B.A.J. **7**, II, 301-309 (2001)

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ASTIN Bulletin

Volume **30** (1), 2000

Cairns, A. J. G. *Some notes on the dynamics and optimal control of stochastic pension fund models in continuous time*, 19-55. This paper discusses the modelling and control of pension funds. A continuous-time stochastic pension fund model is proposed in which there are n risky assets plus the risk-free asset as well as randomness in the level of benefit outgo. We consider Markov control strategies which optimise over the contribution rate and over the range of possible asset-allocation strategies. For a general (not necessarily quadratic) loss function it is shown that the optimal proportions of the fund invested in each of the risky assets remain constant relative to one another. Furthermore, the asset allocation strategy always lies on the capital market line familiar from modern portfolio theory. A general quadratic loss function is proposed which provides an explicit solution for the optimal contribution and asset-allocation strategies. It is noted that these solutions are not dependent on the level of uncertainty in the level of benefit outgo, suggesting that small schemes should operate in the same way as large ones. The optimal asset-allocation strategy, however, is found to be counterintuitive leading to some discussion of the form of the loss function. Power and exponential loss functions are then investigated and related problems discussed. The stationary distribution of the process is considered and optimal strategies compared with dynamic control strategies. Finally there is some discussion of the effects of constraints on contribution and asset-allocation strategies.

Cox, S. H., Fairchild, J. R. & Pedersen, H. W. *Economic aspects of securitization of risk*, 157-193. This paper explains securitization of insurance risk by describing its essential components and its economic rationale. We use examples and describe recent securitization transactions. We explore the key ideas without abstract mathematics. Insurance-based securitizations improve opportunities for all investors. Relative to traditional reinsurance, securitizations provide larger amounts of coverage and more innovative contract terms.

Deelstra, G. *Long-term returns in stochastic interest rate models: applications*, 123-140. We extend the Cox-Ingersoll-Ross (1985) model of the short interest rate by assuming a stochastic reversion level, which better reflects the time dependence caused by the cyclical nature of the economy or by expectations concerning the future impact of monetary policies. In this framework, we have studied the convergence of the long-term return by using the theory of generalised Bessel-square processes. We emphasize the applications of the convergence results. A limit theorem proves evidence of the use of a Brownian motion with drift instead of the integral $\int_0^t r_u du$. For practice, however, this approximation turns out to be only appropriate when there are no explicit formulae and calculations are very time-consuming.

Macdonald, A. S. & Pritchard, D. J. *A mathematical model of Alzheimer's disease and the ApoE gene*, 69-110. Alzheimer's disease (AD) accounts for a significant proportion of long-term care costs. The recent discovery that the $\varepsilon 4$ allele of the ApoE gene indicates a predisposition to earlier onset of AD raises questions about the potential for adverse selection in long-term care insurance, about long-term care costs in general, and about the potential effects on costs of gene therapy, or better targetted treatments for AD. This paper describes a simple Markov model for AD, and the estimation of the transition intensities from the medical and epidemiological literature.

PROMISLOW, S. D. & YOUNG, V. R. *Equity and exact credibility*, 3-11. We consider an alternative to the usual credibility premium that arises from squared-error loss, namely, a so-called *equitable* credibility premium (Promislow and Young, 1999). We derive formulas for the credibility weight in certain cases and give sufficient conditions for exact credibility.

SCHNIEPER, R. *Portfolio optimization*, 195-248. Based on the profit and loss account of an insurance company we derive a probabilistic model for the financial result of the company, thereby both assets and liabilities are marked to market. We thus focus on the economic value of the company. We first analyse the underwriting risk of the company. The maximization of the risk return ratio of the company is derived as optimality criterion. It is shown how the risk return ratio of heterogeneous portfolios or of catastrophe exposed portfolios can be dramatically improved through reinsurance. The improvement of the risk return ratio through portfolio diversification is also analysed. In section 3 of the paper we analyse the loss reserve risk of the company. It is shown that this risk consists of a loss reserve development risk and of a yield curve risk which stems from the discounting of the loss reserves. This latter risk can be fully hedged through asset liability matching. In section 4 we derive our general model. The portfolio of the company consists of a portfolio of insurance risks and of a portfolio of financial risks. Our model allows for a simultaneous optimization of both portfolios of risks. A theorem is derived which gives the optimal retention policy of the company together with its optimal asset allocation. Some of the material presented in this paper is taken from Schnieper, 1997. It has been repeated here in order to make this article self contained.

SUNDT, B. *On multivariate Vernic recursions*, 111-122. In the present paper we extend a recursive algorithm, developed by Vernic (1999) for compound distributions with bivariate counting distribution and univariate severity distributions to more general multivariate counting distributions.

VERNIC, R. *A multivariate generalization of the generalized Poisson distribution*, 57-67. This paper proposes a multivariate generalization of the generalized Poisson distribution. Its definition and main properties are given. The parameters are estimated by the method of moments.

WALHIN, J. F. & PARIS, J. *Recursive formulae for some bivariate counting distributions obtained by the trivariate reduction method*, 141-155. In this paper we study some bivariate counting distributions that are obtained by the trivariate reduction method. We work with Poisson compound distributions and we use their good properties in order to derive recursive algorithms for the bivariate distribution and bivariate aggregate claims distribution. A data set is also fitted.

WANG, J.-L. *A note on Christofides' conjecture regarding Wang's premium principle*, 13-17. Young (1999) discussed the conjecture proposed by Christofides (1998) regarding the premium principle of Wang (1995, 1996). She shows that this conjecture is true for location-scale families and for certain other families, but false in general. In addition Young (1999) states that it remains an open problem to determine under what circumstances Wang's premium principle reduces to the standard deviation (SD) premium principle. In this paper we will provide further discussion of this problem. We will show that, for a fixed distortion, the natural set on which Wang's premium principle can reduce to the SD premium principle is and only is the union of location-scale families which satisfies some condition. Furthermore, it will be shown that the natural set is and only is a location-scale family if Wang's premium principle can be reduced to the SD premium principle for any distortion.

INSURANCE: MATHEMATICS & ECONOMICS

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ALVAREZ, L. H. R. *On the form and risk-sensitivity of zero coupon bonds for a class of interest rate models*, 83-90. We consider the form and the comparative static properties of the price of a zero coupon bond with maturity T for a broad class of interest rate models. We first demonstrate that increased volatility increases the price of a T-claim whenever the price is convex as a function of the current short rate. We then present a class of diffusion models (including, for example, the *Dothan*, the *Black-Derman-Toy*, and the *Merton* model of interest rates) for which the positivity of the sign of the relationship between volatility and the price of zero coupon bonds is always unambiguously guaranteed. Consequently, we find that for the considered class of models the price of zero coupon bonds can be completely ordered in terms of the riskiness of the underlying interest rate by dynamics. We also show that for the proposed class of interest rate models, increased volatility increases the price of all convex and non-increasing T-claims as well.

KALUSZKA, M. *Optimal reinsurance under mean-variance premium principles*, 61-67. We derive optimal reinsurance under premium principles based on the mean and variance of the reinsurer's share of the total claim amount. Both global reinsurance and local reinsurance are studied. Examples considered include standard deviation principle and variance principle.

LEFEVRE, C. & UTEV, S. *Comparison of individual risk models*, 21-30. This paper is concerned with the stochastic comparison of two individual risk models for homogeneous portfolios with different claim size distributions. It is shown that a Lorenz order between the claim sizes, or a hamr-order if the claim sizes are NBUE, are transferred to the corresponding individual risk models.

SCHMIDLI, H. *Distribution of the first ladder height of a stationary risk process perturbed by á-stable Lévy motion*, 13-20. We consider a risk model described by an ergodic stationary marked point process. The model is perturbed by a Lévy process with no downward jumps. The (modified) ladder height is defined as the first epoch where an event of the marked point process leads to a new maximum. Properties of the process until the first ladder height are studied and results of Dufresne and Gerber [IME 10 (1991) 51], Furrer [SAJ (1998) 59], Asmussen and Schmidt [Stochastic Process Appl 58 (1995) 105] and Asmussen et al [ASTIN Bull 25 (1995) 49] are generalized.

SCHWEIZER, M. *From actuarial to financial valuation principles*, 31-47. A valuation principle is a mapping that assigns a number (value) to a random variable (payoff). This paper constructs a transformation on valuation principles by embedding them in a financial environment. Given as a priori valuation rule u, we define the associated a posteriori valuation rule h by an indifference argument: the u-value of optimally investing in the financial market alone should equal the u-value of first selling the payoff at its h-value and then choosing an optimal investment strategy inclusive of the payoff. In an L^2-framework, we explicitly construct in this way the financial transforms of the variance principle and the standard deviation principle.

VAN DER HOEK, J. & SHERRIS, M. *A class of non-expected utility risk measures and implications for asset allocations*, 69-82. This paper discusses a class of risk measures developed from a risk measure recently proposed for insurance pricing. This paper reviews the distortion function approach developed in the actuarial literature for insurance risk. The proportional hazards transform is a particular case. The relationship between this approach to risk and other approaches including the dual theory of choice under risk is discussed. A new class of risk measures with suitable properties for asset allocation based on the distortion function approach to insurance risk is developed. This measure treats upside and downside risk

differently. Properties of special cases of the risk measure and links to conventional portfolio selection risk measures are discussed.

WANG, G. *A decomposition of the ruin probability for the risk process perturbed by diffusion*, 49-59. In this paper, we consider the ruin probabilities (caused by oscillation or by a claim) of the classical risk process perturbed by diffusion and the risk process with return on investments. We will prove their twice continuous differentiability and derive the integro-differential equations satisfied by them. We will present the explicit expressions for them when the claims are exponentially distributed.

ZAKS, A. *Annuities under random rates of interest*, 1-11. We investigate the accumulated value of some annuities-certain over a period of years in which the rate of interest is a random variable under some restrictions. We aim at the expected value and the variance of the accumulated value, and we suggest two methods to derive these moments. In some cases both methods have similar difficulties, while in other cases one method is significantly preferable in terms of the simplicity of calculations. The novelty of our second approach lies in the fact that we find recursive relationships for the variance of the accumulated values, and solve these relationships, whilst previous investigators first obtained the second moment.

Volume **28** (2), 2001

BOOTH, P. M. & WALSH, D. E. P. *An option pricing approach to valuing upward only rent review properties with multiple reviews*, 151-171. We begin by considering how to model market rents using random walk and autoregressive models. We then show how to value rental income on properties subject to upward only rent reviews where market rents are described by these two models. The values are obtained using three valuation methodologies. Two of the valuation techniques take account of the embedded upward only rent review option whereas one of the techniques takes the traditional approach, effectively ignoring the option value. The resulting values depend both on the model of the behaviour of rents and on the valuation method.

BOULIER, J.-F., HUANG, S. & TAILLARD, G. *Optimal management under stochastic interest rates: the case of a protected defined contribution pension fund*, 173-189. This paper deals with the pension fund management issue. We focus on defined-contribution plans where a guarantee is given on the benefits, and the guarantee depends on the level of the stochastic interest rate when the employee retires. It is particularly shown that the optimal composition of this kind of pension fund can be divided into three different parts: a loan which amounts to the present value of the contributions, a contingent claim delivering the guarantee and a hedging fund. A Vasicek interest rate model is considered as an illustration of our analysis.

FELIPE, A., GUILLEN, M. & NIELSEN, J. P. *Longevity studies based on kernel hazard estimation*, 191-204. We propose a non-parametric smoothing method to visualize the evolution of mortality rates. This is used to compare the mortality experiences of Denmark and Spain. Our comparison takes into account the dependence of mortality on chronological time and age. A two-dimensional surface indicating transition intensity is estimated and a number of other interesting estimators can be derived from this surface: ie, ratios of the structural development of mortality, estimation of multiplicative structures using marginal integration (eg, Linton & Nielsen Biometrika 82 [1995]), and smoothed trends for fixed ages. The multiplicative structure effectively separates the chronological time component and the age component.

GOULET, V. *A generalized crossed classification credibility model*, 205-216. In the crossed classification credibility (CCC) model of Dannenburg, every contract in an insurance portfolio is assumed to be affected by the same number of risk factors. One can, however, imagine situations where this may be a restriction to the model. We thus propose a generalization of

the original model where the number of risk factors can vary per contract. This is done by introducing a new category for each risk factor representing the fact of not being affected by the risk factor. The main effect on formulae is that credibility factors are replaced by some other function when used as weights.

LÉVEILLÉ, G. & GARRIDO, J. *Moments of compound renewal sums with discounted claims*, 217-231. Delbaen & Haezendonck [IME 6 (1987)] and Willmot [SAJ 1 (1989)] give an analytical expression for the net premium density of a compound Poisson present value risk (CPPVR) process. Their calculation is based, essentially, on the independence of the increments of the CPPVR process. In this paper, under regularity conditions, we derive the first two moments of a compound renewal present value risk (CRPVR) process using renewal theory arguments. Some examples, extensions and limiting results are also given.

VIGNA, E. & HABERMAN, S. *Optimal investment strategy for defined contribution pension schemes*, 233-262. We analyse the financial risk in a defined contribution pension scheme, applying dynamic programming techniques to find an optimal investment strategy for the scheme member. We use a series of interim targets and a target at retirement linked to the desired net replacement ratio. We consider both the investment risk and the annuitisation risk faced by the individual and specifically consider the properties of the so-called 'lifestyle' investment strategies. The principal results concern the suitability of the lifestyle strategy and the large variability of the level of pension achieved at retirement in the case of a variable annuity conversion rate.

ZIMBIDIS, A. A. & HABERMAN, S. *The combined effect of delay and feedback on the insurance pricing process: a control theory approach*, 263-280. Further to De Finetti's [Su una impostazione alternativa della theoria collectiva del rischio. In: Transactions of the 15th International Congress of Actuaries, Vol. II, New York, pp. 433-443] proposal, of a modified random walk for the (accumulated) surplus reserve (S) of an insurance system with a reflecting barrier at a predefined level, we design a model similar to that of Balzer and Benjamin [J. Inst. Actuaries 107 (1980) 513], involving a smooth control action. Given the basic difference equation, which describes the development of the surplus process and the delays inherent to an insurance system, we propose a particular decision function for the determination of the premium (P). For this purpose, we use the recent claim (C) experience and a negative feedback mechanism based on the latest known surplus value. The model assumes that the delay factor (f) is a free control parameter with a constant accumulation factor (R) for the surplus reserve. We investigate the stability of the system and the optimal parameter design (in terms of the fastest response and return to the initial or steady state). We determine appropriate values for the feedback factor (ε) under the specific premium decision function using the tools of control theory. One of the results is the derivation of a critical value for the delay factor (f_∞) beyond which instability is certain irrespective of the choice of the feedback factor (ε).

NORTH AMERICAN ACTUARIAL JOURNAL

Volume **5** (1), 2001

BROWN, R. L. *Impacts on economic security programs of rapidly shifting demographics*, 12-21. This paper analyzes in some detail potential impacts on economic security programs —

government, employer, and individual — that the aging of the baby boom generation may create. It begins by defining what is meant by 'population aging' and concludes that fertility shifts are more important than improving life expectancy. It also argues that calling the baby boom the 'postwar baby boom' is inaccurate and will lead to missed targets for product development and marketing. Finally, this section of the paper notes that the most rapidly growing segment of the population will be the oldest old — those aged 85 and over, who will also put the greatest stress on the provision of health care and retirement income security. The paper then looks at other demographic shifts of importance, in particular female labor force participation rates. The impact of shifting demographics is reviewed for each sponsor of economic security programs: the government (health care and social security); the employer (pension plans and group benefits); and the individual. Points of concern and offsetting opportunities for the insurance industry are noted. Finally, the paper looks at whether we will be able to 'afford' the sudden retirement of the baby boom. The conclusion is that this will be affordable if we can convince a portion of the labor force to stay active longer, and if we have healthy productivity growth rates. The problems of an aging population can all be viewed as opportunities for those who have the map.

Clark, R. L. & Munzenmaier, F. W. *Impact of replacing a defined benefit pension with a defined contribution plan or a cash balance plan*, 32-56. Four pension plan conversions are examined to determine the impact on retirement benefits of workers. The study was based on interviews with top management, employee surveys, and actuarial analysis of retirement benefits under the old and new pension plans. In general, workers who leave the firm prior to the age of early retirement can expect increased benefits under the new defined contribution and cash balance plans, whereas older, more senior workers can expect to accrue smaller benefits after the plan conversions. Recognizing these potential adverse effects, the employers in our studies provided various types of transition benefits to existing workers or gave employees the choice of remaining in the old defined benefit plan. Employee surveys reveal that younger workers are more supportive of the new pension plans than are older workers. These case studies also indicate that communication by managements with their employees is very important to the successful implementation of plan conversions.

Forman, J. B. *Making federal pension policy work*, 95-103. Millions of Americans retire while they are still productive. Of these, many will have the resources to enjoy all of their golden years. Unfortunately, many others will face economic hardships after they have exhausted their own resources but have become too frail to return to work. Part of the problem is that the current pension system is fraught with financial incentives that push able-bodied elderly workers into retirement just when they should instead be encouraged to remain in the workforce to accumulate additional retirement assets. This paper recommends a number of ways to change federal pension laws in order to encourage elderly workers to remain in the workforce. For example, this paper recommends toughening the penalty on premature distributions, repealing the minimum distribution rules, and repealing the exceptions to the Age Discrimination in Employment Act that permit retirement plans to provide early retirement incentives and subsidies. This paper also considers whether the government should require that all retirement plans be neutral as to the timing of retirement. In an age-neutral world, workers would always accrue more benefits if they kept working. Consequently, more workers would remain in the workforce, accumulating additional assets for their eventual retirement. Finally, this paper also considers how federal pension policy could help counteract the tendency of Americans to retire too early because they underestimate their life expectancies, overestimate their financial resources, and fail to understand the deleterious effects of inflation. In particular, this paper recommends that the government require that virtually all retirement plans pay at least a portion of their benefits in the form of an inflation-adjusted annuity.

JOHNSON, R. W. & LO SASSO, A. T. *Balancing retirement security with the needs of frail parents: Caregiving, financial transfers, and work by women at midlife*, 104-108. Caring for frail elderly parents can interfere with work responsibilities. People who provide care to their parents may need to take time off from work or retire altogether. However, reductions in labor supply at midlife can have serious implications for retirement wealth and, as a result, on economic well-being in later life. This paper examines how family support for the elderly can affect retirement savings by examining the relationship between labor supply, time help to parents, and financial assistance to parents. Using data from the Health and Retirement Study on a nationally representative sample of women ages 53-63, we found that women who helped their parents with personal care assistance worked significantly fewer hours than did those who did not help their parents, whereas those who provided financial assistance worked significantly more hours. Although few persons at midlife presently spend substantial amounts of time helping their elderly parents in any given year, for those who do, the costs can be high. Pressures on families are likely to mount in the near future as falling mortality and fertility rates continue to increase the proportion of the population that is very old and as women continue to play more important roles in the labor market.

MILEVSKY, M. A. *Optimal annuitization policies: analysis of the options*, 57-69. At, or about, the age of retirement, most individuals must decide what additional fraction of their marketable wealth, if any, should be annuitized. Annuitization means purchasing a nonrefundable life annuity from an insurance company, which then guarantees a lifelong consumption stream that cannot be outlived. The decision of whether or not to annuitize additional liquid assets is a difficult one, since it is clearly irreversible and can prove costly in hindsight. Obviously, for a large group of people, the bulk of financial wealth is forcefully annuitized, for example, company pensions and social security. For others, especially as it pertains to personal pension plans, such as 401(k), 403(b), and IRA plans as well as variable annuity contracts, there is much discretion in the matter. The purpose of this paper is to focus on the question of *when and if* to annuitize. Specifically, my objective is to provide practical advice aimed at individual retirees and their advisors. My main conclusions are as follows:

- Annuitization of assets provides unique and valuable longevity insurance and should be actively encouraged at higher ages. Standard microeconomic utility-based arguments indicate that consumers would be willing to pay a substantial 'loading' in order to gain access to a life annuity.
- The large adverse selection costs associated with life annuities, which range from 10% to 20%, might serve as a strong deterrent to full annuitization.
- Retirees with a (strong) bequest motive might be inclined to self-annuitize during the early stages of retirement. Indeed, it appears that most individuals — faced with expensive annuity products — can effectively 'beat' the rate of return from a fixed immediate annuity until age 75-80. I call this strategy *consume term and invest the difference*.
- Variable immediate annuities (VIAs) combine equity market participation together with longevity insurance. This financial product is currently underutilized (and not available in certain jurisdictions) and can only grow in popularity.

UCCELLO, C. E. *401(k) investment decisions and social security reform*, 70-79. This paper uses the 1995 Survey of Consumer Finances to show that 401(k) participants with an underlying defined benefit plan are more likely to invest in equities than are participants whose 401(k) is their primary plan. This suggests that workers with a guaranteed source of retirement income are more likely to invest their other retirement assets more aggressively. Removing this guarantee might result in more conservative investment. Therefore, using current 401(k) asset allocation behavior to project income under a Social Security individual account system with reduced guaranteed benefits could overstate returns to these accounts, thus overstating their attractiveness relative to the current system.

VANDERHEI, J. L. & COPELAND, C. *A behavioral model for predicting employee contributions to 401(k) plans: preliminary results*, 80-94. Previous research on employee contribution behavior to 401(k) plans has often been limited by lack of adequate data. This is primarily because of the types of matching formulas utilized by sponsors. While these formulas are often complicated because of the desire of sponsors to provide sufficient incentives to non-highly compensated employees to contribute in order to comply with technical nondiscrimination testing, this complexity makes it virtually impossible to appropriately analyze the employee's behavior if we are forced either to observe aggregate plan data or to use information on the plan contribution formulas provided by the participant. The purpose of this paper is to provide preliminary findings introducing new methodology to expand the usefulness of modeling these data as well as a better understanding of contribution behavior by 401(k) plan participants. We utilize a sequential response regression model to allow for the differing incentives faced by the employees at various levels of contributions. Based on findings from 137 distinct matching formulas, we have estimated a behavioral model that is able to control for the tendency of employers to substitute between the amount they match per dollar of employee contribution and the maximum percentage of compensation they are willing to match.

SCANDINAVIAN ACTUARIAL JOURNAL

2001-**1**

AASE, K. K. *On the St Petersburg paradox*, 69-78. The classical St. Petersburg Paradox is discussed in terms of doubling strategies. It is claimed that what was originally thought of as a 'paradox' can hardly be considered as very surprising today, but viewed in terms of doubling strategies, we get some results that look paradoxical, at least to the practically oriented investor.

BEDARD, D. & DUFRESNE, D. *Pension funding with moving average rates of return*, 1-17. In the context of the model of pension funding introduced by Dufresne in 1986, explicit expressions are found for the first two moments of fund level and total contributions, when (1) actuarial gains and losses are amortized over N years, and (2) arithmetic rates of return on assets form a moving average process. The results are obtained via a Markovian representation for the bilinear process obtained for the actuarial losses. One conclusion is that the dependence between successive rates of return may have very significant effects on the financial results obtained.

DICKSON, D. C. M. & SUNDT, B. *Comparison of methods for evaluation of the convolution of two compound $\mathscr{R}_1$ distributions*, 40-54. In the present paper we compare four methods for evaluating the convolution of two compound $\mathscr{R}_1$ distributions by counting the numbers of elementary algebraic operations required. Two of the methods are applicable in general, whereas the remaining two are restricted to the case when the two compound distributions have the same severity distribution. This case is discussed separately. We consider in particular the special case when this common severity distribution is concentrated in one, that is, evaluation of the convolution of two $\mathscr{R}_1$ distributions.

ENIKEEVA, F., KALASHNIKOV, V. V. & RUSAITYTE, D. *Continuity estimates for ruin probabilities*, 18-39. A method of continuity analysis of ruin probabilities with respect to variations of parameters governing risk processes is proposed. It is based on the representation of the ruin probability as the stationary probability of a reversed process. We apply

Kartashov's technique designed for continuity analysis of stationary distributions of general Markov chains in order to obtain desired continuity estimates. The method is illustrated by the Sparre Andersen and Markov modulated risk models.

LINDBERGSON, M. *Mortality among the elderly in Sweden, 1988-1997*, 79-84. By replacing the exponential growth in a Makeham function with a straight line at very high ages, graduated mortality rates gives an acceptable adherence to observed data.

SCHMIDLI, H. *Optimal proportional reinsurance policies in a dynamic setting*, 55-68. We consider dynamic proportional reinsurance strategies and derive the optimal strategies in a diffusion setup and a classical risk model. Optimal is meant in the sense of minimizing the ruin probability. Two basic examples are discussed.

https://doi.org/10.1017/S1357321700002269 Published online by Cambridge University Press