

# 40th Actuarial Research Conference

## Abstracts

### **Operational Risk Capital Provisions for Banks and Insurance Companies**

Edoh Fofa Afambo, Georgia State University

Operational risk has become recognized as a major risk class because of huge operational losses experienced by many financial firms over the last past decade. Unlike market risk, credit risk, and insurance risk, for which firms and scholars have designed efficient methodologies, there are few tools to help analyze and quantify operational risk. The new Basel Revised Framework for International Convergence of Capital Measurement and Capital Standards (Basel II) gives substantial flexibility to internationally active banks to set up their own risk assessment models in the context of the Advanced Measurement Approaches (AMA). This paper will investigate the implications for using the AMA as a method to assess operational risk capital charges for large banks and insurance companies within Basel II paradigms and with regard to U.S. regulations. The AMA developed in this context will use actuarial loss models complemented by max-stable extreme value distributions and alpha-stable distribution theories. This approach will be innovative for several reasons. First, it will account for dependency across risk categories. Second, it will offer various approaches to calibrating the observed operational loss severity probability density function, and thereby will appropriately account for the reporting bias that plagues publicly available operational risk loss databases. Third, it will recognize the risk mitigation mechanism that operational risk transfer across financial sectors may provide. Fourth, it will propose a methodology to simulate these databases in order to mitigate data availability issues in empirical exercises. The capital charge will be determined as a function of different risk measures and dependency models. Finally, the methodology will be tested on both simulated and real-world publicly available operational risk database for the banking and

### **Rainfall insurance**

Edgard Baqueiro, ByC Servifin  
Tapen Sinha, ITAM

Abstract: Developing countries are heavily affected by weather related risks. Financial derivatives based on these risks can be very useful alternatives for traditional insurance which suffer from moral hazard problems. Yet, these instruments rare in developing countries. We examine the rainfall data in different weather stations in Mexico City over a period of 70 years and propose a simple pricing mechanism for a set of financial derivatives.

### **Modeling natural catastrophe risk: an application to earthquakes and hurricanes**

Mathieu Boudreault, Université Laval  
Hélène Cossette, Université Laval  
Étienne Marceau, Université Laval

We introduce a model that could appropriately represent natural catastrophe risk to assess individual and aggregate losses considering that the latter risk can be split into frequency, intensity and damage. The model also takes into account the dependence between policyholders and between frequency and intensity of natural catastrophes. Models for each catastrophe risk component are presented for both earthquake and hurricane risks. Earthquake risk is based on ordinary and delayed renewal processes while the intensity of earthquakes can be directly linked to waiting times as earthquakes are stronger when more time has elapsed since the last event. Hurricane risk must consider the cyclical evolution of ocean temperature, phenomenon described as El Niño / Southern Oscillation (ENSO) in meteorology. It is known that ENSO influences both intensity and frequency of tropical cyclones since more hurricanes and also stronger events tend to occur during the cold phase (La Niña). We also present the impacts of incorporating past and present information in the model to assess quantities to help the actuary price and reserve natural catastrophe risk. Finally, data from earthquake-prone areas (Montreal and Vancouver in Canada) and hurricane-prone areas (Florida, U.S.A.) are used to compare the fit of models, analyze the results of each model, examine the impact of past and present information on losses and investigate the effects of dependence between frequency and intensity of natural catastrophes on the time-distribution of individual and aggregate losses.

### **The Valuation of hybrid pension plan**

Kai Chen, University of Waterloo

A hybrid pension plan combines defined contribution and defined benefit features. This study considers the valuation of a defined benefit underpin within a defined contribution plan, using an equilibrium approach.

### **A Comparison of Methods for Modeling an Aggregate Life Insurance Claims Distribution**

Sarah Christiansen, Munich American Reassurance  
Tom Edwalds, Munich American Reassurance

The power of modern computer hardware and software tools makes Monte Carlo simulation cheap, fast, and easy. No wonder it has become a favorite tool in actuarial work! Has it rendered obsolete analytic approaches to solving actuarial problems? In this presentation we compare the speed and accuracy of Monte Carlo simulation against an analytic approach to calculating the moments and percentiles of the distribution of aggregate life insurance claims. We use actual data from X-factor testing from two small companies combined.

## **Ruin Measures in Risk Models with Time Dependent Claim Amounts**

Hélène Cossette, Université Laval

Mathieu Boudreault, Université Laval

David Landriault, Université Laval

Etienne Marceau, Université Laval

In risk theory, the compound Poisson risk model (Cramer-Lundberg) and the renewal risk model (Sparre-Andersen) are used to describe the mechanism underlying the arrival and amount of claims. Within these two risk models, it is assumed that the interclaim times are independent of the amount of a claim. This hypothesis of independence may be inadequate in some contexts, for example in catastrophe insurance. We propose extensions to these classical models in which the distribution of the  $j$ th claim amount  $X_j$  is function of the time  $T_j$  elapsed between the  $(j-1)$ th and  $j$ th claim. The couples  $(X_1, T_1)$ ,  $(X_2, T_2)$ ,  $(X_3, T_3)$ , ... are assumed to form a sequence of bivariate independent random variables. Within this model, we consider the Gerber-Shiu discounted penalty function. We propose Lundberg exponential bounds to the ruin probability obtained with an inductive and a martingale approach and derive the explicit expression for the ruin probability when the amount of claims is a mixture of exponentials. Also, we propose an algorithm which allows the approximation of the ruin probability in our context with its discrete analogue. Numerical examples with different choices of distributions for  $T_j$  et  $X_j$  are considered.

## **A Dynamic Programming Approach to Valuing Reload Executive Stock Options.**

Palahuela W. Dayandanda, St Thomas University

Executive compensation plans normally include the award of executive stock options, which are generally call options on a company stock, and include certain predetermined conditions. These options normally have their strike price equal to the stock price on the grant date. In recent times, many companies have included executive stock options in compensation plans in order to attract and retain executives. In many cases the terms of the plan allow the executive, upon exercise, to receive additional options, (so called reloading) so that those executives who makes the company perform well are further rewarded prior to the expiration date of the original stock option. The paper presents an approach to determine the optimal reload times using dynamic programming and the corresponding optimal value of such executive stock options. Some numerical results are provided as an illustration.

FASB now requires that all executive stock options be valued and recorded in the financial statements of companies. Thus, the research presented is useful in practice.

## **Claims Reserving When There Are Negative Values in the Runoff Triangle: Bayesian analysis using the three-parameter lognormal distribution**

Enrique de Alba, ITAM

Marco Ramirez Corzo, ITAM

In this paper we are concerned with the situation that occurs in claims reserving when there are negative values in the development triangle of the incremental claim amounts. Typically these negative values be the result of salvage recoveries, payments from third parties, total or partial cancellation of outstanding claims, due to initial overestimation of the loss or to possible favorable jury decision in favor of the insurer, rejection by the insurer, or just plain errors. It could be argued that the problem is more with the data than with the methods. Some of the traditional methods of claims reserving, such as the chain-ladder technique may handle this situation. However, any can break down in the presence of a sufficient number of negative incremental claims if certain positivity constraints are not met. Although the chain-ladder is frequently used as a benchmark, due to its generalized use and ease of application, our aim is not to develop Bayesian methods that provide results close to those of the chain-ladder method. We present a full Bayesian model to consider negative incremental values, based on a three parameter log-normal distribution. The model presented here allows the actuary to provide point estimates and measures of dispersion, as well as the complete distribution for outstanding claim reserves. We apply MCMC using the package WinBUGS.

### **Four-Part Models with Correlation between Inpatient and Outpatient Health Care Expenditures**

Jie Gao, University of Wisconsin-Madison

Explaining and predicting the variability in health care expenditures is important for health insurance pricing, capitation payment in managed care plans and risk adjustment. This paper considers models of health care expenditures that include a significant fraction of zero outcomes and non-normal distribution characterized by positive skewness. Two-part models, proposed by Cragg (1971), recognize that when people are deciding whether or not to use health care they usually go through a two-stage decision making process. The first part models the decision whether or not to use health care and the second part models non-zero expenditures. One-part models, in comparison, tend to ignore the mixed features of the data and do not perform as well in explaining and predicting the variability in health care expenditures.

Furthermore, inpatient and outpatient expenditures often display different frequency and severity characteristics that necessitate separate modeling treatment. Previous studies segmented inpatient users from non-inpatient users; however, individuals who incurred both inpatient and outpatient expenditures were grouped under inpatient users. In other words, individuals who have both the inpatient and outpatient expenditures should be grouped separately. In addition, correlation between inpatient and outpatient expenditures should receive attention. This study extends the literature on two-part models by combining two two-part models, one for inpatient expenditure and one for outpatient expenditure building in a correlation structure for those who incurred both inpatient and outpatient expenditures. The data used in this study are from the Medical Expenditure

Panel Survey (MEPS), which is nationally representative. Bayesian analysis that offers advantages in computation and prediction over classical approaches will be considered. Possible other approach includes copula. Prediction results from alternative modeling approaches for health care expenditures will be compared using various criteria.

### **A Comparative Study of IBNR Methodologies for the Colombian Pension System**

Luis Gutierrez, University of Nebraska-Lincoln  
Andres-Felipe Ochoa, Suramericana de Seguros  
Angela Correa, Suramericana de Seguros

In Colombia, affiliates to obligatory pension funds (AFPs) buy coverage in order to guarantee a lifetime monthly income in case of death or permanent and total disability. Insurers issuing these group life policies must carry IBNR reserves following guidelines issued in 1996 by the Bank and Insurance Superintendency. This paper will be devoted mainly to examining the behavior of IBNR reserves estimates using four different methods, based on historical losses of one leading pension fund for the past ten years. Our objective is to set up a new set of guidelines for estimating IBNR reserves for the Colombian Pension System.

### **A joined-up syllabus for technical actuarial education.**

Mary Hardy, University of Waterloo

Actuarial education in many areas has been developed somewhat piecemeal. Often students fail to see the purpose of much of the syllabus, and examiners and text book writers fail to draw the connections between the different parts. In curriculum development is notoriously resistant to addition of new science or deletion of obsolete material. In this talk I look at the development of the technical curriculum of the Society of Actuaries over the last 50 years, and propose a holistic approach for the future.

### **Topics in Lump Sum Payments from Defined Benefit Pension Plans**

Kyle Hays, University of Iowa

This paper will investigate current issues surrounding lump sum payments made from American defined benefit plans. At the heart of this discussion will be the pension reform proposal from the Bush administration. In particular, the administration has proposed that the long-term corporate bond rate currently used to calculate pension plan liabilities should be replaced by a spot yield curve of high grade corporate bond and that plans offering lump sum payments use this spot yield curve to determine the minimum value of these payments. Furthermore, the administration has proposed that companies whose pension funding status has fallen below a set level be required to stop distribution of lump sum payments. This paper will investigate the implications and motivations of these proposals and discuss reactions of critics and proponents of the potential reforms.

### **Tail Index Estimation for Partitioned Insurance Losses**

John Henry, III, Oregon State University  
Ping-Hung Hsieh, Oregon State University

The heavy-tailed nature of insurance claims requires that special attention be put into the analysis of the tail of a loss distribution. In particular, the Pareto function has been demonstrated to fit large claims of several lines of insurance well and, as a result, estimating tail index, which measures the heaviness of the tail of a loss distribution, has received a great deal of attention. Although numerous tail index estimators have been proposed in the literature, many of them are limited in a way that knowledge of individual losses is required, and thus, are inappropriate for insurance data that are often in a partitioned form. In this study, we bridge the gap by developing a tail index estimator suitable for loss data in a partitioned form, in which only the frequencies and the sums of the claims locating in certain intervals are known. We focus only on fitting the model in the tail of the distribution without assuming global density. Theoretical properties of the estimator are derived and its strengths and weaknesses are explored through simulation. An application of the estimator to real world partitioned insurance data is given.

### **Applications of Capture-Recapture Methods**

Thomas N. Herzog, FHA/HUD

Applications of capture-recapture procedures go back to at least 1896, to the work of Petersen [1896], who was interested in the size of fish populations. Another early paper by Lincoln [1930] was concerned with waterfowl. The method gets its name from such applications concerned with estimating the number of fish in a pond, or more generally, estimating the population size of various species in the wild.

Another classic paper, by Sekar and Deming [1949] was concerned with estimating birth and death rates in an area near Calcutta, India. Capture-recapture procedures have more recent application to (1) estimating the size of the undercount in censuses and (2) estimating the number of duplicate records on a list or a database. Other possible applications include (1) estimating the number of drug addicts in the United States and (2) estimating the number of children in Massachusetts possessing a specific congenital abnormality. Finally, Betts et al. [1999] have used capture-recapture methods to estimate the number of people killed in Kosovo. We review the general methodology first and then describe a few of these applications.

### **An Interpolation Method to Produce Continuous Force of Mortality**

Syed A. Hossain, University of Nebraska – Kearney

This paper introduces a fractional age assumption that will produce continuous force of mortality. Most familiar fractional age assumptions are uniform distribution of death, constant force of mortality, Balducci assumptions and family of fractional age (FAA) assumptions. The problem of discontinuities in the force of mortality at integer ages is an inherent characteristic of these models except in FAA. This paper introduces the idea of a

polynomial with respect to time to rid the discontinuities. Related actuarial functions and the condition for existence of such a model are derived. Application of the model is shown with an artificial example and compared with existing popular models.

### **On Indifference Pricing for Double-Trigger Reinsurance Products**

Sebastian Jaimungal, University of Toronto  
Suhay Nayak, Stanford University

We consider the pricing problem for insurance companies facing losses that are linked to a tradable risky asset or index. The risky asset is assumed to follow a geometric Brownian motion and the insurance risk is assumed to be non-hedgeable; consequently, the market is incomplete. We determine the indifference premium that the insurer charges under exponential utility and find that it can be explicitly represented in terms of an expectation under a particular equivalent martingale measure. We then determine the indifference price that the insurer would be willing to pay for a reinsurance contract that pays to the insurer a function of the total observed losses and the risky asset at a future maturity date - a so-called double-trigger styled contract. The resulting HJB equations are highly non-linear and we provide numerical examples to assist intuition.

### **Catastrophe Options with Stochastic Interest Rates and Compound Poisson Losses**

Sebastian Jaimungal, University of Toronto  
Tao Wang, University of Toronto

We analyze the pricing and hedging of catastrophe put options under stochastic interest rates with losses generated by a compound Poisson process. Asset prices are modeled through a jump-diffusion process which is correlated to the loss process. We obtain explicit closed form formulae for the price of the option, and the hedging parameters Delta, Gamma and Rho. The effects of stochastic interest rates and variance of the loss process are illustrated through numerical experiments. Furthermore, we carry out a simulation analysis of the Delta-Gamma-Rho hedging scheme and illustrate that accounting for stochastic interest rates, through Rho hedging, can significantly reduce the expected conditional loss of the hedged portfolio.

### **A Better Defined Benefit Contribution Policy: Contribute No Less than the Normal Cost.**

David Kausch, University of Michigan

A frustrating aspect of pension funding rules for U.S. plan sponsors is that contribution requirements are adversely correlated with business cycles. For example, not only did plan sponsors get hit with large contribution requirements in the perfect storm of the early

2000s, but many sponsors were prohibited from contributing in the late 1990s boom due to full funding limitations.

We propose that plan sponsors be allowed to contribute the normal cost as a deductible contribution each year. We view this as a fundamental component of any set of pension funding relations. This change could be layered on to existing regulations or be part of a new set of regulations.

We demonstrate that expanding the existing U.S. funding rules to allow sponsors to deduct contribution at least equal to the normal cost results in less volatility of contributions and of the pension fund, more flexibility for the plan sponsors and more benefit security for plan participants and beneficiaries.

We explore the impact of the change with dynamic asset returns and dynamic valuation interest rates. We assume that demographic assumptions are always met and that the population is stationary with respect to the given demographic assumptions.

Our analysis of risk measures uses a simulation of a random pension valuation with contributions ranging between the minimum required and maximum deductible contributions under the current and revised rules. An optimal contribution policy would minimize the volatility of contributions, volatility of fund level, or other risk measure for the plan sponsor.

As a final point of interest, we apply our analysis to the Bush administrations proposed pension funding reform for comparison.

### **Bootstrap estimation of the conditional tail expectation (CTE)**

HyunTae Kim, University of Waterloo

The bootstrap offers a useful nonparametric method to determine the CTE. Using the exact bootstrap (EB) by Hutson and Earnst, it turns out that the bootstrap estimation of the CTE does not need simulations at all, thus completely eliminating the resampling error and also saving computing time significantly; the estimation of the variance of the CTE is also can be computed similarly. Simulation studies for some known fat-tailed distributions show that this EB method works better than ordinary resampling bootstrap method. For the estimation of the variance of the CTE, we show that EB produces better results than the nonparametric delta (or the influence function) approach proposed by Manistre and Hancock in NAAJ.

### **Pricing American options on exponential Levy processes.**

Adam Kolkiewicz, University of Waterloo

This paper presents a numerical method for pricing American style options where the underlying asset price follows a Levy process of exponential type. For such models,



several techniques have been proposed for the valuation of European options. The problem of the American option valuation is more complex and remains a contemporary research topic. In the case of several assets following a diffusion process, a method that recently gained popularity utilizes a least-square technique combined with Monte Carlo simulation (Longstaff and Schwartz, 2001). Unless a Levy process is amenable to simulation, however, this Monte Carlo method may not be used. In the paper we show how the method can be modified so that the least-square component can be determined using only the characteristic function of the process combined with the fast Fourier transform method. We illustrate the approach with several examples.

### **Study of Variance Reduction Techniques for American Option Pricing**

Jennie La, University of Calgary  
Christine Lemieux, University of Calgary

American option pricing is a challenging problem in financial mathematics for which several approaches have been proposed in recent years. In this paper, we consider the regression-based method of Longstaff and Schwartz (2001) to price these options and then investigate the use of different variance reduction techniques to improve the efficiency of the Monte Carlo estimators thus obtained. One of the techniques we use is importance sampling, in which the approach of Glasserman, Heidelberger and Shahabuddin (1999) is applied to find an appropriate change of measure. We also use control variates and randomized quasi-Monte Carlo methods to reduce the variance further, and give numerical results to investigate the use of these combined techniques for single-asset Asian call options.

### **Analysis of the discounted penalty function in a discrete-time risk model with dependence**

David Landriault, University of Waterloo

In this paper, we consider an extension to the well-known compound binomial risk model similar, in a continuous-time framework, to the extension proposed by Albrecher et Boxma (2004) [A ruin model with dependence between claim sizes and claim intervals, *Ins. Math. Econ.* 35, 245-254] of the classical compound Poisson risk model. Indeed, we consider a discrete-time risk model for which the interclaim times and the claim amounts r.v.'s are no longer independent. More precisely, we suppose that the distribution of the time between two claims depends on the amount of the previous claim. An exact analytical expression for the generating function of the expected discounted penalty (Gerber-Shiu) function is derived. Using Rouché's theorem, this generating function is then inverted to find the exact solutions to the Gerber-Shiu discounted penalty function. As an illustration, computation of ruin probabilities and the joint distribution of the surplus one period prior to ruin and the deficit at ruin are also carried out.

### **Projecting the Mortality Experience of Canadian Assured Lives**

Johnny Siu-hang Li, The University of Waterloo

To protect the insurance company from the threats of mortality improvements, actuaries have to resort to life tables including a forecast of the future trends of mortality. In this study, we project the Canadian assured life mortality experience to some specific future dates, separately for male/female and smoker/non-smoker. We begin by forecasting future mortality rates of the Canadian population, and then we relate the results to the assured life experience, which is relatively too short for direct projection. Finally, we provide In addition, point-wise confidence intervals for each forecast of age-specific death rate to reflect the uncertainties involved.

### **Phase-type law of mortality**

X. Sheldon Lin, University of Toronto  
Xiaoming Liu, University of Toronto

Mortality models have played a fundamental role in insurance modelling and pricing. In this paper we propose a dynamic modelling framework to describe various mortality patterns observed from insect to human being. Aging mechanism is explicitly modeled using a finite-state markov process with one absorbing state, and interpreted as the intrinsic force of mortality. As a result, the time to death follows a phase-type distribution. One main advantage of this stochastic approach is that it allows for separation of the intrinsic aging force from the external hazard possibilities. Another advantage is that the model parameters provide quantitative measurement of aging rates. They thus can assist the research on aging mechanism and its interacting with age trajectory of mortality. Our model is demonstrated using Australian and Japanese population data from 1900 to 2000.

### **The Compound Poisson Risk Model with a Threshold Dividend Strategy**

X. Sheldon Lin, University of Toronto  
Kristina P. Pavlova, University of Western Ontario

In this talk we discuss a threshold dividend strategy implemented into the classical compound Poisson model. More specifically, we assume that no dividends are paid if the current surplus of the insurance company is below certain threshold level. When the surplus is above this fixed level, dividends are paid at a constant rate that does not exceed the premium rate. This model may also be viewed as the compound Poisson model with the two-step premium rate. Two integro-differential equations for the Gerber-Shiu discounted penalty function are derived and solved. When the initial surplus is below the threshold, the solution is a linear combination of the Gerber-Shiu function with no barrier and the solution of the associated homogeneous integro-differential equation. This latter function is proportional to the product of an exponential function and a compound geometric distribution function. When the initial surplus is above the threshold, the solution involves the respective Gerber-Shiu function with initial surplus lower than the threshold level. These analytic results are utilized to find the probability of ultimate ruin,

the time of ruin, the distribution of the first surplus drop below the initial level, and the joint distributions and moments of the surplus immediately before ruin and the deficit at ruin. The special cases where the claim size distribution is exponential and a combination of exponentials are considered in some detail.

### **Long Term Deferred Annuity Products**

Yan Liu, University of Waterloo

This talk examines a recent innovation in the US annuity marketplace. Long term deferred annuities have recently been introduced to provide longevity insurance. We will examine the pricing of these products and their associated risks. We will also discuss their role in retirement planning and their impact on asset allocation.

### **The Work of the SOA Accreditation Implementation Task Force: A Status Report and Opportunity for Feedback**

Warren Luckner, University of Nebraska-Lincoln

At its October 2004 meeting, the Society of Actuaries (SOA) Board of Governors passed the following motion

“The Board of Governors accepts and approves the Report of the Task Force on Academic Infrastructure. The Board approves, in principle, the undertaking of a process of accreditation for academic actuarial science programs, consistent with the recommendations contained in the Report, and appoints an Implementation Task Force to establish the rules and procedures of such accreditation process. The Implementation Working Group is to report its completed task to the Board at its June 2005, meeting.”

As of the end of May 2005, the SOA Accreditation Implementation Task Force (AITF) has draft rules and procedures for a system of accrediting academic actuarial science programs, and is scheduled to discuss several issues with the SOA Board in June. After the June Board meeting, the AITF will update its draft materials for presentation and discussion at the Actuarial Research Conference (ARC). The goal is to post a draft to the SOA website, along with a survey for feedback, in September before presentation of final recommendations to the SOA Board in November.

The presentation at ARC will discuss the why, how and what - the motivation, the design process and the resulting design - of an accreditation system as then currently envisioned by the task force, and include an opportunity for ARC attendees to provide feedback.

### **Insurance Capital as a Shared Asset**

Donald Mango, GE Insurance Solutions

Merton and Perold (1993) offered a framework for determining risk capital in a financial firm based on the cost of the implicit guarantee the firm provides to the individual financial products sold. Merton and Perold assume the price of such guarantees is observable from the market at large. For an insurer, this may not be a realistic

assumption. This paper proposes an insurance-specific framework for determining the cost of those parental guarantees, and utilizing that cost in pricing and portfolio mix evaluation. An insurer's capital is treated as a shared asset, with the insurance contracts in the portfolio having simultaneous rights to access potentially all that shared capital. By granting underwriting capacity, an insurer's management team is implicitly issuing a set of capital call options—similar in structure to letters of credit (LOC), except the calls are not for loans but for funding. The paper will (i) discuss the valuation of parental guarantees, beginning with Merton and Perold; (ii) treat insurer capital as a shared asset and explore the dual nature of insurer capital usage; (iii) offer a method for determining insurer capital usage cost; and (iv) demonstrate how this method could be used for product pricing and portfolio mix evaluation using economic value added concepts.

### **On the Expected Discounted Penalty Function for Generalized Risk Lévy Processes**

Manuel Morales, York University  
Jose Garrido, Concordia University

We will review, from a historical point of view, the use of Lévy processes in ruin theory. We focus on the decomposition for the ruin probability and we argue how its convolution structure is inherited from the Lévy family of processes. This motivates the study of the discounted penalty function in these general risk models. Ever since the introduction of this function [Gerber and Shiu (1998)], extensions of this function have been worked out in the literature. Here, we explore it in the context of a risk process driven by a Lévy process. We will introduce the notion of discounted penalty function and discuss its importance in ruin theory. The problem of finding expressions for this function in a risk model driven by a Lévy process will be addressed. Examples for which these expressions are available will be discussed. Actual computation of ruin probabilities, distribution of the time of ruin and joint distribution of the process prior and at the moment of ruin, are carried out for a few examples. These include the gamma process and the inverse Gaussian process. Finally, forms for the discounted penalty function in more general Lévy risk models will be presented.

### **Factors Affecting Labour Risks Severity**

Nadia Paulina Pérez Guerrero, HSBC  
Angeles Yáñez, ITAM

Labour Risks is one of the most important branches of Mexican Social Security. These risks can produce health problems (consequences) ranging from a small injury without consequences to the death of the person. This paper analyses the relationship between personal characteristics and the individual behavior of employees who have suffered a labour risk. The study also includes considerations on the inherent characteristics of labour risks and their consequences. Using the information about the assureds of the Mexican Social Security Institute who suffered a labour risks from 1998 to 2002, the consequence's severity is classified in three levels (mild, moderate, high) and related to

the labour risks details and the workers characteristics. The model was built using a multilogistic regression which allows us to predict the severity of physical sequels caused by a labour risk in 65.5%.

The variables that resulted most significant in explaining the severity of a labour risk consequence are divided in three main groups: physical characteristics (gender and age), social characteristics (occupation and time of employment) and the risk characteristics (physical risk and risky activity). One of the most important features of this model is that none of the variables implies any medical examination to determine the severity of a labour risks consequence.

### **Mortality under Standard Individually Life Insurance Between 1999 and 2002 Anniversaries**

Jorge Rendón, ITAM

This study is the latest in continuing annual reports on intercompany mortality experience. Several companies contributed their data to both the study of 1995 – 1998 and this study, but the 95% of the study was supported by the four largest companies with individual underwritten life insurance.

With this data 1999 - 2002 we obtained the mortality ratios during policy years 1-4 and we using credibility formulas to adjust the result, pondering the mortality ratios with the expected ratios found on the 1980 CS0 selection factors.

### **The Cost of Pension Guarantee**

Alejandro Renteria, ITAM

Tapen Sinha, ITAM

When countries move from pay as you go systems to government mandated individualized pension funds, the government guarantees certain minimum level of benefits for the system. The level of accumulation depends on a number of stochastic factors such as the rates of return of the funds in the future. Thus, with these guarantees the governments become liable for future possible payments. We explore this stochastic costs for a specific case: Minimum pension level promised by the Mexican Social Security Law of 1997.

### **Pricing of Guaranteed Products for Defined Benefit Pension Funds.**

Mark Saxonov, New York Life

We will discuss mathematical modeling and pricing of "Stable Value" financial products offered to pension plan providers. These products target a risk-averse population of

investors, who have a significant preference for stability of returns. The Stable Value Products are most appealing to the defined benefit pension plan sponsors

Traditional products have three main agents:

Plan Participants – investors;

Plan Sponsor –an intermediary representing plan participants;

Guarantee Provider;

In a nutshell, the structure works as follows.

Plan Participants pool money through a Plan Sponsor arrangement to invest with a Guarantee Provider. The Guarantee Provider and Plan Sponsor develop a contract stipulating the type of cashflow guarantee, conditions terminating the contract and portfolio manager selection.

As a first approximation these products can be described as debt instruments with some specific cashflow and contract arrangements. In a majority of cases, a contract does not terminate at once. Each contract is comprised of a number of participants who have a right to terminate (may be for unrelated personal reasons). For this reason, termination of the contract by the investor (put option) may randomly deviate from the optimal. Subsequent mathematical formalization will lead to a randomized stopping-time problem.

A predictability of returns is an essential component of portfolio manager performance. The cost of a product from the guarantee provider's point of view depends on volatility of return. At the same time the stability of return is also an investor's objective. Consequently, a portfolio management criterion should penalize for a high volatility of a return.

The biggest challenge is pricing. The traditional arbitrage free argument is not applicable because the underlying market is incomplete and not efficient since each contract is unique.

It turns out that required capital may serve as an indicator of a company's risk averseness. Subsequently we define a related optimization problem solving for a minimum fee that makes the product economically feasible.

I will discuss a mathematical framework and describe a series of optimization problems and their solutions related to the above financial products.

### **Provisions for Adverse Deviations: The Margin Based Approach for Setting Assumptions for Pension Plans**

Kevin Shand, University of Manitoba

An actuary must adopt a number of assumptions when evaluating the assets, liabilities and annual costs of a pension plan. These assumptions involve demographic and economic standards. The assumptions themselves will be based on observed probabilities

and while they may be based on the equal likelihood of certain outcomes, the actuary may be more concerned with the impact of actual future experience deviating adversely from that assumed and how it will impact on benefit security. In this case, the actuary may explicitly adopt a more conservative posture so that the probability of an actuarial gain is greater than that of a loss. This would require a provision for adverse deviation such that a modification made to the assumptions would involve the addition or subtraction of a margin i.e. a cushion. This paper first examines the traditional approach to selecting such a margin and shows that this approach does not provide for the purpose that it was selected for. As well, using a variety of scenarios, the expected outcomes from using the traditional approach are compared to actual outcomes where a number of anomalies are revealed. Some alternative approaches are then investigated keeping in mind the objectives of providing for some acceptable level of protection from adverse deviations.

### **Fuzzy Regression Models and the Term Structure of Interest Rates**

Arnold F. Shapiro, Penn State University

Recent articles of Sánchez and Gómez (2003a, 2003b, 2004) addressed the subject of fuzzy regression (FR) and the term structure of interest rates (TSIR). Following Tanaka et. Al. (1982), their regression models included a fuzzy output, fuzzy coefficients and a non-fuzzy input vector. The fuzzy components were assumed to be triangular fuzzy numbers (TFNs). The basic idea was to minimize the fuzziness of the model by minimizing the total support of the fuzzy coefficients, subject to including all the given data. Key components of the Sánchez and Gómez methodology included constructing a discount function from a linear combination of splines, the coefficients of which were assumed to be TFNs, and using the minimum and maximum negotiated price of fixed income assets to represent the fuzziness of the dependent variable observations. Given the fuzzy discount functions, the authors provided TFN approximations for the corresponding spot rates and forward rates.

The purpose of this article is to revisit the fuzzy regression portions of the foregoing studies, and to discuss issues related to the Tanaka approach, including a consideration of fuzzy least-squares regression models.

### **Mistakes? We've seen a few**

John Shepherd, Macquarie University

As the actuarial profession in North America moves further towards recognition of university studies for the purpose of professional qualification, it is timely to consider what may be learned from the Australian experience. Professional bodies have been accrediting Australian actuarial programs since 1969. This paper identifies some of the cultural differences between professional actuarial bodies and university actuarial departments, and discusses how these differences can affect their relationship. As far as actuarial education is concerned, there is considerable scope for misalignment, on the part

of the partners, of perspectives, objectives and expected outcomes. Starting with the characteristics of a good education system as a benchmark, the paper evaluates the approaches to actuarial education of professional bodies and university departments, and draws out some implications for the facilitation of such partnerships.

### **Bancassurance: Who Ties the Knot and Why**

Tapen Sinha, ITAM

Why do banks and insurance companies get into bancassurance? Little has been studied of this phenomenon in emerging markets. Economies of scale and scope make such an alliance attractive for both banks and insurance companies. We examine the factors behind bancassurance by examining the developments and performing quantitative tests.

### **A Poisson Regression Model for Mortality Data**

N. D. Shyamalkumar, The University of Iowa

We discuss the analysis of mortality data using Poisson Regression – the log mortality rate is estimated by a cubic spline. We also discuss the approximate Bayesian confidence interval and discuss derivation of confidence intervals for other actuarial quantities of interest. The computation is done using the gss package of R – a language and environment for statistical computing and graphics – a Free Software.

### **CTE and Capital Allocation under the Skew Elliptical Distributions**

Ken Seng Tan, University of Waterloo

In recent years, there has been a growing interest among actuaries and finance experts on adopting the Conditional Tail Expectation (CTE) as a "coherent" risk measure for risk management. More recently CTE has been proposed in the context of capital allocation in which CTE provides a convenient way of determining the capital requirement for individual lines of business among correlated business units. Analytic results are derived in Panjer (2002) in the case of multivariate Normal risks. Landsman and Valdez (2003) extend the results of Panjer (2002) to elliptical distributions. In this paper, we further generalize these results by considering a relatively new class of distributions known as the skew elliptical distributions. These distributions have the desirable properties that they need not be symmetric and there is an additional parameter which regulates the skewness.

### **Longitudinal Modeling of Singapore Automobile Insurance**

Emiliano Valdez, University of New South Wales  
Edward W. Frees, University of Wisconsin-Madison



This work describes statistical modeling of detailed, micro-level automobile insurance records. We consider 1993-2001 data from the General Insurance Association of Singapore, an organization of insurance companies. We demonstrate the importance of predictor variables useful for rating purposes and implement longitudinal models that can be used for credibility pricing.

By detailed micro-level records, we refer to three different types of insurance information. The first file provides policyholder information such as the premium paid, the type of vehicle driven and whether a no claims discount was in effect. The second file records the type of insurance claim such as whether the claim is due to injury to a third party, property damage to a third party or claims for damage to the insured. The third file records the loss amount for each type of claim.

We propose statistical models for each component, corresponding to information in the three files types. The first is a random effects Poisson regression model for assessing claim frequency, using the policyholder file to calibrate the model. Vehicle type and no claims discount are among the more important variables for predicting the event of a claim. The second is a multinomial logit model to predict the type of insurance claim, whether it is third party injury, third party property damage, insured damage or some combination. Premiums and year effects turn out to be important predictors for this component.

Our third model for the severity component is the most innovative. Here, we use a Burr XII long-tailed distribution for claim amounts and also incorporate predictor variables. Not surprisingly, there is a dependence among different claim types; we use a t-copula to account for this dependence.

The three component models provide justification for assessing the importance of a rating variable. When taken together, the integrated model allows an actuary to price automobile claims more efficiently than traditional methods.

### **Useful properties of the three-parameter Burr XII distribution**

Yao Wang, Roosevelt University

Several useful distributions related to the Burr distribution are presented. It is shown that the log-odds function for the Burr distribution, in terms of  $\ln(t)$ , is convex upward for  $k > 1$ . For model formulation, it is shown that the Burr distribution is the family of distributions that has the accelerated life property, Lehmann proportional odds property, and asymptotic proportional hazards property.

### **The adjustment coefficient with QS and XL reinsurance**

Li Zhi, University of Waterloo

Maria de Lourdes Centeno provided the insurer's adjustment coefficient as a function of retention levels for a combination of quota-share with excess of loss reinsurance in the Sparre Anderson Model (2002). Francois Dufresne and Hans U. Gerber studied the collective risk theory when a classical model extended to the diffusion process (1991). Here we combine these two cases. We show that the insurer's adjustment coefficient is a unimodal function of the retention levels when the quota-share reinsurance premium is calculated on original terms and when the excess of loss is calculated according to the expected value principle.

Compared to the original model, the excess of loss retention limit decreases due to the diffusion process, which means that for increasing uncertainty, the insurance company should cede more business to the reinsurer.

### **Risk Management at a Leading Canadian Bank: An Actuarial Science Graduate's View**

Yu Zhou, TD Bank Financial Group

In this presentation, we briefly review a leading Canadian Bank's Enterprise Risk Management (ERM) framework using an actuarial graduate's view. We present an overview of Market Risk, Credit Risk and Operational Risk management issues. Finally, we provide a comprehensive discussion of credit derivatives and review the evolution and valuation of Tranche Portfolio Credit products that relate closely to the actuarial science field.