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Journal of Risk and Insurance

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Cowley, A. & Cummins, J. D. *Securitization of life insurance assets and liabilities.* 193-226.

Dhaene, J., Vanduffell, S., Goovaerts, M. J., Kaas, K. P. & Vyncke, D. *Comonotonic approximations for optimal portfolio selection problems.* 253-300. We investigate multiperiod portfolio selection problems in a Black and Scholes type market where a basket of 1 riskfree and m risky securities are traded continuously. We look for the optimal allocation of wealth within the class of "constant mix" portfolios. First, we consider the portfolio selection problem of a decision maker who invests money at predetermined points in time in order to obtain a target capital at the end of the time period under consideration. A second problem concerns a decision maker who invests some amount of money (the initial wealth or provision) in order to be able to fulfil a series of future consumptions or payment obligations. Several optimality criteria and their interpretation within Yaari's dual theory of choice under risk are presented. For both selection problems, we propose accurate approximations based on the concept of comonotonicity, as studied in Dhaene et al. (2002 a,b). Our analytical approach avoids simulation, and hence reduces the computing effort drastically.

Lin, Y. & Cox, S. H. *Securitization of mortality risks in life annuities.* 227-252. The purpose of this article is to study mortality-based securities, such as mortality bonds and swaps, and to price the proposed mortality securities. We focus on individual annuity data, although some of the modeling techniques could be applied to other lines of annuity or life insurance.

Milevsky, M. A. *The implied longevity yield: a note on developing an index for life annuities.* 301-320. I develop an index for tracking the dynamic behavior of life (pension) annuity payouts over time, based on the concept of self-annuitization. Our implied longevity yield (ILY) value is defined equal to the internal rate of return (IRR) over a fixed deferral period that an individual would have to earn on their investable wealth if they decided to self-annuitize using a systematic withdrawal plan. A larger ILY number indicates a greater relative benefit from immediate annuitization. I use age 65 with a 10-year period certain compared against the same annuity at age 75 as the standard benchmark for the index, and calibrate to a comprehensive time series of weekly (Canadian) life annuity quotes from 2000 through 2004. I find that during this period the ILY varied from 5.45 percent to 6.90 percent for males and from 5.00 percent to 6.42 percent for females and was highly correlated with a duration-weighted average yield of 10-year and long-term Government of Canada bonds. I believe our ILY metric can help promote and explain the benefits of acquiring lifetime payout annuities by translating the abstract-sounding longevity insurance into more concrete and measurable financial rates of return.

Niehaus, G. & Tong, Y. *Cash-balance plan conversions: evidence on excise taxes and implicit contracts.* 321-352. Firms that wish to switch from a traditional defined-benefit pension plan to a defined-contribution-type plan have a choice between converting to a cash-balance plan or replacing the defined-benefit plan with a full-fledged defined-contribution plan. According to Ippolito and Thompson's (1999; Industrial Relations, 39: 228-245) excise tax avoidance

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hypothesis, a number of firms have switched to cash-balance plans because conversion allows the firm to avoid excise taxes on its excess pension assets. In contrast to existing studies, our evidence supports the excise tax avoidance hypothesis. Cash-balance plan conversions also have been criticized for imposing pension losses on older employees. The implicit contract theory of pensions predicts that poorly performing firms would be the ones that would impose losses on employees. However, our evidence indicates that firms converting to cash-balance plans typically are not poor performers.

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NORTH AMERICAN ACTUARIAL JOURNAL

Volume **9** (1), 2005

EXLEY, J. *Pension funds and the UK economy*. 73-87. The paper considers the impact of U.K. defined benefit (DB) pension plan funding and investment on the U.K. economy. It suggests that many conventional theories are based on incomplete or inconsistent economics. In particular, the author suggests that: An economy cannot really gain competitive advantage from high returns on the domestic assets in which pension funds invest. DB liabilities are essentially similar for most schemes and can be closely matched with bonds. Funding pension liabilities has no primary impact on individuals' consumption and saving or on firms' capital investment. Pension funds are not natural investors in the equity of new ventures. The conclusion of the paper is that the most significant impact of pension funds on the U.K. economy relates to the costs imposed by extreme mismatching between their financial assets and liabilities. The author argues that such risks can, in essence, "crowd out" entrepreneurial risk. He asserts that the U.K. economy would gain from greater focus on the matching of these assets and liabilities, and that the best way to stimulate enterprise is by eliminating the frictional costs in the economy arising from current practices.

FELLINGHAM, G. W., TOLLEY, H. D. & HERZOG, T. N. *Comparing credibility estimates of health insurance claims costs.* 1-12. We fit a linear mixed model and a Bayesian hierarchical model to data provided by an insurance company located in the Midwest. We used models fit to the 1994 data to predict health insurance claims costs for 1995. We implemented the linear mixed model in SAS and used two different prediction methods to predict 1995 costs. In the linear mixed model we assumed a normal likelihood. In the hierarchical Bayes model, we used Markov chain Monte Carlo methods to obtain posterior distributions of the parameters, as well as predictive distributions of the next year's costs. We assumed the likelihood for this model to be a mixture of a gamma distribution for the nonzero costs, with a point mass for the zero costs. All prediction methods use credibility-type estimators that use relevant information from related experience. The linear mixed model was heavily influenced by the skewed nature of the data. The assumed gamma likelihood of the full Bayesian analysis appeared to underestimate the tails of the distributions. All prediction models underestimated costs for 1995.

GOLD, J. *Retirement benefits, economics and accounting: moral hazards and frail benefit designs.* 88-111. This paper uses economic principles to analyze alternative recognition schemes for end-of-period retirement plan liabilities; the candidates, using U.S. nomenclature, are the vested benefit obligation (VBO), the accumulated benefit obligation (ABO) and the projected benefit obligation (PBO). In competitive employment markets with rational contracting we are unable to justify projected costing (PBO-based) for typical pay-related defined benefit plans. Projected costing misrepresents the economic obligations incurred by shareholders and invites

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moral hazard. Employee exposure to moral hazard may be minimized by exit costing (VBO-based) which recognizes only those benefits to which an exiting employee is entitled under the explicit benefit contract. But exit costing may not fully inform shareholders about the obligations that they have incurred under implicit contracts that extend beyond the plan document. Accrued costing (represented in the United States by the ABO) may better measure shareholders' economic commitments. Small differences between the ABO and the VBO may measure a human capital asset incented by delayed vesting and benefit eligibility. Large differences are a marker for frail benefit design and potential moral hazard. Moral hazard options exercised by employers disappoint employees and may lead to unwelcome ex-post results-oriented repairs imposed by legislators, regulators and courts.

MACDONALD, A. S., WATERS, H. R. & WEKWETE, C. T. *A model for coronary heart disease and stroke with applications to critical illness insurance underwriting I: the model.* 13-40. In Part I we construct a model for the development of coronary heart disease (CHD) or stroke that either incorporates, or includes pathways through, the major risk factors of interest when underwriting for critical illness insurance. Our main purpose is to develop a model that could be used to assess the impact on insurance underwriting of genetic information relevant to CHD and/or stroke. Our model is parameterized using data from the Framingham Heart Study in the United States. In Part II we extend this model to include other critical illnesses, for example, cancers and kidney failure, and describe some applications of the model.

MACDONALD, A. S., WATERS, H. R. & WEKWETE, C. T. *A model for coronary heart disease and stroke with applications to critical illness insurance underwriting II: applications.* 41-56. In Part I we constructed a model for the development of coronary heart disease (CHD) or stroke that either incorporates, or includes pathways through, the major risk factors of interest when underwriting for critical illness (CI) insurance. In Part II we extend this model to include other critical illnesses, for example, cancers and kidney failure, and describe some applications of the model. In particular, we discuss CI premium ratings for applicants with combinations of some or all of high body mass index, smoking, high blood pressure, high cholesterol, and diabetes. We also consider the possible effect on CI premium ratings of genetic conditions that increase the likelihood of high blood pressure, high cholesterol, diabetes, CHD event, or stroke.

MOORE, K. S. & YOUNG, V. R. *Optimal design of a perpetual equity-indexed annuity.* 57-72. We find the participation rate, guaranteed death benefit, guaranteed surrender benefit, and initial and maintenance fees that most appeal to a buyer of a perpetual equity-indexed annuity (EIA) from the standpoint of maximizing the buyer's expected discounted utility of wealth at death, also called bequest, while still allowing the issuer of the EIA to (at least) break even on the basis of the expected discounted value of the issuer's payout. In calculating the buyer's expected utility, we use the physical probability faced by the buyer. However, in calculating the expected value of the issuer's payout, we use a type of risk-neutral probability by assuming that the issuer sells many independent policies. We demonstrate our method with an illustrative numerical example.

PETERTIL, J. P. *Measuring terminable postretirement obligations.* 112-119. New approaches are needed to value benefit plans subject to unilateral changes or termination. The paper focuses on postretirement health benefits, but the thesis may be relevant to any flow not guaranteed by law or accumulating funds. Retiree health benefits have usually been extended to participating active employees only in concert with a reserved right by the plan sponsor to control the design and, by implication, the cash flow. Over the course of the last fifteen years, this reserved extension of benefits has almost invariably led to reductions in benefits, when compared to the plan of benefits at an earlier period. In most cases, such reductions were anticipated under the circumstances that came to prevail (high health care cost increases), but

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were not taken into account by most of the projection and discounting methods of the time. Current actuarial and accounting methods generate present values for terminable retiree health plans that have little credibility as measures of the beneficiary's asset or the sponsor's liability. Improvements are needed that will expand the actuarial toolbox and provide solutions to economic and accounting problems. This paper provides a basis for discussion of assumptions that are appropriate when the plan sponsor can unilaterally and dramatically change future cash flows. The paper discusses how actuaries might best approach measurement situations where further plan reductions, or outright terminations, are to be anticipated. It introduces refinements and briefly discusses how each would fit with the usual actuarial model and how differences might affect behavior. These ideas are related to financial economics and the Bader-Gold paper "Reinventing Pension Actuarial Science." Before concluding, the wider topic of discount rate selection is briefly addressed.

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Scandinavian Actuarial Journal
2005 (**2**)

Albrecher, H., Hartinger, J. & Tichy, R. F. *On the distribution of dividend payments and the discounted penalty function in a risk model with linear dividend barrier.* 103-126. In the framework of classical risk theory we investigate a model that allows for dividend payments according to a time-dependent linear barrier strategy. Partial integro-differential equations for Gerber and Shiu's discounted penalty function and for the moment generating function of the discounted sum of dividend payments are derived, which generalises several recent results. Explicit expressions for the nth moment of the discounted sum of dividend payments and for the joint Laplace transform of the time to ruin and the surplus prior to ruin are derived for exponentially distributed claim amounts.

Badescu, A., Breuer, L., Soares, A., Latouches, G., Remiche, M.-A. & Stanford, D. *Risk processes analysed as fluid queues.* 127-141. This paper presents the Laplace transform of the time until ruin for a fairly general risk model. The model includes both the classical and most Sparre-Andersen risk models with phase-distributed claim amounts as special cases. It also allows for correlated arrival processes, and claim sizes that depend upon environmental factors such as periods of contagion. The paper exploits the relationship between the surplus process and fluid queues, where a number of recent developments have provided the basis for our analysis.

Irgens, C. & Paulsen, J. *Maximising terminal utility by controlling risk exposure: a discrete-time dynamic control approach.* 142-160. Consider an investor, e.g. an insurance company whose assets evolve according to

$$Y^a_{t+1} = Y^a_t + 1_{\{Y^a_t \geq 0\}} a_t Z_{t+1}, \quad Y^a_0 = y > 0,$$

where the $\{Z_t\}$ are i.i.d. Thus if $T^a_y = \min\{t : Y^a_t < 0\}$ is the time of ruin, $Y^a_t = Y^a_T$ for $t \geq T^a_y$, i.e. the process is put on hold after ruin. In an insurance context, the $\{Z_t\}$ can be absolute net returns of its underwriting business (minus expenses), and the $\{a_t\}$ the proportion of the business the company chooses to cover itself. Alternatively, the $\{Z_t\}$ can be seen as the combined profit ratio, i.e. one minus the combined ratio, and the $\{a_t\}$ will then be net premiums. In this context, using the reparametrization $a_t = \alpha_t Y^a_t$, the $\{\alpha_t\}$ are the net premium/assets ratio, and in practical insurance this quantity enters frequently in solvency considerations.

We seek to choose the $\{a_t\}$, or equivalently the $\{\alpha_t\}$, in order to maximize $E[U(Y^a_T)]$, with T

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a fixed terminal time. The maximization is done for "utility" functions of the form $U(y) = y_+^c - y_-^c$ with $0 < c \leq 1$, the case $c = 1$ gives the risk neutral utility function $U(y) = y$. The optimal solution turns out to be of the form $a_t^* = \alpha_t^* Y_t^{a^*}$, where α_t^* is constant for each t, finite or infinite. Given a tolerance level $\bar{\varepsilon}_T$, it is shown that the solvency constraint $\psi^a(y; 0, T) = p(T_y^a \leq T) \leq \bar{\varepsilon}_T$ can be turned into constraints of the form $\alpha_t \leq \alpha$ for some fixed α, and the optimal solution under this constraint is again $a_t^* = \alpha_t^* Y_t^{a^*}$, where now the constraints $\alpha_t^* \leq \alpha$. We also show how to compute the optimal $\{\alpha_t^*\}$ numerically. As an illustration of the theoretical results, three extensive examples are given at the end of the paper.

Nielsen, P. H. *Optimal bonus strategies in life insurance: the Markov chain interest rate case.* 81-102. We study the problem of optimal redistribution of surplus in life and pension insurance when the interest rate is modelled as a continuous time Markov chain with a finite state space. We work with traditional participating life insurance policies with payments consisting of a specified contractual payment stream and an unspecified additional bonus payment stream. Our model allows for interest rates below the technical interest rate. We apply stochastic control techniques in our search for optimal strategies, and we prove the dynamic programming principle for our particular type of problem. Furthermore, we state and prove a verification theorem and obtain an explicit solution that leads to a characterisation of optimal strategies, indicating that some widely used redistribution schemes are suboptimal.

Scandinavian Actuarial Journal
2005 (**3**)

Brouhns, N., Denuit, M. & Van Keilegom, I. *Bootstrapping, the Poisson log-bilinear model for mortality forecasting.* 212-224. This paper proposes bootstrap procedures for expected remaining lifetimes and life annuity single premiums in a dynamic mortality environment. Assuming a further continuation of the stable pace of mortality decline, a Poisson log-bilinear projection model is applied to the forecasting of the gender- and age-specific mortality rates for Belgium on the basis of mortality statistics relating to the period 1950–2000. Bootstrap procedures are then used to obtain confidence intervals on the aforementioned quantities.

Lampaert, I. & Wahlin, J.-F. *On the optimality of proportional reinsurance.* 225-239. Proportional reinsurance is often thought to be a very simple method of covering the portfolio of an insurer. Theoreticians are not really interested in analysing the optimality properties of these types of reinsurance covers. In this paper, we will use a real-life insurance portfolio in order to compare four proportional structures: quota share reinsurance, variable quota share reinsurance, surplus reinsurance and surplus reinsurance with a table of lines.

Li, S. & Garrido, J. *The Gerber–Shiu function in a Sparre Andersen risk process perturbed by diffusion.* 161-186. We consider a Sparre Andersen risk process that is perturbed by an independent diffusion process, in which claim inter-arrival times have a generalized Erlang(n) distribution (i.e. as the sum of n independent exponentials, with possibly different means). This leads to a generalization of the defective renewal equations for the expected discounted penalty function at the time of ruin given by Tsai and Willmot [10,11] and Gerber and Shiu [21,22]. The limiting behavior of the expected discounted penalty function is studied, when the dispersion coefficient goes to zero. Finally, explicit results are given for the case where $n = 2$.

Li, S.-H. & Chan, W.-S. *Outlier analysis and mortality forecasting: the United Kingdom and Scandinavian countries.* 187-211. The Lee-Carter model and its variants have been extensively employed by actuaries, demographers, and many others to forecast age-specific mortality. In this study, we use mortality data from England and Wales, and four Scandinavian countries to perform time-series outlier analysis of the key component of the Lee-Carter model — the

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mortality index. We begin by employing a systematic outlier detection process to ascertain the timing, magnitude, and persistence of any outliers present in historical mortality trends. We then try to match the identified outliers with imperative events that could possibly justify the vacillations in human mortality levels. At the same time, we adjust the effect of the outliers for model re-estimation. A new iterative model re-estimation method is proposed to reduce the chance of erroneous model specification. The empirical results indicate that the outlier-adjusted model could achieve more efficient forecasts of variables such as death rates and life expectancies. Finally, we point out that the Lee-Carter forecasts are especially vulnerable to outliers near the forecast origin, and discuss the potential limitations of the application of the Lee-Carter model to mortality forecasting.

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