necessary and sufficient condition for the ruin probability to approach zero becomes much more restrictive.

RIBAS, C., MARÍN-SOLANO, J. & ALEGRE, A. *On the computation of the aggregate claims distribution in the individual life model with bivariate dependencies.* 201-215. In this paper, we focus on the computation of the aggregate claims distribution in the individual life model when the portfolio is composed of independent pairs of dependent risks. We prove that the bivariate probabilities associated to each couple under any intermediate positive (negative) dependency hypothesis about their mortality can always be written as a convex linear combination between the independent and the comonotonic (mutually exclusive) ones. Considering this structure for the bivariate probabilities, we then obtain two recursive schemes for computing the distribution of the aggregate claims of the portfolio. These recursions greatly facilitate the computation of the aggregate claims distribution of a life insurance (sub)portfolio exclusively composed of dependent couples, and ease the interpretation of the impact of the dependence on the associated stop-loss premiums. Numerical results are given to demonstrate the applicability and efficiency of the method.

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AMBAGASPITIYA, R. S. *Aggregate survival probability of a portfolio with dependent subportfolios.* 431-443. In this paper we consider a portfolio in which claim inter-arrival times have multivariate gamma distribution. We consider a multivariate gamma distribution obtained by dimension reduction technique. We obtain explicit solution of the aggregate survival probability of the portfolio.

ASMUSSEN, S. & MØLLER, J. R. *Risk comparisons of premium rules: optimality and a life insurance study.* 331-344. Consider a risk $Y_1(x)$ depending on an observable covariate x which is the outcome of a random variable A with a known distribution, and consider a premium $p(x)$ of the form $p(x) = \mathbb{E}Y_1(x) + \eta p_1(x)$. The corresponding adjustment coefficient γ is the solution of $\mathbb{E}\exp\{\gamma[Y_1(A) - p(A)]\} = 1$, and we characterize the rule for the loading premium $p_1(\cdot)$ which maximizes γ subject to the constraint $\mathbb{E}p_1(A) = 1$.

In a life insurance study, the optimal $p_1^*(\cdot)$ is compared to other premium principles like the expected value, the variance and the standard deviation principles as well as the practically important rules based on safe mortality rates (i.e., using the first order basis rather than the third order one). The life insurance model incorporates premium reserves, discounting, and interest return on the premium reserve but not on the free reserve. Bonus is not included either.

AVRAM, F. & USABEL, M. A. *Finite time ruin probabilities with one Laplace inversion.* 371-377. In this work we present an explicit formula for the Laplace transform in time of the finite time ruin probabilities of a classical Levy model with phase-type claims. Our result generalizes the ultimate ruin probability formula of Asmussen and Rolski [IME 10] — see also the analog queuing formula for the stationary waiting time of the M/Ph/1 queue in Neuts [Matrix-geometric Solutions in Stochastic Models: An Algorithmic Approach. Johns Hopkins University Press, Baltimore, MD, 1981] — and it considers the deficit at ruin as well.

BURNECKI, K., MARCINIUK, A. & WERON, A. *Annuities under random rates of interest — revisited.* 457-460. In the article we consider accumulated values of annuities-certain with yearly payments with independent random interest rates. We present the variance formulae of the final values of the annuities, which leads to a correction of Theorems 4.2, 4.3, 4.5 and 4.6 from Zaks [IME 28].

CHAN, W.-S., YANG, H. & ZHANG, L. *Some results on ruin probabilities in a two-dimensional risk model.* 345-358. Ruin theory under multi-dimensional risk models is very complex. Even in the two-dimensional case, the problem is challenging. In this paper, we consider a bivariate risk model. Three different types of ruin probabilities are defined. Using some results of one-dimensional risk processes, simple bounds for the two-dimensional ruin probabilities are obtained. Numerical examples and simulation experiments are given to illustrate the tightness of the bounds. A partial integral–differential equation satisfied by the two-dimensional ruin probabilities is derived. Although special cases and examples in this paper provide some exciting results, the problem of ruin probability in a multi-dimensional risk model is still far from solved. We hope that this paper stimulates more research by actuaries in this area.

DE WAEGENAERE, A., KAST, R. & LAPIED, A. *Choquet pricing and equilibrium.* 359-370. Choquet pricing and in particular Wang's premium principle, have recently been put forward as an alternative to traditional pricing principles in finance and insurance. With Choquet pricing, the price of an insurance contract or financial asset equals the Choquet integral of the corresponding payoff with respect to a concave sub-additive measure. Since the resulting pricing rule is non-linear, existing theories do not provide an answer to the question of whether equilibrium exists. We introduce a general equilibrium model that allows for non-linearity, and show that Choquet pricing is consistent with general equilibrium.

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JASCHKE, S. *A note on the inhomogeneous linear stochastic differential equation.* 461-464. The inhomogeneous linear SDE $X = C + \int_{0+} X_{-} \mathrm{d}R$, where X and C are càdlàg processes and R is a semimartingale, is solved. We give the solution in a 'nice' form, which is also more general than that of Yoeurp and Yor [Espace orthogonal à une semi-martingale, Unpublished, 1977]. This SDE has a very natural interpretation in finance. If C is a stochastic cash flow and R is the return process of a money market account (that is, $N_t = N_0 \mathcal{E}(R)_t$ is the value of the money market account at time t), then the solution X_t is the time-t value of the cash flow C accumulated in the money market account (at the stochastic interest 'rate' $\mathrm{d}R$) over the time interval $[0, t]$.

RENSHAW, A. E. & HABERMAN, S. *On the forecasting of mortality reduction factors.* 379 -401. Ways in which the so-called Lee–Carter time series approach to forecasting mortality patterns can be modified to forecast the possible future behaviour of mortality reduction factors (RFs) are described. A comparison is drawn with an alternative regression type approach to the forecasting of mortality RFs, based on the same model structure. Case studies, illustrating different aspects of the methodology, making use of both the more recent mortality experience of UK male pensioner lives and the historical mortality experience of UK male annuitants, are presented.

TSAI, C. C.-L. *On the expectations of the present values of the time of ruin perturbed by diffusion.* 413-429. In this paper, we consider the surplus process of the classical continuous time risk model containing an independent diffusion (Wiener) process. A compound geometric distribution and the expectations of the present values of the time of ruin due to oscillation and a claim, respectively, are studied. Recursive formulas and explicit expressions for the moments of, and the asymptotic formulas and the Tijms-type approximations for, the compound geometric distribution and the expectations of the present values of the time of ruin are derived. In addition, explicit analytical solutions to the compound geometric distribution and to these expectations can be obtained if the claim size distribution is a combination of exponentials or a mixture of Erlangs. Finally, a lower bound and an upper bound on the compound geometric distribution are proposed, provided the associated claim size distribution is in some of the reliability-based classes.

WILLMOT, G. E. & DICKSON, D. C. M. *The Gerber-Shiu discounted penalty function in the stationary renewal risk model.* 403-411. The discounted penalty function introduced by Gerber and Shiu [NAAJ 2] is considered in the stationary renewal risk model, where it is expressed in terms of the same discounted penalty function in the ordinary renewal risk model. This relationship unifies and generalizes known special cases. An invariance property between the stationary renewal risk model and the classical Poisson model with respect to the ruin probability is also generalized as a result.

ZHANG, C. & WANG, G. *The joint density function of three characteristics on jump-diffusion risk process.* 445-455. In this paper, we consider the jump-diffusion risk process, i.e., the classical risk process that is perturbed by diffusion. We derive the explicit expression for the joint density function of three characteristics: the time of ruin, the surplus immediately before ruin, and the deficit at ruin. By using the explicit joint density function, we extend some of Dickson's [IME 11] results to the jump-diffusion risk process. We also obtain the distribution of the time that the negative surplus first reaches the level zero.

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JOURNAL OF RISK AND INSURANCE

Volume **70**(2), 2003

COLQUITT, L. L. *An analysis of risk, insurance, and actuarial research: citations from 1996 to 2000.* 315-338. This article evaluates the relative significance of research published in 16 risk, insurance, and actuarial journals by examining the frequency of citations in these risk, insurance, and actuarial journals and 16 of the leading finance journals during the years 1996 through 2000. First, the article provides the frequency with which each sample risk, insurance, and actuarial journal cites itself and the other sample journals so as to communicate the degree to which each journal's published research has had an influence on the other sample journals. Then the article divides the 16 journals into two groups: (1) the risk and insurance journal group, and (2) the actuarial journal group, and ranks them within their group based on their total number of citations, including and excluding self-citations. A ranking within each group is based on the journals' influence on a per article published basis. Finally, this study observes and reports on the most frequently cited articles from the sample risk, insurance, and actuarial journals.

DOERPINGHAUS, H. I., SCHMIT, J. T. & YEH, J. H.-H. *Personal bias in automobile claims settlement.* 185-205. Despite the importance of claims handling practices to consumers and insurers, relatively little research has been done in this area. Our purpose here is to consider one aspect of automobile bodily injury liability claims management: the assignment of fault across parties as judged by the insured defendant's claims adjuster. Because legal fault assessment directly affects whether a defendant is held liable, and if so, for how much, this aspect of claims management is significant. We use accident data from the 1997 Insurance Research Council Closed Claim Survey to test for relationships between fault assessment and gender, age, and state comparative negligence rules. Controlling for actual fault, we find a greater assessment of fault against female, young, and elderly drivers. The results of the study are of interest to insurers seeking to provide better customer service, to consumer advocacy groups interested in claims settlement practices, and to insurance regulators.

DOWD, K. *Survivor bonds: a comment on Blake and Burrows.* 339-348. This article offers a critical assessment of the 'survivor bonds' (SBs) proposal recently put forward by Blake and Burrows, which calls for the government to issue bonds whose coupon payments are contingent on the proportions of retirees surviving to particular ages. It suggests that the proposal has considerable merit and discusses the circumstances in which SBs would be useful risk management tools for insurance companies. It also discusses alternatives such as reinsurance, hedging with life contracts, dynamic hedging, and other forms of survivor derivative. Finally, it evaluates and rejects the argument that SBs should be issued by the state.

EECKHOUDT, L., MAHUL, O. & MORAN, J. *Fixed-reimbursement insurance: basic properties and comparative statics.* 207-218. In a number of settings, insurance contracts specify a fixed reimbursement in the event of a loss which is not conditioned on the size of the realized loss. In this article, we explore the theoretical properties of this form of insurance and draw comparisons with other types of insurance policies, such as those based on coinsurance and deductibles. We also examine links between our results and those from the literature on precautionary saving.

LAURY, S. K. & MCINNES, M. M. *The impact of insurance prices on decision making biases: an experimental analysis.* 219-233. This article tests whether the use of endogenous risk categorization by insurers enables consumers to make better-informed decisions even if they do not choose to purchase insurance. We do so by adding a simple insurance market to an experimental test of optimal (Bayesian) updating. In some sessions, no insurance is offered. In others, actuarially fair insurance prices are posted, and a subset of subjects is allowed to

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purchase this insurance. We find significant differences in the decision rules used depending on whether one observes insurance prices. Although the majority of choices correspond to Bayesian updating, the incidence of optimal decisions is higher in sessions with an insurance option. Most subjects given the option to purchase actuarially fair insurance choose to do so. However, fewer subjects purchase insurance when the probability of a loss is higher.

LI, D., MOSHIRIAN, F. & SIM, A.-B. *The determinants of intra-industry trade in insurance services.* 269-287. In light of the growing significance of trade in financial services, and the emphasis placed on trade in financial services during the Uruguay round of trade negotiations, this article is the first study of the determinants of intra-industry trade (IIT) in insurance services. The article analyzes and measures the magnitude of IIT in insurance services for the United States. The empirical results of the determinants of IIT indicate that foreign direct investment in insurance services (FDI) is a significant contributor to the volume of trade in insurance services. These empirical findings confirm the new theoretical trade models that, unlike the traditional trade theory that considered trade and foreign direct investment in insurance services as substitutes, trade and FDI complement each other and hence multinational insurance companies are contributing to an increase in the volume of trade in insurance services. Furthermore, this study shows that trade intensity between the United States and its trading partners leads to product differentiation in insurance services and hence an increase in consumer welfare.

MA, Y.-L. & POPE, N. *Determinants of international insurers' participation in foreign non-life markets.* 235-248. Mirroring the trend in the broader marketplace, the global insurance industry is steadily moving toward increased liberalization and deregulation. This study seeks to develop the first empirical model that examines the importance of foreign market characteristics as they relate to the participation of international insurers in the non-life business of those countries. The analysis reveals that market structure is an important factor in determining whether international insurers participate in a given foreign market. In addition, for markets that are not competitive, removing trade barriers would significantly improve the desirability of those countries as host markets. The results also suggest that countries with higher gross domestic product tend to attract more involvement from international insurers. While this research focuses on the markets of industrialized countries, the findings will provide significant implications for those emerging markets that have not yet collected relevant data on a number of the variables included in this study.

YOSHIDA, K. & HORIBA, Y. *Japanese corporate pension plans and the impact on stock prices.* 249-268. This study focuses on the stock market impact of Japanese corporate decisions to adopt pension plans. Implementing corporate pension plans in Japan is complicated because they are heavily regulated by the government and the traditional lump-sum-only severance benefit plans already exist, requiring interfacing newly adopted plans with existing ones. Using the GARCH estimation method, the market model applied in this article for the relatively long period 1975-1995 yields evidence that suggests that the stock market responds to some of the more specific characteristics of adopted plans. Alternative specifications of the pension 'event' also suggest that relatively little of the market impact comes from public announcements about pension adoption occasioned by the release of a firm's financial statement.

ZOU, H., ADAMS, M. B. & BUCKLE, M. J. *Corporate risks and property insurance: evidence from the People's Republic of China.* 289-314. Using panel data (1997-1999) for 235 publicly listed companies in the People's Republic of China, this study empirically tests the linkage between corporate risks and the decision to purchase property insurance and its financial extent. To achieve these objectives, we first estimate a probit insurance participation decision model and then a fixed-effects insurance volume decision model with Heckman's sample

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selection correction. Our results indicate that the managerial decision to purchase property insurance is positively related to company size and insolvency risks. By contrast, the amount of property insurance purchased is positively related to systematic risks but negatively related to insolvency and unsystematic risks and company size. We find that the amount of property insurance used by Chinese companies can also be affected by other factors (e.g., the cash flow constraints). In addition, the decision to purchase property insurance and the financial extent to which it is used varies among Chinese companies according to their geographical location. However, state ownership does not appear to be an important determinant of the purchase of property insurance by Chinese publicly listed companies.

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North American Actuarial Journal

Volume **7**(2), 2003

Bolnick, H. J. *Designing a world-class healthcare system.* 1-23. Public health systems are finding it increasingly difficult to fund all the health care that their citizens want and need. Fiscal constraint is causing many nations to reconsider the respective roles of their public programs and private health insurance. The author examines the potential for and performance of health systems around the world and the advantages and disadvantages of public and private health financing. This analysis leads to the development of a framework for improvements in today's mix of health care financing and to high-level principles for a better-coordinated relationship between public and private programs. The role of health actuaries in moving toward more effective health systems is then explored.

Brown, R. L. & McDaid, J. *Factors affecting retirement mortality.* 24-43. As many countries consider mandatory individual retirement accounts as their answer to a secure social security system, the question arises as to whether all workers can get true 'market value' annuities when they retire. It is clear today that private-sector life annuities are priced assuming that the applicant is healthy — very healthy. Very little underwriting or risk classification now exists in the individual annuity market place. However, if a large percentage of the population were looking to annuitize their social security accounts upon retirement, there would be strong pressure for more risk classes in the annuity-pricing structure. Even without the advent of individual accounts for social security, the authors of this paper feel there may be real market opportunities for more risk classification in the individual annuity market and the offering of 'impaired life annuities.' Given that this pressure does or might soon exist, this paper reviews 45 recent research papers that look at factors that affect mortality after retirement. In particular, factors that seem to be important in predicting retirement mortality include age, gender, race and ethnicity, education, income, occupation, marital status, religion, health behaviours, smoking, alcohol, and obesity. For each factor, this paper gives highlights relative to the named factor of the impact expected from that variable as described in the 45 reviewed research papers. The authors believe there is a wealth of information contained in the summaries that follow, and it is our sincere hope that this paper will cause an increased interest in a more broadly based risk classification structure for individual annuities. Summaries of the 45 papers can be found at www.soa.org/sections/farm/farm.html.

Dhaene, J., Goovaerts, M. J. & Kaas, R. *Economic capital allocation derived from risk measures.* 44-59. We examine properties of risk measures that can be considered to be in line with some 'best practice' rules in insurance, based on solvency margins. We give ample motivation that all economic aspects related to an insurance portfolio should be considered in

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the definition of a risk measure. As a consequence, conditions arise for comparison as well as for addition of risk measures. We demonstrate that imposing properties that are generally valid for risk measures, in all possible dependency structures, based on the difference of the risk and the solvency margin, though providing opportunities to derive nice mathematical results, violates best practice rules. We show that so-called coherent risk measures lead to problems. In particular we consider an exponential risk measure related to a discrete ruin model, depending on the initial surplus, the desired ruin probability, and the risk distribution.

GUTIERREZ, C. & MACDONALD, A. S. *Adult polycystic kidney disease and critical illness insurance.* 93-115. 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 at least two genes, APKD1 and APKD2, but diagnosis is mostly by ultrasonography. We propose a model for critical illness (CI) insurance and estimate rates of onset of ESRD from APKD using two studies. Other events leading to claims under CI policies are included in the model, which we use to study (a) extra premiums under CI policies if the presence of an APKD mutation is known, and (b) the possible costs arising from adverse selection if this information is unavailable to insurers. The extra premiums are typically very high, but because APKD is rare, the possible cost of adverse selection is low. However, APKD is just one of a significant number of single-gene disorders, and this benign conclusion cannot be assumed to apply to all genetic disorders taken together. Moreover, ignoring known genetic risks in underwriting sets a precedent that could have unintended consequences for the underwriting of nongenetic risks of similar magnitude.

LANDSMAN, Z. M. & MAKOV, U. E. *Contaminated exponential dispersion loss models.* 116-127. A new family of contaminated exponential dispersion loss models is defined and some of its properties are examined. These models offer a wider family of loss distributions, allowing the modelling of extreme claims. Their usefulness is illustrated with real data.

MCLEISH, D. L. & REESOR, R. M. *Risk, entropy, and the transformation of distributions.* 128-144. Relative entropy optimization (REO) and distortion are tools for transforming probability measures, and they are closely related to the exponential family. In this paper, the authors establish the link between REO and distortion. REO is commonly used for pricing risky financial assets in incomplete markets, while distortion methods are widely used in pricing insurance risks and in risk management. The link between REO and distortion provides some intuition behind distorted risk measures such as value-at-risk. Furthermore, distorted risk measures having desirable properties, such as coherence, are easily generated via REO.

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