B.A.J. **10**, IV, 899-907 (2004)

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Australian Actuarial Journal

Volume **9**(4), 2003

Institute of Actuaries of Australia. *2004 Pre-budget submission to the Commonwealth Government.* 787-804. The 2004 Pre-Budget Submission to the Commonwealth Government, made in November 2003, focuses on areas of strong correspondence between the interests of the Commonwealth Government and areas in which actuaries and the actuarial profession play a leadership role; medical indemnity insurance, workers' compensation, long term care, health financing, intergenerational issues, environment and energy markets, and the Chief Government Actuary.

Institute of Actuaries of Australia, Accident Compensation Sub-Committee. *Submission to the Productivity Commission Interim Report on National Workers' Compensation and OHS Frameworks.*

Institute of Actuaries of Australia, General Insurance Practice Committee. *Submission to the Safety Rehabilitation and Compensation Commission on Workers' Compensation.* 723-724.

Institute of Actuaries of Australia, International Accounting Standards Board. *Submission to Australian Accounting Standards Board on Exposure Draft 115.* 669-677.

Institute of Actuaries of Australia, International Accounting Standards Committee. *Submission to Australian Accounting Standards Board on Exposure Draft 122.* 679-722.

Institute of Actuaries of Australia, International Accounting Standards Committee. *Submission to the International Accounting Standards Board Exposure Draft 5 (Insurance Contracts)* 729-768.

Institute of Actuaries of Australia, Superannuation and Employee Benefits Committee. *Submission to the Department of the Treasury on Draft Superannuation Splitting Regulations.* 773-785.

Institute of Actuaries of Australia, Superannuation and Employee Benefits Practice Committee. *Submission to the Senate Economics Legislation Committee Inquiry into the Taxation Laws Amendment (Superannuation Contributions Splitting) Bill 2003.* 725-727.

Elliot, R. J., Siu, T. K. & Yang, H. *On a generalised form of risk measure.* This paper surveys risk measures and proposes a generalised form of risk measure which covers most of the risk measures in literature such as volatility, Value-at-Risk, ruin probability, scenario-based risk measures, utility-based risk measures and risk function in decision theory. The generalised form of risk measure is defined based on three components of risk, namely

https://doi.org/10.1017/S1357321700002786 Published online by Cambridge University Press

uncertainty, exposure to uncertainty and the attitude toward risk of a consumer of risk information. The nature of risk and basic properties satisfied by the generalised form of risk measure are discussed.

SHERRIS, M. *Economic valuation: something old, something new.* 625-665. Economic valuation involves the application of economic assumptions and an economic model to derive the value of an asset or set of cashflows or the price of a commodity or service. This paper discusses the theory underlying economic valuation models of interest to actuaries and reviews their application to insurance and energy markets. The insurance CAPM is an example of an economic valuation framework that is used in practice and worthy of discussion, particularly in respect of recent developments in frictional cost approaches to insurance pricing. Electricity markets and economic valuation of electricity assets have been areas where actuaries have been involved in recent years. A new and recently developed economic valuation model using the theory of storage, and equilibrium analysis from microeconomics, is reviewed.

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INSURANCE: MATHEMATICS & ECONOMICS

Volume **35**(1), 2004

ALINK, S., LOWE, M. & WUTHRICH, M. V. *Diversification of aggregate dependent risks.* 77-95. We give a new proof of the central result in Wüthrich [Astin Bulletin **33**(1) (2003) 75]. For d identically and continuously distributed dependent risks $X_1, \ldots, X_d$, the probability of a large aggregate loss of $\sum_{i=1}^{d} X_i$ scales like the probability of a large individual loss of X_1, times a proportionality factor q_d. This factor q_d depends on the dependence strength and the tail behaviour of the individual risks X_1, i.e. whether this tail behaviour falls into the domain of attraction of the Fréchet, the Weibull or the Gumbel distribution; see Embrechts *et al.* [Modelling Extremal Events for Insurance and Finance, Springer, Berlin]. We give explicit formulas for q_2 and describe their behaviour with respect to the dependence strength.

DAHAN, M., FROSTIG, E. & LANGBERG, N. A. *Insurance contracts portfolios with heterogenous insured ages.* 137-153. In this paper we consider two portfolios: one of m endowment insurance contracts and one of m whole life insurance contracts. We introduce the majorization order and Schur functions. We assume that the owners of the portfolios are of different ages at issue time and are exposed to a common life-distribution. We study the effect of the ageing heterogeneity on the premiums and on the death benefits of the insurance contracts. We show that the premiums paid in both contracts and the death benefit awarded in the whole life contract are Schur functions. We provide upper and lower bounds for the premiums and for the death benefit, and compute the bounds for some distribution functions used frequently in the actuarial sciences.

DAHL, M. *Stochastic mortality in life insurance: market reserves and mortality-linked insurance contracts.* 113-136. In life insurance, actuaries have traditionally calculated premiums and reserves using a deterministic mortality intensity, which is a function of the age of the insured only. Here, we model the mortality intensity as a stochastic process. This allows us to capture two important features of the mortality intensity: time dependency and uncertainty of the future development. The advantage of introducing a stochastic mortality intensity is twofold. Firstly, it gives more realistic premiums and reserves, and secondly, it quantifies the risk of the insurance companies associated with the underlying mortality intensity. Having

https://doi.org/10.1017/S1357321700002786 Published online by Cambridge University Press

introduced a stochastic mortality intensity, we study possible ways of transferring the systematic mortality risk to other parties. One possibility is to introduce mortality-linked insurance contracts. Here the premiums and/or benefits are linked to the development of the mortality intensity, thereby transferring the systematic mortality risk to the insured. Alternatively, the insurance company can transfer some or all of the systematic mortality risk to agents in the financial market by trading derivatives depending on the mortality intensity.

Frangos, N. & Karlis, D. *Modelling losses using an exponential-inverse Gaussian distribution.* 53-67. An exponential-inverse Gaussian distribution is used to model the claim size distribution. The distribution has shorter tails than the Pareto distribution and it is considered as a plausible model for data without large tails. We present the model allowing for covariates. Properties of the model are discussed. An EM algorithm is provided to fit the model. The algorithm is quite simple and programmable without need for any special functions. The model can be seen as a random effect model for exponential survival times regression. A real data application using a car-insurance company portfolio data is provided.

Irgens, C. & Paulsen, J. *Optimal control of risk exposure, reinsurance and investments for insurance portfolios.* 21-51. We consider an insurance company whose insurance business follows a diffusion perturbated classical risk process. Assets can be invested in a risk-free asset or in a risky one, the return of the latter follows an independent diffusion perturbated classical risk process (in finance it is called a jump-diffusion process). The company can dynamically control the proportion of the insurance business that is ceded to reinsurers, and in addition it can dynamically cover parts of its remaining business using excess of loss reinsurance. It can also dynamically control the proportion of the assets it invests in the risky asset. We seek to find the controls that maximize expected utility of assets at a terminal time. We do so for three different utility functions. Let T be a fixed time and T_y be the time of ruin, i.e. the first time assets become nonpositive. Then the utility functions and terminal times are:

1. $U(y) = (\max\{0, y\})^c$, $0 < c < 1$ and terminal time is $T \wedge T_y$.
2. $U(y) = \ln y$ when $y > 0$ and $U(y) = -\infty$ when $y \leq 0$. Terminal time is T.
3. $U(y) = -\mathrm{e}^{-cy}$, $c > 0$, and terminal time is T.

It turns out that in spite of the complexity of the problem, provided there are no complicating constraints on the controls, the problems have rather simple solutions. Our vehicle is the Hamilton–Jacobi–Bellmann equations, and we seek to verify that the suggested solutions are in fact optimal among a fairly large easily verifiable admissible class of controls. We also discuss quantitative and qualitative aspects of the solutions.

Jang, J.-W. & Krvavych, Y. *Arbitrage-free premium calculation for extreme losses using the shot noise process and the Esscher transform.* 97-111. We consider the classical compound Poisson model of insurance risk, with the additional economic assumption of a positive interest rate. Insurance premiums, that are the present values of the aggregate claims, are priced by enforcing a no-arbitrage condition between the insurance and reinsurance markets. We note a duality result relating the aggregate accumulated claims and the shot noise process and so we apply the piecewise deterministic Markov processes theory. It is assumed that the claim sizes are Loggamma, Fréchet and truncated Gumbel to deal with heavy-tail losses in practice. We also use an exponential distribution for the case of non-heavy-tail losses. In order to obtain an arbitrage-free premium, we use an equivalent martingale probability measure obtained via the Esscher transform. In case of Loggamma and Fréchet distribution for claim sizes, which allow us to derive the explicit forms for the insurance premium calculations, we find that the arbitrage-free premiums can only be obtained by levying the loading in terms of claim arrival rate, not in terms of claim size measure. It is due to the non-existence of the Laplace transforms of Loggamma and Fréchet distribution for claim sizes after changing

https://doi.org/10.1017/S1357321700002786 Published online by Cambridge University Press

measure. We find that if claim size follows truncated Gumbel distribution, the security loading can be levied either in terms of claim arrival rate or in terms of claim size measure (or both). However, it is not possible for us to obtain the explicit form for the insurance premium calculation. Using the analytical/explicit forms for four different claim size distributions, we also provide several numerical examples.

Lu, T.-Y. & Yi, Z. *Generalized correlation order and stop-loss order.* 69-76. In this paper, we give a natural generalization of correlation order to higher dimensions, which has been investigated by Dhaene and Goovaerts [ASTIN Bulletin 26 (1996)] for the bivariate case. We show that the correlation order is stronger than upper orthant order and lower orthant order so that it implies stop-loss order. This extends the results of Dhaene and Goovaerts. Moreover, we give some properties of correlation order and its application to premium calculation principle, which also extends some results of Wang and Dhaene [IME 22 (1998)].

Tsai, C. C.-L. & Sun, L. *On the discounted distribution functions for the Erlang(2) risk process.* 5-19. In this paper, we derive explicit expressions for the discounted joint and marginal distribution functions of the surplus immediately prior to the time of ruin and the deficit at the time of ruin, and for the discounted distribution function of the amount of the claim causing ruin, for the Erlang(2) process. We also show that these distribution functions satisfy defective renewal equations. Moreover, we find the similarity between expressions for these functions based on the Erlang(1) and Erlang(2) processes, respectively.

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Journal of Risk and Insurance

Volume **71**(3), 2004

Chen, R. & Wong, K. A. *The determinants of financial health of Asian insurance companies.* 469-499. Previous studies of financial health of insurance companies are mainly focused on insurers operating in the United States and developed economies. This article focuses on the solvency of general (property-liability) and life insurance companies in Asia using firm data and macro data separately. It uses different classification methods to classify the financial status of both general and life insurance companies. With the exception of Japan, failures of insurers in Singapore, Malaysia, and Taiwan are nonexistent. We find that, first, the factors that significantly affect general insurers' financial health in Asian economies are firm size, investment performance, liquidity ratio, surplus growth, combined ratio, and operating margin. Second, the factors that significantly affect life insurers' financial health are firm size, change in asset mix, investment performance, and change in product mix, but the last three factors are more applicable to Japan. Third, the financial health of insurance companies in Singapore seems to be significantly weakened by the Asian Financial Crisis. As the insurance industry in different Asian economies is at different stages of development, they require different regulatory guidelines.

Gajek, L. & Zagrodny, D. *Reinsurance arrangements maximizing insurer's survival probability.* 421-435. The article concerns the problem of purchasing a reinsurance policy that maximizes the survival probability of the insurer. Explicit forms of the contracts optimal for the insurer are derived which are stop loss or truncated stop loss depending on the initial surplus, a quota to be spent on reinsurance and pricing rules of both the insurer and the reinsurer.

https://doi.org/10.1017/S1357321700002786 Published online by Cambridge University Press

GRACE, M. F., KLEIN, R. W. & KLEINDORFER, P. R. *Homeowner's insurance with bundled catastrophe coverage.* 351-379. We estimate the demand for homeowners insurance in Florida and New York with indicated loss costs as our proxy for the quantity of real insurance services demanded. We decompose the demand into the demand for coverage of catastrophe perils and the demand for noncatastrophe coverage and estimate these demand functions separately. Our results are relatively consistent in New York and Florida, including evidence that catastrophe demand is more price elastic than noncatastrophe demand. We also find evidence that consumers value options that expand coverage, buy more insurance when it is subsidized through regulatory price constraints, and consider state guaranty fund provisions when purchasing insurance.

HARAO, Y., INOUE, T. *On the cost structure of the Japanese property-casualty insurance industry.* 501-530. This article tests economies of scale and economies of scope for the property-casualty insurance companies in Japan. We fit a composite cost function to a set of Japanese firms over the period from 1980 to 1995 and employ an error components model. Our main findings are as follows. First, statistically significant economies of scale are observed in both Japanese firms and foreign firms operating in Japan. Second, economies of scope are also statistically significant for Japanese firms and most of the foreign insurers between the 'third sector' products and the rest of the property-casualty insurance lines.

KRIESEL, W. & LANDRY, C. *Participation in the National Flood Insurance Program: an empirical analysis for coastal properties.* 405-420. A perennial question about the National Flood Insurance Program is: how can participation be increased? An empirical analysis of individual-level data reveals that in a sample of coastal areas the participation rate is 49 percent of eligible properties. Participation responsiveness to price is inelastic, but it has been increased by the mandatory purchase requirements for mortgage borrowers. Easing conditions for participation in the program would probably not reduce flood control measures, such as seawalls, which may degrade beach conditions and coastal ecosystems.

MILEVSKY, M. A. & PROMISLOW, S. D. *Florida's pension election: from DB to DC and back.* 381-404. During the year 2002, the State of Florida's 600,000 public employees were given the choice of converting their traditional defined benefit (DB) pension plan into an individual-account defined contribution (DC) plan with full control over asset allocation and investment decisions. To mitigate some of the risk and uncertainty in the decision, the State granted each employee electing the DC plan an additional option to switch back (i.e., change their mind once) at any point prior to retirement. This option has been labeled the 2nd election by the State and the cost of reentry is fixed at the accumulated benefit obligation of their pension entitlement, which is the present value of the life annuity. Our article presents some original analytic insights relating to the optimal time and financial value of this unique 2nd election. Although our model is deterministic in nature, we believe that it provides a number of intuitive insights that are quite robust. Our results can be contrasted with Lachance, Mitchell, and Smetters (2003). We estimate that the increase in retirement wealth that arises from having the 2nd election is equivalent to at most 30 percent in future value, and only when utilized optimally. Furthermore, for most State employees above the age of 45, the 2nd election has little economic value because the DB plan dominates the DC plan from day one. Of course, it remains to be seen what percent of Florida's 600,000 employees will elect to behave rationally with their newfound pension autonomy.

WEISS, M. A. & CHUNG, J.-H. *US reinsurance prices, financial quality, and global capacity.* 437-467. The puzzle of underwriting cycles and insurance crises in property-liability insurance has led to numerous economic hypotheses and analyses, yet no single theory seems capable of explaining all of its aspects. Reinsurance is hypothesized to be a potential factor in observed

https://doi.org/10.1017/S1357321700002786 Published online by Cambridge University Press

cycles in the primary market; despite this, few underwriting cycle studies focus on reinsurance. The purpose of this research is to investigate determinants of reinsurance prices in the US. Nonproportional reinsurance is highlighted, since it is designed to cover the tail of the loss distribution and is considered to be relatively riskier than proportional reinsurance as a result. Separate samples of professional US reinsurers for property and for casualty are studied, based upon the reinsurers' writings of property versus casualty nonproportional reinsurance. The sample period is 1991-1995. The results support both the capacity constraint hypothesis and the risky debt hypothesis, and this is the first research to support both. A major innovation in this study is the use of capacity variables that are broken down by major region of the world.

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NORTH AMERICAN ACTUARIAL JOURNAL

Volume **8**(2), 2004

BROWN, R. L. & SURESH, U. *Further analysis of future Canadian health care costs.* 1-10. The Canadian public health care delivery system continues to experience growing needs for increased funding. The total health care delivery system today costs Canadians $98 billion a year or about 9.7% of GDP. Of that total cost, 71% is paid by the government, which means the taxpayers. While that may pale in comparison to the costs in the United States, it does make the Canadian system one of the five most expensive health care delivery systems in the world. While today's cost pressures are of major concern, of even more concern are the costs being projected by many participants in the current health care debate for the period when the baby boom makes higher demands on the Canadian health care delivery system.

Traditional projection methods, however, do not differentiate as to the use of health care systems between the elderly who survive the year versus those who die. This paper first looks at the impact that this differentiation could have on projected costs. It then looks at the impact that the wide use of advance directives might have on future health care costs and some of the issues surrounding their use.

LIU, C. S. & YANG, H. *Optimal investment for an insurer to minimize its probability of ruin.* 11-31. This paper studies optimal investment strategies of an insurance company. We assume that the insurance company receives premiums at a constant rate, the total claims are modeled by a compound Poisson process, and the insurance company can invest in the money market and in a risky asset such as stocks. This model generalizes the model in Hipp and Plum (2000) by including a risk-free asset. The investment behavior is investigated numerically for various claim-size distributions. The optimal policy and the solution of the associated Hamilton–Jacobi–Bellman equation are then computed under each assumed distribution. Our results provide insights for managers of insurance companies on how to invest. We also investigate the effects of changes in various factors, such as stock volatility, on optimal investment strategies, and survival probability. The model is generalized to cases in which borrowing constraints or reinsurance are present.

MILDENHALL, S. J. *A note on the Myers and Read capital allocation formula.* 32-44. The Myers and Read capital allocation formula is an important new actuarial result. This paper gives an overview of the Myers and Read result, explains its significance to actuaries, and provides a simple proof. Then it explains the assumption that the allocation formula makes on the underlying families of loss distributions as expected losses by line vary. It shows that this

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assumption does not hold when insurers grow by writing more risks from a discrete group of insureds — as is typically the case. Finally, it shows that this failure has a material impact on the predicted results in a realistically sized portfolio of property casualty risks which will severely limit the practical application of the Myers and Read allocation formula.

SUTTON, H. L., FELDMAN, R. & DOWD, B. *Disruption of a managed competition environment by low-ball premium bids: The Minnesota State Employees Group Insurance Program.* 45-55. This paper reviews the movement among multiple health plan options between 1994 and 1998 for Minnesota state employees whose work site was located in the Minneapolis/St. Paul metropolitan area. During this period the employer contribution was based on the lowest family premium bid from a qualified plan in the county of the employee's work site. In 1995 the largest individual practice association model HMO in the state, Medica, reduced its state premium by 25%, becoming the lowest-priced option. This resulted in massive transfers of enrollees between plans. The point of this study was to estimate the risk changes that resulted from these movements between plan options. We obtained enrollment data by age and gender from Blue Cross Blue Shield of Minnesota (Blue Cross) and applied age/gender risk weight factors derived from actuarial rate tables to the Blue Cross cells. Annual changes in risk weights by 10-20% were common in a number of Blue Cross subpopulations, and in one case, by more than 50%.

The Blue Cross POS plan experienced increases in risk and went into a death spiral, while a second Blue Cross plan with a more restrictive provider network started with low risk, but experienced increases in risk when the Medica plan was withdrawn. Similar demographic data were not available from other plans offered by the state and claim costs were confidential, so the results pertain only to Blue Cross risks. The question is raised as to whether managed competition can work without some means of adjusting premium rates to the expected cost level of the enrollees of a particular health plan. All carriers seemed reluctant to guarantee premium rates after the 1994-1998 experience, and the state soon became self-insured.

VENTER, G. G. *Capital allocation survey with commentary: (Bowles Symposium 2003)* 96-107. This paper discusses a number of methods of allocating capital to business units, for example, line of business, profit center, etc. The goals of capital allocation include testing the profitability of business units and determining which units could best be grown to add value to the firm. Methods of approaching these questions without allocating capital are included in the discussion.

WONG-FUPUY, C. & HABERMAN, S. *Projecting mortality trends: recent developments in the United Kingdom and the United States.* 56-83. The sustained reduction in mortality rates and its systematic underestimation has been attracting the significant interest of researchers in recent times because of its potential impact on population size and structure, social security systems, and (from an actuarial perspective) the life insurance and pensions industry worldwide. Despite the number of papers published in recent years, a comprehensive review has not yet been developed.

This paper attempts to be the starting point for that review, highlighting the importance of recently published research — most of the references cited span the last 10 years — and covering the main methodologies that have been applied to the projection of mortality rates in the United Kingdom and the United States. A comparative review of techniques used in official population projections, actuarial applications, and the most influential scientific approaches is provided. In the course of the review an attempt is made to identify common themes and similarities in methods and results.

In both official projections and actuarial applications there is some evidence of systematic overestimation of mortality rates. Models developed by academic researchers seem to reveal a trade-off between the plausibility of the projected age pattern and the ease of measuring the uncertainty involved. The Lee-Carter model is one approach that appears to solve this

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apparent dilemma. There is a broad consensus across the resulting projections: (1) an approximately log-linear relationship between mortality rates and time, (2) decreasing improvements according to age, and (3) an increasing trend in the relative rate of mortality change over age. In addition, evidence suggests that excessive reliance on expert opinion — present to some extent in all methods — has led to systematic underestimation of mortality improvements.

Zhu, W. *Risk-based capital factor determination with jump risk.* 84-95. Two approaches exist to set the risk-based capital (RBC) factors: the traditional probability of ruin approach and the more recently developed expected policyholder deficit approach, the latter of which has been accepted as a basis for NAIC regulatory RBC formula. For both approaches, there are examples illustrating the advantages of one over the other. The goal of this paper is to present a discussion of this issue by modeling the evolution of insurance risk as a jump-diffusion process. It is more consistent with modern financial theory to consider the issue in an intertemporal general equilibrium framework. By comparing the two approaches as applied to the jump-diffusion model, we may help clarify the ambiguity arising from using the two approaches in different examples.

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Scandinavian Actuarial Journal

2004-**4**

Gaier, J. & Grandits, P. *Ruin probabilities and investment under interest force in the presence of regularly varying tails.* 256-278. This paper consists of three parts. In the first part we derive the asymptotic behavior of the optimal ruin probability of an insurer who invests optimally in a stock in the presence of positive interest force and claims with tails of regular variation. Our results extend previously obtained results by Gaier & Grandits (2002) with zero interest, and by Klüppelberg & Stadtmüller (1998) without investment possibility. In the second part we prove an existence theorem for the integro-differential equation for the survival probability of an insurer, who invests a constant fraction of his wealth in a risky stock, and his remaining wealth in a bond with nonnegative interest. Our result extends a previously known result by Wang & Wu (2001). Finally, in the third part we derive the asymptotic behavior of the ruin probability of the insurer, introduced in the second part, in the presence of claims with tails of regular variation.

Gutiérrez, C. & Macdonald, A. S. *Huntingdon's disease, critical illness insurance and life insurance.* 279-313. We describe briefly a model of Huntington's disease (HD), a highly penetrant, dominantly inherited, fatal neurological disorder. Although it is a single-gene disorder, mutations are variable in their effects, depending on the number of times that the CAG trinucleotide is repeated in a certain region of the HD gene. The model covers: (a) rates of onset, depending on CAG repeat length as well as age; (b) post-onset rates of mortality; and (c) the distribution of CAG repeat lengths in the population. Using these, we study the critical illness and life insurance markets. We calculate premiums based on genetic test results that disclose the CAG repeat length, or more simply on a family history of HD. These vary widely with age and policy term; some are exceptionally high, but in a large number of cases cover could be offered within normal underwriting limits. We then consider the possible costs of adverse selection, in terms of increased premiums, under various possible moratoria on

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the use of genetic information, including family history. These are uniformly very small, because of the rarity of HD, but do show that the costs would be much larger in relative terms if family history could not be used in underwriting. We point out some difficulties involved in applying a moratorium that recognises simply a dichotomy between 'carriers' and 'non-carriers' of any mutation in a gene when these mutations are, in fact, very variable in their effects. These complexities suggest that restrictions on the disclosure, rather than on the use, of genetic information, if it became established as a principle, could deprive insurers of information needed for risk management even if not used in underwriting.

WILLMOT, G. E., DICKSON, D. C. M., DREKIC, S. & STANFORD, D. A. *The deficit at ruin in the stationary renewal risk model.* 241-255. Properties of the distribution of the deficit at ruin in the stationary renewal risk model are studied. A mixture representation for the conditional distribution of the deficit at ruin (given that ruin occurs) is derived, as well as a stochastic decomposition involving the residual lifetime associated with the maximal aggregate loss. When the individual claims have a phase-type distribution, the deficit at ruin is also of phase-type.

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