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ABSTRACTS



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THINKING OF THE WORLD Statistics & Actuarial Science



Education & Research
Joint Risk Management
Entrepreneurial Actuaries
Investment

TOWERS WATSON



<u>Content</u>	
Invited Talks	2
Contributed Talks	3
Posters	13
Speakers	14

Invited Talks

Actuarial accounting--a cautionary report

Dan R. Young, Law Offices of Dan R. Young, U.S.A.

With two CAS actuaries convicted of violating securities and criminal laws, and one of those actuaries recently sentenced, it is important that we remind ourselves of our legal obligations to the public. This presentation relays the case against five AIG and Gen Re insurance professionals, largely concerning the accounting of reinsurance contracts. The facts of the case are reviewed, according to the publicly available court records, and the audience is walked through the relevant securities and criminal laws. It is an eye-opening, professional presentation that will educate actuaries on the facts of the case, how important documentation is, how important it is to be conscious and precise in communications, and other pertinent professionalism considerations.

Society of Actuaries education update

Stuart Klugman, Society of Actuaries, U.S.A.

Recent and planned SOA Education activities will be presented. These include curriculum and examination issues as well as academic initiatives.

Spatio-temporal models for rates and survival analysis

Charmaine Dean, Simon Fraser University, Canada

The development of methods for spatio-temporal analyses has seen tremendous growth over the last two decades. There has also been considerable impact on determining spatial differences in diseases, for monitoring and surveillance purposes, and for allocating differential health funding to regions. Much of this literature, though relevant to actuarial policy, has been focused in the health policy fields. This talk aims to relieve this gap by introducing spatial-temporal models and methods for analysis with specific emphasis on quantities of interest in actuarial science: spatio-temporal analysis of rates and spatio-temporal survival analysis. Generalized additive mixed models are used for the analysis of geographic and temporal variability of mortality rates. This class of models accommodates random spatial effects and fixed and random temporal components. Spatiotemporal models that use autoregressive local smoothing across the spatial dimension and B-spline smoothing over the temporal dimension are developed. The objective is the identification of temporal trends and spatial patterns of risks. Regions with consistently high risk estimates may be identified through such analyses for differential policy implications. The emphasis of the presentation is on concepts underpinning analyses which describe and contrast the spatial distribution of rates over a region, and the use of illustrative examples to display such distributions.

The Canadian pensioners mortality table: some results on mortality level and trends

Louis Adam, Université Laval, Canada

The presentation will show some results obtained from a mortality study based on Canadian pensioners data available from the combined records of the Canada Pension Plan and Quebec Pension Plan as at December 31st, 2008. This research project conducted by the author shows results by source, gender, age, income level and calendar year. Specifically, mortality results for the 2005-2007 triennial period will be illustrated by gender and income level. Based on this study, a 15-year projection scale is also derived and used to develop a set of projected mortality tables. The obtained results might be of relevance for pension valuation purposes in Canada, and will be useful in the determination of a new standard for pension mortality table in Canada. The results will also be of interest to actuaries involved in individual and group annuities pricing and reserving.

Forecasting mortality in the presence of missing data: an application to Chinese population

Ping An, Central University of Finance and Economics, China

In recent years, a number of stochastic mortality models have been proposed. Given all the required data, these models can be estimated readily by standard methods such as maximum likelihood. However, for some populations, part of the required data may be missing, therefore prohibiting us from fitting a stochastic mortality model directly. This problem is encountered when we forecast mortality for Chinese population. In particular, although the government has made age-specific central death rates available to the public since 1986, for a few years over the period of 1986-2008, the death rates cannot be found in the public domain. The primary objective of this paper is to investigate how we can apply a stochastic mortality model in the presence of missing data. To accomplish this goal, a statistical tool called 'multiple imputation' is used. On the basis of the proposed method, we derive a Lee-Carter projection of Chinese mortality, which can then be applied to, for example, the valuation of social security. Finally, we validate our proposed method by using data from populations for which complete mortality data are available.

Inference for a family of statistical distributions with heavy tails

Maciej Augustyniak, Université de Montréal, Canada
Co-Author: Louis G. Doray, Université de Montréal, Canada

We introduce a family of leptokurtic symmetric distributions represented by the difference of two gamma variates. Properties of this family are discussed. The Laplace, sums of Laplace and normal distributions all arise as special cases of this family. We propose a two-step method for fitting data to this family. First, we perform a test of symmetry, and second, we estimate the parameters by minimizing the quadratic distance between the real parts of the empirical and theoretical characteristic functions. The quadratic distance estimator obtained is consistent, robust and asymptotically normally distributed. We develop a statistical test for goodness-of-fit and introduce a test of normality of the data. A simulation study is provided to illustrate the theory.

Optimal reinsurance problems involving risk measures

Beatriz Balbás-Aparicio, Universidad Rey Juan Carlos, Spain

This paper studies the optimal reinsurance problem when risk is measured by a general risk measure. Necessary and sufficient optimality conditions are given for a wide family of risk measures, including deviation measures, expectation bounded risk measures and coherent measures of risk. Concrete solutions will be provided for important particular cases.

Besides, since there is no consensus about the risk measure that the insurer must use the paper analyzes the stability of the optimal reinsurance with respect to the risk measure. We will demonstrate that there is a "stable optimal retention" that will show no sensitivity, insofar as it will solve the optimal reinsurance problem for many risk measures, thus providing a very robust reinsurance plan. This stable optimal retention is a stop-loss contract, and it is easy to compute in practice. A fast linear time algorithm will be given, and a numerical example presented.

Compatibility between prices and risks

Raquel Balbás, Complutense University of Madrid, Spain

We will deal with linear pricing rules and risk measures (including deviations and coherent or expectation bounded risk measures), and we will introduce two kinds of compatibility between prices and risks. Prices and risks are not (strongly) compatible if returns tend to infinite as risks (remain constant) tend to plus infinite. We will show that the lack of (strong) compatibility arises for very important pricing models (Black and Scholes, Heston, etc.) and risk measures (absolute deviation, value at risk, expected shortfall, etc.) and will give build practical portfolios that should be able to make use of this fact in practice.

Optimal multi-period proportional reinsurance strategy

Jianfa Cong, University of Waterloo, Canada

Co-Authors: Zhongfei Li, Sun Yat-sen University, China

Ken Seng Tan, University of Waterloo, Canada

The problem of optimal reinsurance has been an area of active research in the last few decades. There are many scholars who have studied the optimal reinsurance strategy which minimizes the insurer's ruin probability. However, in the literature, the optimal reinsurance strategy is most commonly explored in the continuous-time framework.

Our research focuses on the optimal multi-period proportional reinsurance strategy that minimizes the ruin probability of the insurer. We express the minimal ruin probability inductively, and then show that the dynamic programming approach can be used to solve this problem. Applying the dynamic programming approach, we derive several necessary conditions of the optimal multi-period proportional reinsurance strategy. Based on these results, a new concept, capital threshold of proportional reinsurance, is introduced. In the case of two periods, a lower bound of the capital threshold of proportional reinsurance is derived explicitly. We then prove that it is also a lower bound of the capital threshold of proportional reinsurance in the general case. Also the significance and properties of this new concept are discussed. Using this new concept, we obtain the optimal multi-period proportional reinsurance strategy and the according minimal ruin probability in some special cases. Finally, we offer some numerical examples to illustrate the theoretical results aforementioned.

Ruin related quantities in a risk model based on time series for count data

Hélène Cossette, Université Laval, Canada

Co-Authors: Etienne Marceau, Université Laval, Canada

Véronique Maume-Deschamps, ISFA Lyon 1, France

Florent Tourelle, Université Laval, Canada and ISFA Lyon 1, France

We consider various specifications of the general discrete time risk model in which a serial dependence structure is introduced between the claims for each period. We consider risk models based on compound distributions assuming a Poisson INAR(1) process as specific dependence structure. Within this model, we investigate the expected aggregate claim amount and we derive expressions for a function that allows us to find the Lundberg coefficient. We also discuss the expected discounted Gerber-Shiu penalty function in finite and infinite time.

Inference for the discrete stable distribution with the probability generating function

Louis G. Doray, Université de Montréal, Canada

We develop a method to estimate the two parameters of the discrete stable distribution. By minimizing the quadratic distance between transforms of the empirical and theoretical probability generating functions, we obtain estimators simple to calculate, asymptotically unbiased and normally distributed. We also derive the expression for their variance-covariance matrix. We simulate several samples of discrete stable distributed datasets with different parameters, to analyze the effect of truncation on the right tail of the distribution.

Changes of measure for the square-root stochastic volatility process

Daniel Dufresne, University of Melbourne, Australia
Co-Author: Stephen Chin, University of Melbourne, Australia

From empirical observations, many have come to consider that volatility varies "randomly". The square-root process is a well-known model for stochastic volatility. We consider this process and its time integral as they occur in pricing options in stochastic volatility models. An explicit measure change formula for the square-root process is used to price European options. Numerical results show that the measure-change approach and Andersen's quadratic exponential (QE) scheme perform similarly. We also examine the numerical behaviour of the Radon-Nikodym derivative.

Mortality improvement: an actuarial perspective

José Garrido, Concordia University, Canada
Co-Author: Ana Debón, Universidad Politécnica de Valencia, Spain

We study the relation between the two basic random events associated with human mortality; birth and death. Recorded dates of birth and death provide strong evidence of a positive association between longevity and cohort. That means, people born in more recent cohorts tend to live longer. Forecasting models such as that of Lee & Carter (1992, JASA) have attempted, with limited success, to give a parametric description of this association. We investigate a copula model for a bivariate survival function, with non-parametric marginals. The estimation and fit of extreme value copulas is presented and compared to current parametric model.

Loss reserving with random selection

Wu-Chyuan Gau, Kemper Insurance, U.S.A.

This paper presents a random selection method with the Monte Carlo simulation technique in the estimation of loss reserves. The future loss development factors are randomly selected from a weighted empirical distribution of observed loss-development factors. This nonparametric approach provides an estimate of the distribution of total loss reserve. By assigning proper weights, the mean of this distribution is statistically equivalent to the result from the traditional Chain-Ladder method. The variance of total loss reserve can also be approximated through this approach. In general, the proposed method is very flexible and can be easily extended to many circumstances, including the Bornheutter-Ferguson (BF) method (Bornheutter and Ferguson, 1972). The results are further enhanced by implementing the simulation scheme with smoothing techniques.

Bayesian methods for fitting regime-switching models

Brian Hartman, Texas A&M University, U.S.A.

Regime-switching models are prominently used in actuarial science and risk management. I describe various Bayesian methods for fitting regime-switching models and compare their benefits and disadvantages.

A multiple state model for the joint-life reverse mortgage termination speed

Min Ji, University of Waterloo, Canada

Reverse mortgage loans have no scheduled periodic repayments of principal or interest. The lenders and investors have positive cash flow only at the loan termination time. It is widely recognized that termination speed is a major risk factor in assessing reverse mortgage loan performance. The original Home Equity Conversion Mortgage (HECM) termination assumption has been proved outdated. Multivariate statistical models have thereafter been applied, in order to improve accuracy in predicting HECM repayment rates. However, multivariate statistical models need much economic and non-economic information about the borrowers, and the model specification is data-driven. This research extends a semi-Markovian joint-life mortality model to incorporate three main termination modes of reverse mortgages: death, long-term care (LTC) entry, and non-health related termination, which arises when the mortgagee moves out for non-health related reasons. The proposed model is practical, intuitive, and easy to capture dynamic termination patterns of reverse mortgages. Combined with an appropriate interest rate model and house price appreciation rate model, the proposed approach gives a comprehensive evaluation of the embedded "nonrecourse" provision in the reverse mortgages.

Investment forecasting using conditional probabilities

Richard Joss, Towers Watson, U.S.A.

This presentation will take a fresh look at the traditional lognormal model for making investment forecasts. A key role for conditional probabilities will be introduced. The impact of the proposed changes will be highlighted with detailed illustrations using actual data from both employee savings plans and traditional defined benefit pension plans.

Measuring and managing systemic risk

Joseph Kim, University of Waterloo, Canada

Co-Author: Phelim Boyle, Wilfrid Laurier University, Canada

In the wake of the current financial crisis, there is an ongoing debate on the importance of managing systemic risk in the financial sector. Much of the conventional regulation focuses on the safeguarding of the solvency of individual firms using for example the Value at Risk (VaR) or Conditional Tail Expectation (CTE) metric. The recent crisis has highlighted the importance of systemic risk and the shortcomings of pure firm specific regulation. Brunnermeier has noted that measures that are prudential at the micro level need not be prudential at the macro level and together with his coauthors introduced an extension of VaR known as CoVaR to include the impact of systemic risk. This paper proposes the use of the Co Conditional Tail Expectation (CoCTE) to measure systemic risk since it has some advantages over CoVaR. We explain how CoCTE can be used in constructing a fund to protect the financial sector in times of severe crises. When the fund is financed through the contributions of individual companies based on their relative risk contribution towards the whole system, one major question is how to determine each member's contribution, and consequently the premium for this insurance program. We suggest a possible solution to this problem using the generalized CoCTE risk measure.

The second goal of this paper is to endogenize the pro-cyclicality of capital requirements. Current regulatory frameworks, such as Basel I and Basel II, have been criticized for their role in the ongoing financial crisis. In particular, it is argued that the regulations by their nature require higher (lower) level capital in economically bad (good) times and may serve to encourage bubbles and deepen recessions. For example, in times of crisis more capital constraints are put on banks, as banks suffer from operational losses and reduction in the value of the assets. One possible way to solve this problem is to use a regime switching model. We combine this with a modified CoCTE that can be used to determine premium contributions. This metric manipulates the regime switching structure of the underlying model and provides a counter-cyclical contribution of each firm towards the protection fund. Finally we show how to apply these tools in practice.

Ruin theory with Parisian delays

David Landriault, University of Waterloo, Canada

Co-Authors: Jean-François Renaud, University of Waterloo, Canada

Xiaowen Zhou, Concordia University, Canada

Inspired by Parisian barrier options, we consider the following definition of ruin for an insurance risk model: the surplus process is allowed to spend time under a pre-specified default level before ruin is recognized. The same idea can also be applied to the classical dividend barrier strategy. Using the modern language of scale functions, we study Gerber-Shiu functions and dividend payments in an insurance risk model driven by a spectrally negative Levy process of bounded variation. In the process, a generalization of the two-sided exit problem is obtained.

Discounted compound renewal sums with a stochastic force of interest

Ghislain Lévêillé, Université Laval, Canada

Co-Author: Franck Adékambi, Université Laval, Canada

Recursive moments, moments generating functions, distributions functions and risk measures have been found for the compound renewal sums with discounted claims, for a constant force of real interest. In this talk we present several results on the (joint) moments, on the (joint) moments generating functions and on the (joint) distribution functions of these discounted renewal sums, in a context that may involve a stochastic force of real interest. Examples will be given for ordinary or delayed renewal counting processes and for different interest rate models.

Claim forecasting using econometric stepwise regression

Andrew Loach, Insurance Corporation of British Columbia, Canada
Co-Author: Eric Vaagen, Insurance Corporation of British Columbia, Canada

The prediction of insurance claims trends at the Insurance Corporation of British Columbia (ICBC) involves consideration of economic conditions, weather, loss prevention programs, demographics and other forces over time. To make predictions about the future trend rates of claims frequency and severity, econometric stepwise regression may be used to analyze the historical data, but with the important element of informed judgment.

The expected discounted penalty at ruin for a risk model with two-sided jumps

Yi Lu, Simon Fraser University, Canada
Co-Author: Shuanming Li, University of Melbourne, Australia

We consider a general risk model in which both the claim and income (gain) arrivals follow Poisson processes. The expected discounted penalty functions at ruin are investigated when the distributions of claim and income amounts belong to some distribution families. Some special cases of the model and diffusion approximations are also discussed.

TVaR-based capital allocation with dependence

Etienne Marceau, Université Laval, Canada
Co-Authors: Hélène Cossette; Mélina Mailhot, Université Laval, Canada

The present study considers an insurance portfolio consisting of several dependent risks and aims to evaluate not only the capital allocation for the overall portfolio but also the contribution of each risk over their aggregation. We use the Tail Value at Risk (TVaR) as risk measure. We consider the following dependence models: multivariate compound distributions, models based on common mixtures and models based on copulas. We present special cases where exact expressions for the TVaR of the sum of the risks and for the TVaR-based allocations. We then propose numerical methods applicable for any proposed dependence models in order to approximate the TVaR of the aggregate risk for the portfolio and the contribution of each risk of the portfolio. Several numerical examples are presented in order to illustrate the topics exposed in the paper. An important aspect of the paper is to provide tools for practical applications.

A note on optimal insurance under ambiguity

Mostafa Mashayekhi, University of Nebraska-Lincoln, U.S.A.

This paper investigates the effect of ambiguity on the market for insurance when preferences are ordered by comparison of Choquet expected utilities (see for example (Gilboa (1987), Schmeidler (1989), and Gilboa and Schmeidler (1989))). We show that Arrow's theorem on optimal insurance easily extends to the ambiguity case when the Choquet integrals are with respect to a common capacity. A discussion of conditions that justify the assumption of a common capacity for the insurer and insureds is also presented.

Diversity in the actuarial profession – why college summer programs for high school students can make a difference

Barry McKeown, Towers Watson / Committee on Actuarial Diversity (COAD), U.S.A.

The actuarial profession does not have the diversity that it needs or desires. Black, Hispanic and Native American populations are underrepresented. There is significant competition among professions for top students. Other professions, such as engineering, are better known and have long standing initiatives in place to introduce minority students to their professions. Many high school students choose colleges and majors based on careers they already know about and are considering while in high school. It is important that these top students are aware of the actuarial profession when they are making these decisions. The Committee on Actuarial Diversity, a joint committee of the Casualty Actuarial Society and the Society of Actuaries, makes presentations at high schools and supports summer actuarial programs at colleges targeted at minority high school

students. Howard University, Illinois State University and Morgan State University have summer actuarial science programs for minority high school students. These programs serve an important role in enabling students to make informed decisions about the actuarial profession. The presentation at the Actuarial Research Conference will briefly describe these programs and the role they have in the profession's diversity efforts. There will be an exploration and discussion about expanding the number of actuarial summer programs. Program costs and start up considerations will be included in the presentation. A desirable result would be to identify several colleges that would be willing to explore the possibility of starting such a program at their college.

The technical provisions in Solvency II - what EU Insurers could do if they had schedule P

Glenn Meyers, ISO Innovative Analytics, U.S.A.

The goal of this paper is to demonstrate how publicly available data can be used to calculate the technical provisions in Solvency II. This is a purely hypothetical exercise, since the publicly available data is in America, and Solvency II applies to the European Union. Using American Schedule P data, this paper:

1. Develops "prior information" to be used in an empirical Bayesian loss reserving method.
2. Uses the Metropolis-Hastings algorithm to develop a posterior distribution of parameters for a Bayesian Analysis.
3. Develops a series of diagnostics to assess the applicability of the Bayesian model.
4. Uses the results to calculate the best estimate and the risk margin in accordance with the principles underlying Solvency II.
5. Develops an ongoing process to regularly compare projected results against experience.

The paper includes analyses of the Schedule P data for four American Insurers based on its methodology.

How phased retirement affects defined benefits

Patrick Mignault, Université Laval, Canada

Co-Author: Claire Bilodeau, Université Laval, Canada

The aging of the societies increasingly raises concerns about economic growth and shortages of workers in the traditional age groups. In the future, people may need to work longer. In many countries, implementing phased retirement mechanisms in private pension plans is encouraged. However, this solution, particularly in defined benefit plans, raises actuarial questions and issues as to how to determine benefits to be paid to the participants. Taking all existing forms of retirement (early, normal, and postponed) into account, we present an actuarial model which determines benefits to be paid in phased retirement and in full retirement.

Solvency appraisal for life annuities: demographic risk measures

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Marilena Sibillo, University of Salerno, Italy

The demographic risk is the risk due to the uncertainty in the demographic scenario assumptions by which life insurance products are designed and valued. The uncertainty lies both in accidental (insurance risk) and systematic (longevity risk) deviations of the number of deaths from the value anticipated for it. This last component gives rise to the risk due to the randomness in the choice of the survival models for valuations (model risk or projection risk). If the insurance risk component can be assumed negligible for well-diversified portfolios, longevity risk is crucial in actuarial valuations. The paper focuses in particular the solvency appraisal for a portfolio of life annuities, deepening the impact of the demographic risk according to suitable risk indexes apt to describe its evolution in time. The financial quantity proposed for representing the economic wealth of the life insurance company is the stochastic surplus and the paper analyzes the impact on it of different demographic assumptions by means of risk indicators as the projection risk index, the quantile surplus and the ruin probability. The longevity risk is mainly taken into account in a stochastic scenario for the financial risk component. Numerical applications clarify the practical meaning of the models in the solvency context.

Evaluation of parameter risk via first order approximation of distortion risk measures

Jacques Rioux, SAS Institute, U.S.A.

Co-Authors: Steven Major; Donald Erdman, SAS Institute, U.S.A.

In this paper we address the issue of parameter risk in the loss distribution approach to operational risk management. When the risk measure belongs to the class of distortion risk measures and the asymptotic distribution of the estimate of the parameters is normal, we use a linearization of the risk measure to examine how parameter changes can be mapped into corresponding risk measure changes. With this methodology, it is possible to approximate the confidence interval for the risk measure estimate associated with parameter uncertainty. We discuss computation time of these estimates, which we have found to be very reasonable. Examples are given for some common risk measures, including value-at-risk and conditional value-at-risk.

Technology enhanced learning for actuarial science education

Margie Rosenberg, University of Wisconsin-Madison, U.S.A.

Co-Author: Edward (Jed) Frees, University of Wisconsin-Madison, U.S.A.

Like many successful actuarial programs, UW-Madison has recently enjoyed a substantial uptake in student interest in our program. Technology enhanced learning tools provide a new way for students to help themselves to master the classroom material, and to accomplish this at anytime and anywhere they choose.

We categorize learning modules as helping students with (1) software, (2) theory, (3) applications, (4) historical vignettes and (5) practice problems. With applied statistics as our springboard, we will use these tools in other courses, ranging from our introductory probability (Exam P/1) to doctoral level courses. We will integrate other tools, such as the statistical package “R,” into our curriculum. In this presentation, we will provide an introduction to the tools that are available and how they will be used in our classrooms and beyond.

Analysis of variable benefit plans

Barbara Sanders, Simon Fraser University, Canada

The operational characteristics of a group pension scheme with fixed annual contributions and variable benefit accruals are studied both analytically and by simulation using an aggregate funding requirement under the assumption of a constant valuation rate and log-normal returns. The distribution of the pension entitlement at retirement is compared under three different parameter sets for asset returns. The performance of the variable benefit plan is then compared to a DC benchmark in terms of the proximity of the retirement benefits to the targeted benefit level. Finally, practical modifications to the benefit policy are considered and their effect on performance is assessed.

Fuzzy post-retirement financial strategies

Arnold Shapiro, Penn State University, U.S.A.

The purpose of this study is to investigate and model the fuzziness inherent in post-retirement financial strategies. To this end, we focus is on an agent who has been a retirement savings plan participant, who has made consistent significant contributions to the plan, and who has followed a life-cycle approach to accumulation. It is assumed that only pension assets will be used to fund retirement benefits, and that the estate, if any, will be comprised of non-pension assets and residual pension assets. It also is assumed that there is some leeway with respect to the agent’s actual retirement date. The topics addressed include the conceptualization of fuzzy post-retirement financial strategies and related concepts and parameters, and the mechanics of their implementation.

Finite-time ruin problems in Sparre Andersen models with arbitrary interclaim times

Tianxiang Shi, University of Waterloo, Canada

Co-Authors: David Landriault; Gordon E. Willmot, University of Waterloo, Canada

An explicit expression for the joint distribution of the time to ruin and the number of claims at ruin is derived in Sparre Andersen models with arbitrary interclaim times. We first assume claim sizes are exponential and make use of Lagrange's expansion theorem to obtain a closed-form expression for the aforementioned ruin quantity. In the second part of my talk, claim sizes are assumed to be a finite sum of exponentials. An extension of Lagrange's expansion theorem in multiple dimensions is used to examine the density of the time to ruin.

Estimation and nonparametric testing of heterogeneous life data models

Jaap Spreeuw, City University London, U.K.

Co-Authors: Søren Fiig Jarner, Danish Labour Market Supplementary Pensions, Denmark
Jens Perch Nielsen, City University London, U.K.

We consider heterogeneous life data models and introduce a new visual inspection technique capable of detecting the credibility of our model assumptions. Our technique is based on a transformed data approach, where the density of the transformed data should be close to the uniform distribution when our model assumptions are correct. To estimate this filtered density estimator on the transform axis we take advantage of the recently defined local linear density estimator based on filtered data of Nielsen, Tanggaard and Jones (2009). We apply our method to mortality data and relate it to the recently published SAINT model, see Jarner and Kryger (2009), that is real life asset-liability model used by one of the major European pension funds.

Pricing and hedging with discontinuous functions: quasi-Monte Carlo methods and dimension reduction

Ken Seng Tan, University of Waterloo, Canada

Co-Author: Xiaoqun Wang, Tsinghua University, China

Quasi-Monte Carlo (QMC) methods have become important numerical tools in computational finance. Many studies have demonstrated the greater efficiency of QMC relative to Monte Carlo (MC) methods, even for pricing high-dimensional exotic derivative securities. Some of these studies have argued the importance of effective dimension in determining the efficiency of QMC. Consequently, dimension reduction methods based on Brownian bridge (BB) and principal component analysis (PCA) have been proposed to enhance QMC. While the notion of effective dimension is an important factor for affecting the performance of QMC methods, in this paper we demonstrate that the adverse effect from the discontinuity is even more pronounced. This calls for a significant concern as discontinuities occur naturally in pricing and hedging exotic derivative securities. The estimation of Greeks using pathwise approach is another example which induces discontinuity. The purpose of this paper is twofold. The first is to establish the relationship among the dimension reduction methods, the feature of discontinuity and the performance of QMC methods, with special interest in understanding why BB and PCA do not offer a consistent advantage in QMC. The key is that dimension reduction methods could change the structure of discontinuity and thus could adversely affect the performance of QMC methods. In particular, we demonstrate that for digital options, BB and PCA make the problems harder for QMC, since they implicitly introduce irregular discontinuities and increase the effective dimension comparing with the standard discretization. The second purpose of the paper is to overcome the obstacle of discontinuity. We develop a new and novel way of handling discontinuity by ensuring the inherent discontinuity to be "QMC-friendly" in the sense that the discontinuity occurs in the axis-parallel hyperplanes. By making the discontinuity "QMC-friendly", we recover the greater efficiency of QMC. Extensive numerical experiments are conducted to demonstrate the efficiency and robustness of the proposed method for pricing exotic options with discontinuous payoffs and for estimating Greeks. It is also of interest to note that while our proposed method significantly outperforms other competitive approaches such as BB and PCA, the resulting problem also has a strong degree of additivity as well as low effective dimension. All these evidences support the overwhelming success of our proposed method.

Valuation of segregated funds in India

Emmanuel Thompson, University of Calgary, Canada

Co-Author: Rohana Ambagaspitiya, University of Calgary, Canada

Stochastic valuation modeling is an important area for actuaries and financial experts who deal in equity-linked insurance including segregated fund contracts. A stochastic analysis of the guarantee liabilities under any given segregated fund contract requires a credible long-term model of the underlying stock return process. However, there are many stochastic models in common use for the stock return process. Actuaries have no general agreement on the form of such a model (CIA (2001) and AAA (2005)).

A model of stock and bond returns for long-term applications was developed by Wilkie (1986, 1995) in relation to the U.K. market, and subsequently fitted to data from other markets, including both the United States and Canada. It has been applied to segregated fund liabilities by a number of Canadian companies. In spite of it being an invaluable tool for actuaries particularly in the context of measuring and managing financial risk, it has as well been subjected to vigorous criticisms (Huber (1997)). While different markets behave differently, it is important to factor market characteristics at an early stage in the modeling process.

In this paper, we introduce an econometric (valuation) model which is less complex than the Wilkie model for valuing and managing financial risks associated with combined guaranteed minimum maturity benefit and guaranteed minimum death benefit (GMMB/GMDB) regarding segregated fund contracts in India. Currently, the regulation of unit-linked insurance contracts in India is being developed to follow the Canadian regulation of segregated fund contracts.

The long-term stock market returns and the security bond processes are modeled by the vector autoregressive (VAR) and the Cointegrated vector autoregressive (COINT-VAR) models respectively. They offer an alternative class of models to actuaries and other financial experts.

For the VAR model, we use monthly data from the Colombo Stock, Bombay Stock and the Karachi Stock indices. However, we use the Monthly Yield to Maturity (YTM) of up to 14 days, 15 to 91 day, 92 to 182 days and 183 to 364 days from the Indian Money Market to fit the COINT-VAR model.

Finally, we assess the valuation model via simulation for a 10 year contract under the combined GMMB/GMDB for a life age 50. The simulation results clearly indicate that, the net present value of outgo is mostly in the negative.

Actuarial Applications of the Linear Hazard Transform in Mortality Fitting and Prediction

Cary Chi-Liang Tsai, Simon Fraser University, Canada

Co-Author: Chris Lingzhi Jiang, Simon Fraser University, Canada

In this talk, we study actuarial applications of the linear hazard transform in actuarial science. Under the linear hazard transform, the survival function of a risk is distorted, which provides a safety margin for pricing insurance products. We find that the linear hazard transform is very good at fitting by regression between two mortality curves. With the method of mortality fitting, the mortality for a future year can be predicted as well. Numerical examples will be given for illustration.

Measuring supplier performance using generalized linear modeling

Eric Vaagen, Insurance Corporation of British Columbia, Canada

The Collision Repair Industry Agreement (CRIA) is a performance-based program through which the Insurance Corporation of British Columbia (ICBC) rewards its partner repair shops for financial efficiency. Annual increases to labor rates are tied to performance measures. Targets are set by fitting generalized linear models (GLMs) to past claim severity.

Replicated stratified sampling – a practical approach to financial modeling

Jay Vadiveloo, University of Connecticut and Towers Watson, USA

Replicated Stratified Sampling (RSS) is a new technique in statistics and actuarial science. It uses a generalized risk management algorithm which can exponentially speed up the calculation process for changes in any risk measure with a pre-determined accuracy level. It has applications in all areas of actuarial science and financial modeling in general. While the RSS technique is new for actuarial science, it opens up a new area of research in statistics as well since it works with multiple samples and pools the sample distributions to estimate the underlying population distribution. The RSS technique uses basic statistics techniques of stratified sampling to estimate the population distribution, but incorporates a unique feature of utilizing repeated new samples and combining results in order to speed up the convergence to the population distribution. Unlike other existing techniques used to speed up processing time. The RSS technique is flexible and robust since it does not attempt to simplify the underlying population distribution of the risk measure. It is also easy to implement since the RSS algorithm attaches to and utilizes a company's existing actuarial software. The technique has been empirically tested and validated for a VACARVM calculation of a major insurance company and the results are extremely promising.

Distribution of discounted compound sums when the mean of inter-arrival time is small

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Co-Authors: José Garrido, Concordia University, Canada

Ghislain Léveillé, Université Laval, Canada

Léveillé, G., Garrido, J. and Wang, Y.F. (2009) derived the moment generating function (mgf) for the discounted compound Poisson sums and the mgf for the Erlang (2) inter-arrival times. In this talk, I will show how to calculate the distribution of discounted compound PH-renewal sums by inverting the Laplace transform. A Differential system will be studied for the mgf of discounted compound PH-renewal sums. If the mean of inter-arrival times is very small, obtaining the solution of the differential equations is difficult. Series methods and transform differential equations will be discussed in details. Application such as stop-loss premium, VaR and CTE is also investigated.

Optimal reinsurance strategy in two dimensional risk model

Wei Wei, University of Waterloo, Canada

It is well known that, when considering one single risk, the stop loss reinsurance strategy minimizes the ruin probability or maximizes the adjustment coefficient of the surplus process for the first insurer in compound Poisson model. Instead of considering one single risk, we study optimal reinsurance strategy regarding two-dimensional risk in this paper. We prove that under certain dependence structure, the stop loss strategy preserve its optimality in minimizing ruin probability. On the other hand, we also prove from a new approach that stop loss reinsurance strategy maximizes the adjustment coefficient provided it is well defined. Different from single risk case, the optimal strategy for our model turns out to be a two-dimensional stop loss reinsurance strategy with two retention levels to be determined. We further find out the optimal retention levels under the constraint of fixed reinsurance premium assumption.

Premium forecasting using principal components analysis

Brant Wipperman, Insurance Corporation of British Columbia, Canada

Co-Author: Eric Vaagen, Insurance Corporation of British Columbia, Canada

The Insurance Corporation of British Columbia (ICBC) recently filed with its regulator a new methodology for predicting average premium levels. The model explicitly accounts for shifts in the mix of business by class, territory, and other rating variables in order to produce the forecast. Principal components analysis (PCA) is used to compress the data into a smaller, more powerful set of predictors.

Actuarial and financial valuations of guaranteed annuity options

Ruowei Zhou, Southwestern University of Finance and Economics, China

Guaranteed Annuity Options (GAOs) are options available to holders of certain pension policies. Under these contracts, policyholders contribute premiums into a fund managed by the insurer. At retirement, the policyholders buy life annuities at a guaranteed rate provided by the original insurer, or annuitize with another insurer. If the guaranteed annuity rates are better than the prevailing rates in the market, the insurer has to make up the difference. GAOs can be viewed as interest rate options, since retiring policyholders can choose to use the higher of the guaranteed annuity rate and the prevailing market rate. In this paper, GAOs are studied using two models for the interest rate; the Vasicek and the Cox-Ingersoll-Ross models. An actuarial approach is used to value the GAOs and compared with the value of a replicating portfolio.

Posters

Assessing longevity risk with generalized linear array models

Jill Falkenberg, Simon Fraser University, Canada

Longevity risk is becoming more important in the current economic environment; if mortality improvements are larger than expected, profits erode in the annuity business and in defined benefit pension schemes. The Lee-Carter model, although a popular model for mortality rates by age and calendar year, has been critiqued for its inflexibility. A recently proposed alternative is to smooth the mortality surface with a generalized linear array model (GLAM), allowing for an additive surface of shocks.

We compare the GLAM and Lee-Carter models by fitting them to Swedish mortality data. Lee-Carter mortality predictions are calculated, and a time series method for GLAM prediction is developed. The predicted mortality rates and associated uncertainties are calculated and compared.

Using cohort change ratios to estimate life expectancy in populations closed to migration: a new approach

David Swanson, University of California-Riverside, U.S.A.
Co-Author: Lucky M. Tedrow, Western Washington University, U.S.A.

As noted in the UN Manual, Methods for Estimating Adult Mortality from Census Data (United Nations (2002: 5), "Census survival methods are the oldest and most widely applicable methods of estimating adult mortality ... (and can) provide excellent results (for) populations that experience negligible migration ... " The general approach can be used only for populations that are closed to migration, or approximately so. but there populations meeting these requirement that are of interest. The world as a whole meets this requirement, for example. Countries with populations closed to migration include North Korea and Burma, among others. Other such populations are found in the historical record - the former Soviet Union, Albania from 1950 to 1980, and the Peoples Republic of China from 1950 through 1970, for example. Still others may be defined by race and ethnicity or other 'rules' of membership (e. g., Indigenous Populations in Australia and Canada, Native Hawaiians). The same UN manual shows a procedure for developing life expectancy at age x (where $x > 0$). In our presentation, we propose an alternative procedure to the one shown by the UN that allows one to calculate e_x (including e_0) in a more direct manner from cohort change ratios. We discuss the benefits and limitations of our approach and compare life expectancy estimates derived from our approach to those derived from the approach of the UN and others, where available. As well as some nuances and cautions, we discuss benefits in using this approach to estimating life expectancy, including the ability to develop estimates of average remaining life at any age. We find that the technique appears to be worthy of consideration for use.

Modeling investment returns with a multivariate Ornstein-Uhlenbeck process

Zhong Wan, Simon Fraser University, Canada

A multivariate Ornstein-Uhlenbeck process is used to model the returns on different investment instruments. Model parameters are estimated under the principle of covariance equivalence. Fitted models can be used to price insurance products and analyze the risk associated with different asset allocation strategies. To illustrate the results obtained, an annuity is studied when assets are allocated between equity and two types of bonds. To show the importance of using a multivariate model, annuity prices are compared to those obtained from independent univariate processes.

An INAR(1) model with dynamic heterogeneity for claim counts in automobile insurance

Ting Zhang, Simon Fraser University, Canada

Bonus-malus systems in automobile insurance describe how the past claim counts determine the future insurance premiums. The potential risks of the policyholders vary due to differences in driving behavior, which leads to the unobserved heterogeneity in individual average claim counts. This work proposes an integer-valued autoregressive (INAR) process with dynamic heterogeneity for claim counts to reflect the stochastic effect of past count variables as well as the fluctuation and correlation of the time varying heterogeneity. Numerical comparisons with Poisson-Gamma credibility model are provided on the estimated heterogeneity and the predictive premiums based on past claim history.

SPEAKERS

Invited Talks

Young, Dan R.
Klugman, Stuart
Dean, Charmaine

Posters

Falkenberg, Jill
Swanson, David
Wan, Zhong (Joan)
Zhang, Ting

Contributed Talks

Adam, Louis2B
An, Ping2B
Augustyniak, Maciej6A
Balbás-Aparicio, Beatriz1B
Balbás, Raquel7B
Cong, Jianfa1B
Cossette, Hélène5B
Doray, Louis G.5A
Dufresne, Daniel4B
Garrido, José1A
Gau, Wu-Chyuan4A
Hartman, Brian5A
Ji, Min7A
Joss, Richard7B
Kim, Joseph4B
Landriault, David3A
Léveillé, Ghislain5B
Loach, Andrew4A
Lu, Yi3A
Marceau, Etienne6B

Mashayekhi, Mostafa6B
McKeown, Barry2A
Meyers, Glenn4A
Mignault, Patrick3B
Orlando, Albina1A
Rioux, Jacques6B
Rosenberg, Margie2A
Sanders, Barbara3B
Shapiro, Arnold3B
Shi, Tianxiang3A
Spreeuw, Jaap7A
Tan, Ken Seng4B
Thompson, Emmanuel7B
Tsai, Cary Chi-Liang1A
Vaagen, Eric5A
Vadiveloo, Jay6A
Wang, Ya Fang5B
Wei, Wei1B
Wipperman, Brant6A
Zhou, Ruowei7A