49th Actuarial Research Conference

July 13 –16, 2014

PROGRAM and ABSTRACTS

University of California, Santa Barbara

The 49th Actuarial Research Conference

University of California
Santa Barbara, California, USA

July 13 — July 16, 2014

Organized by
Center for Financial Mathematics and Actuarial Research
Department of Statistics and Applied Probability
University of California Santa Barbara

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Contents

ARC 2014 Program at a Glance

5:00 pm - 8:00 pm	Registration, Corwin Lobby
6:00 pm - 8:00 pm	Welcome Dinner, Lagoon Plaza

DAY 1, Monday, 7/14

7:30 am - noon	Registration opened, Corwin Lobby
8:00 am - 8:30 am	Continental breakfast, Corwin West
8:30 am - 9:00 am	Welcoming remarks, Corwin West
	Pierre Wiltzius, Susan & Bruce Worster Dean of Science and Professor of Physics
	Patrick L. Brockett, Editor, North American Actuarial Journal
	Jean-Pierre Fouque, Director, Center for Financial Mathematics and Actuarial Research
9:00 am - 10:00 am	Plenary Speaker: Paul Embrechts, ETH Zurich, Corwin West
10:00 am - 10:20 am	Coffee Break, Lagoon Plaza
10:00 am - 6:00 pm	Exhibits opened, MultiCultural Center Lounge
10:00 am - 6:00 pm	Poster Exhibit opened, Corwin East
10:20 am - 11:50 am	Panel on Actuarial Research, Corwin West
	Alice Underwood (CAS); Jose Garrido (CIA); Sarah Mathieson (IFoA); Dale Hall (SOA)
	Chair: Ian Duncan, UC Santa Barbara
11:50 am - noon	ARC 2015 Presentation by Sam Broverman, U. of Toronto, Corwin West
noon - 1:30 pm	Lunch, Lagoon Plaza
	Presentation: Mark Freedman, President of SOA
	Introduction: Mike Ludkovski, UC Santa Barbara
1:30 pm - 3:10 pm	Break-out Sessions, Corwin rooms: Flying A, Harbor, State Street
3:10 pm - 3:30 pm	Coffee Break, Lagoon Plaza
3:30 pm - 5:10 pm	Break-out Sessions, Corwin rooms: Flying A, Harbor, State Street
5:10 pm - 6:00 pm	Poster session with presenters next to their posters, Corwin East
	Note: posters are available for viewing during the whole day
5:15 pm - 6:00 pm	Wine and Cheese Reception, Lagoon Plaza
5:30 pm - 6:30 pm	Speed Networking Session, Corwin West
	Organizers: Margaret Milkint, Jacobson Group, and Natalia Humphreys, UT Dallas
6:00 pm and **7:00 pm**	Passenger buses depart from campus for downtown SB
9:00 pm and **10:00 pm**	Passenger buses depart from downtown SB to campus.

DAY 2, Tuesday, 7/15

7:30 am - noon	Registration opened, Corwin Lobby
8:00 am - 8:30 am	Continental breakfast in meeting rooms
8:20 am - 10:00 am	Breakout Sessions, Corwin rooms: Flying A, Harbor, State Street
10:00 am - 10:20 am	Coffee Break, Lagoon Plaza
10:00 am - 3:30 pm	Exhibits opened, MultiCultural Center Lounge
10:20 am - noon	Breakout Sessions, Corwin rooms: Flying A, Harbor, State Street
noon - 1:30 pm	Lunch, Lagoon Plaza Presentation: Wayne Fisher, President of CAS Introduction: Roger Hayne, Milliman, Past President of CAS
1:30 pm - 3:10 pm	Break-out sessions, Corwin rooms: Flying A, Harbor, State Street
3:10 pm - 3:30 pm	Coffee Break, Lagoon Plaza
3:30 pm - 5:10 pm	Break-out sessions, Corwin rooms: Flying A, Harbor, State Street
5:45 pm - 7:30 pm	Catered Goleta Beach BBQ. Mariachi band. Walk is approximately 1 mile; Transportation available for those needing it
7:30pm -	An informal gathering at the Beachside Cafe (Goleta Beach) for networking

DAY 3, Wednesday 7/16

8:00 am - 8:20 am	Continental breakfast in meeting rooms
8:20 am - 10:00 am	Break-out sessions, Corwin rooms: Flying A, Harbor, State Street
10:00 am -10:20 am	Coffee Break, Lagoon Plaza
10:20 am - 11:30 am	Break-out sessions, Corwin rooms: Flying A, Harbor, State Street
11:30 am	Box lunch pick-up in Lagoon Plaza
12:00 pm	Departure for Santa Ynez wine tour (Optional). Return at 6:00 pm.

Schedule of Breakout Sessions

Monday, July 14

Time	A Flying A	B State Street	C Harbor
	A1 – Optimal Investments *Chaired by Jean-Pierre Fouque*	**B1 – Enterprise Risk Management** *Chaired by Jim Trimble*	**C1 – Dependence Modeling & Copulas** *Chaired by John Xu*
1:30~1:50	S. David Promislow Purchasing Term Life Insurance to Reach a Bequest Goal	Greg Taylor Claim Dependencies in Economic Capital Modeling: The Australian Experience	N.D. Shyamalkumar On the Dependent Structure of Compound Loss Models
1:55~2:15	Hong-Chih Huang An Optimal Investment Strategy with Multivariate Jump Diffusion Models	Daoping Yu Model Uncertainty in Operational Risk Modeling	Edward Furman Paths and Indices of Maximal Tail Dependence
2:20~2:40	Phelim Boyle Correlation Matrices and the Perron Frobenius theorem	Marie-Claire Koissi Using Fuzzy Logic to Model Risk -- Case Studies	Marie-Pier Cote A Copula-based Risk Aggregation Model
2:45~3:05	James Bridgeman Structure of the CAPM Covariance Matrix	Mahesh Joshi Methods of Computing a Large Number of Quantiles from an Aggregate Loss Distribution	Ranadeera Samanthi Comparing the Riskiness of Dependent Portfolios
3:10~3:30	Coffee Break		
	A2 – Retirement Panel *Chaired by Errol Cramer*	**B2 – General Insurance** *Chaired by Mark Maxwell*	**C2 – Actuarial Statistics I** *Chaired by Vytaras Brazauskas*
3:30~3:50	Emily Kessler (SOA) Report on the Blue Ribbon Panel on Public Pension plan Funding	Mingjie Hao Adverse selection and loss coverage in insurance markets	Jose Garrido Full Credibility with GLMs and GLMMs
3:55~4:15	Mary Hardy (Waterloo) Reviewing Target Benefit Pension Plans	Ping Wang The Effects of Urbanization on Insurance Consumption- The experience of China	Thomas Hartl Extrapolating co-linear payment year trends for development triangle GLMs
4:20~4:40	Craig Turnbull (Edinburgh) Dynamic Hedge Projection for Variable Annuity Capital Assessment	Jacques Rioux Exploring Copulas	Sam Efromovich Nonparametric Curve Estimation with Incomplete Data
4:45~5:05		Sharon Yang Pricing Joint-Life Reverse Mortgages and Non-Recourse Provisions Considering Mortality Dependence: a Copula Approach	Adrian O'Hagan A Model-Based Clustering Approach to Data Reduction for Actuarial Modeling

Tuesday, July 15

Time	A Flying A	B State Street	C Harbor
	A3 – Healthcare Modeling I *Chaired by Yair Babad*	**B3 – Finance Applications I** *Chaired by Tomoyuki Ichiba*	**C3 – Risk Modeling I** *Chaired by Sam Broverman*
8:20~8:40	Shujuan Huang Model Selection and Averaging of Health Costs in Episode Treatment Groups	Jonathan Ziveyi Valuing Variable Annuity Guarantees on Multiple Assets	Hélène Cossette Finite Mixed Erlang Distribution: Moment-Based Approximation And Loss Modeling With Actuarial Applications
8:45~9:05	Harry Frech Anatomy of a Slow-Motion Health Insurance Death Spiral	Yi-Tai Chiu Systemic Risk with Jump Diffusion Processes	Christian Walter Regulatory risk: is there a danger in reducing the volatility?
9:10~9:30	Andrew Sykes The relative value of health habits and how best to create them. Two research models: A Dose Value model and a Four Powers model for creating health habits	Xiao Wang Valuing Guaranteed Minimum Death Benefits in Variable Annuities with Knock-Out Options	Jiandong Ren On the use of long term risk measures
9:35~9:55	Zeinab Amin Bayesian Modeling of Health Insurance Losses	Zhenhao Zhou Valuing Equity-linked Death Benefits	Krzysztof Ostaszewski Optimal Capital Allocation: Mean-Variance Models
10:00~10:20	Coffee Break		
	A4 – Healthcare Modeling II *Chaired by Ian Duncan*	**B4 – Finance Applications II** *Chaired by Phelim Boyle*	**C4 – Actuarial Statistics II** *Chaired by Ron Gebhardtsbauer*
10:20~10:40	Margie Rosenberg Comparison of Imputation Techniques for Missing Data when the Reason for Missingness May be Informative: An Application to Childhood Obesity using the Medical Expenditures Panel Survey	Yuchen Mei Introduction to Housing Finance and Mortgage Insurance	Vytaras Brazauskas CATL Methods and Robust Credibility: A Study Using Hachemeister's Data
10:45~11:05	Michael Ludkovski Predictive Modeling of Healthcare Claims	Jack Chang Fed's Ultra-Low Interest Rate Policy and the new Norm in the Catastrophe Space: Implications for Optimum Mix with Catastrophe Reinsurance and Bonds	Paul Ferrara Advancements in Common Shock Modeling
11:10~11:30	Yan Yang Using Population Census and Actuarial Analytics to Price for Individual Products	Natalia Humphreys Nonparametric Model of Capital Appreciation of Portfolio	Nathan Lally Predictive Modeling in Long-term Care Insurance
11:35~11:55	Maria Govorun Physiological Age, Health costs and their Interrelation	Xuemiao Hao Pricing Credit Default Swaps with Random Recovery Rates	Ponmalar Ratnam Percentile-Matching for Poisson and Zero-Inflated Poisson Models, with Applications to Risk Measurement

Tuesday, July 15 (cont)

	A5– Technology *Chaired by Raya Feldman*	B5 – Professionalism Panel *Chaired by Margie Rosenberg*	C5 – Longevity Modeling II *Chaired by Michael Ludkovski*
1:30~1:50	Brian Spector Fixing a Broken Correlation Matrix	Rich Veys (SOA) Professionalism for Academic Actuaries	Craig Blackburn Forward Mortality Modelling of Multiple Populations
1:55~2:15	Joann Fifield 3 R's - Will All Enrollees Stand up and Be Counted	Sarah Mathieson (IFoA) Professionalism in the UK	Cary Chi-LiangTsai Variations of the linear logarithm hazard transform for modelling cohort mortality rates
2:20~2:40	Yvonne Chueh Actuarial Model Outcome Optimal Fit (AMOOF) 3.0: Probability Modeling Tool for Education and Research	Barry McKeown Diversity in the Actuarial Profession	Andrew Hunt Forward Mortality Rates: Applications to the Risk Management of Annuities
2:45~3:05	David Kester How Well Does Adapt™ Predict Success?		
3:10~3:30	Coffee Break		
	A6 – Actuarial Education Panel *Chaired by Ian Duncan*	B6 – Automated Vehicles *Chaired by Rick Gorvett*	
3:30~3:50	Stuart Klugman (SOA) Recent developments in Actuarial Exam syllabus: SOA	Matthew Antol (CAS) Alyce Chow (CAS)	
3:55~4:15	Steve Armstrong (CAS) Recent developments in Actuarial Exam syllabus: CAS	Automated Vehicles and the Impact on the Insurance Industry	
4:20~4:40	Jose Garrido (CIA) Recent developments in Actuarial Exam syllabus: CIA	(CAS special session)	
4:45~5:05	Mark Maxwell Eurekas, Ah has, and Other Epiphanies		

Wednesday, July 16

Time	A Flying A	B State Street	C Harbor
	A7 – Property & Casualty I *Chaired by Janet Duncan*	**B7 – Ruin Theory** *Chaired by Ed Furman*	**C7 – Longevity Modeling II** *Chaired by Eric Ulm*
8:20~8:40	Philip Wong Applications of Price Elasticities in Auto Insurance	Etienne Marceau Infinite-time ruin measures for compound renewal risk models with dependence	Ian Duncan Member Plan Choice and Migration in Response to Changes in Member Premiums after Massachusetts Health Insurance Reform
8:45~9:05	Samuel Perreault Constrained clustering of territories: a "k-means"-based algorithm aiming to minimize intra-cluster variation in the context of car insurance	Zhenyu Cui Stochastic Areas of Diffusion and Applications in Risk theory	Louis Adam Canadian Pensioners Mortality Trends by Region, Income and Cohort as at December 31, 2012
9:10~9:30	Zia Rehman Measurement & Classification of Risk Loads for Property Casualty Insurers and its Applications to Loss Reserve Margins and Optimal Business Mix	Ionica Groparu-Cojocaru The finite-time Gerber-Shiu penalty functions for two classes of risk processes	David Smith On the Decomposition of Life Expectancy and Limits to Life
9:35~9:55		Jean-Philippe LeCavalier Ruin And Risk Measures In A Bivariate Discrete-Time Ruin Model	Kenneth Buffin Actuarial Metrics for Monitoring the Sustainability of the US Social Security System
10:00~10:20	Coffee Break		
	A8 – Property & Casualty II *Chaired by Richard Manship*	**B8 – Risk Modeling II** *Chaired by Natalia Humphreys*	**C8– Pensions & Annuities** *Chaired by Barbara Sanders*
10:20~10:40	Rick Gorvett Modeling Competition: Predator-Prey Dynamics and Agent-Based Modeling	Liang Hong A new approach for studying stochastic ordering of risks	Anne MacKay Fixed and Variable Payout Annuities: how Optimal are "optimal strategies"?
10:45~11:05	Gao Niu Agent Based Modeling of P&C Underwriting Cycles	Andrei Badescu Insurance risk models with reporting delays	Wenyuan Zheng Portfolio Choice with Life Annuities under Probability Distortion
11:10~11:30	Brian Hartman Risk Management of Storm Damage to Overhead Power Lines	Zhongyi Yuan Interplay of Asymptotically Dependent Insurance and Financial Risks	Eric Ulm On the Interaction between Transfer Restrictions and Crediting Strategies in Guaranteed Funds

Actuarial Research Conference ARC 2014

Poster Session -- Monday, July 14 – Corwin East

Time	Corwin East
10:00am~6:00pm	1. **Francisca Amoatemaa** Pricing Distance Education through Multiple Decrement Approach 2. **Frederick Guillot** Challenges and opportunities for flood insurance in Canada 3. **Thomas Hartl** A Comparison of Resampling Methods for Bootstrapping Triangle GLMs 4. **Dinghai Lv** Applications of GAMLSS in Non-life Insurance Ratemaking Analysis 5. **Richard Pulliam** Pure Premium Trend Analysis for Auto and Home Insurance Coverages 6. **Zia Rehman** Quantifying Economic Capital for Insurance Risk 7. **Kenneth Sanford** Simulating Portfolio Losses from Adverse Events 8. **David Smith** Using patient records to investigate mortality and deprivation 9. **Craig Turnbull** Dynamic Hedge Projection for Variable Annuity Capital Assessment 10. **Lu Xiong** Using Monte Carlo Simulation to Solve Complex Actuarial Problems 11. **Jinyuan Zhang** Extreme Behaviour for Bivariate Skew-Elliptical Distributions

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EXHIBITS

Please take time to visit our wonderful exhibits!

ARC 2014 Keynote Speakers

Prof. Dr. Paul Embrechts

Professor, ETH Zurich

 Paul Embrechts is Professor of Mathematics at the ETH Zurich specialising in actuarial mathematics and quantitative risk management. He was Visiting Man Chair 2014 at the Oxford-Man Institute of Oxford University, and has Honorary Doctorates from the University of Waterloo, the Heriot-Watt University, Edinburgh, and the Université Catholique de Louvain. Dr. Embrechts is an Elected Fellow of the Institute of Mathematical Statistics, Actuary-SAA, Honorary Fellow of the Institute and the Faculty of Actuaries, Corresponding Member of the Italian Institute of Actuaries, Member Honoris Causa of the Belgian Institute of Actuaries and is on the editorial board of numerous scientific journals and academic advisory committees. He co-authored the influential books "Modelling of Extremal Events for Insurance and Finance", Springer, 1997 and "Quantitative Risk Management: Concepts, Techniques, Tools", Princeton UP, 2005. Dr. Embrechts consults on issues in quantitative risk management for financial institutions, insurance companies and international regulatory authorities.

Wayne H. Fisher, FCAS, FCIA, MAAA

President, Casualty Actuarial Society

 Wayne Fisher is President of the Casualty Actuarial Society. In addition to being a Fellow of the CAS, he is an Associate of the Society of Actuaries, an FCIA, and was one of the first actuaries to hold the CERA credential.

Wayne is an independent director of the Zurich American Insurance Companies and chairs its audit committee. ZAIC is the primary company for Zurich's insurance businesses in the US. Prior to retiring from Zurich Financial Services, he was the Group Chief Risk Officer in Zurich, Switzerland. Previous responsibilities at Zurich included head of Global Specialties, in Zurich, and chief actuary and chief risk officer for Zurich in North America.

Mark J. Freedman, FSA, MAAA

President, Society of Actuaries

 Mark J. Freedman recently retired as principal of Ernst & Young, a global accounting arm with a large actuarial consulting practice. Prior to that, he worked at Philadelphia Life Insurance Company.

His most recent experience has been in financial reporting, mergers & acquisitions, and financial modeling. Before that, he developed life and health products and performed pension valuations as an enrolled actuary.

Among Mark's many volunteer efforts, he notably chaired the SOA's strategic planning task force in 2012, and he was a co-author of the Society of Actuaries textbook, US GAAP for life insurers. Freedman holds a Bachelor of Arts in Mathematics from the University of Pennsylvania.

Abstracts

Abstracts of invited and contributed talks are listed in alphabetical order under the family name of the author.

An index for all speakers can be found on page 104. A further index for all (co-)authors is on page 105.

Canadian Pensioners Mortality Trends by Region, Income and Cohort as at December 31, 2012

Louis Adam (speaker)

Laval University [louis.adam@act.ulaval.ca]

This paper presents some results of a research project focused on measuring the level and trend of mortality using recent Canadian pensioners data as at December 31, 2012. The presentation will compare the mortality trends with respect to gender, age, and period for distinct subsets of the population under study. In particular, the impact of income and region (data source) as explanatory variables will be compared to the impact of the cohort variable.

Bayesian Modeling of Health Insurance Losses

ZEINAB AMIN (speaker)

The American University in Cairo   [zeinabha@aucegypt.edu]

MARAM SALEM

Cairo University   [marammagdysalem@yahoo.com]

The purpose of this paper is to build a model for aggregate losses which constitutes a crucial step in evaluating premiums for health insurance systems. It aims at obtaining the predictive distribution of the aggregate loss within each age class of insured persons over the time horizon involved in planning. The model proposed using Bayesian methodology is a generalization of the collective risk model, a commonly used model for analyzing risk of an insurance system. Aggregate loss prediction is based on past information on size of loss, number of losses and size of population at risk. In modeling the frequency and severity of losses, number of losses is assumed to follow a negative binomial distribution, individual loss sizes are independent and identically distributed exponential random variables, while the number of insured persons in a finite number of possible age groups is assumed to follow the multinomial distribution. Deriving the form of the predictive distribution of aggregate losses and the value of its summary statistics is not analytically feasible. Instead Gibbs sampling routine which incorporates the missing data approach is used to provide a set of imputed data points from the predictive density. Density estimation is then used to construct estimates of the predictive density function based on the observed and imputed data. The problem of determining health insurance premiums based on past information on number of losses, size of loss, and size of population at risk is considered in Migon and Penna (2006) where the Markov Chain Monte Carlo approach has been used in the parameter estimation process under a Bayesian model. This paper makes its contribution in developing an alternative Bayesian model with real conceptual improvement in assumptions. The conceptual simplicity, ease of implementation by practitioners and the reasonable computing time makes this model a useful contribution to techniques available to health actuaries. A practical example is presented using two small data sets available at Migon and Penna (2006) [?] from the loss experience of two small Brazilian health care plans. We describe the conclusions that we reached from implementing our proposed model and show that while our conclusions are consistent with the original data, the major conclusions of Migon and Penna (2006), aside from not being supported by the data, are simply implausible.

References:

Migon HS, Penna EM (2006) Bayesian analysis of a health insurance model. Journal of Actuarial Practice 13, 61–80.

Pricing Distance Education through Multiple Decrement Approach

FRANCISCA AMOATEMAA (speaker)

Kwame Nkrumah University of Science and Technology Ghana   [francawing@gmail.com]

 In this paper, Multiple Decrement model will be developed to Price Distance Education. In a country with majority bean farmers, where payment of services from this group depends so much on the weather pattern. This paper seek to develop a pricing model, looking at parameters such as rainfall pattern, nature of roads, plant , market availability , level of education of farmer, government subsidies, etc.

Automated Vehicles and the Impact on the Insurance Industry

MATT ANTOL (speaker)

Farmers Insurance [matt.antol@farmersinsurance.com]

ALYCE CHOW (speaker)

CSAA Insurance Exchange [alyce.chow@csaa.com]

Advancements over the past decade have allowed companies such as Google, Audi, Nissan, and Mercedes to bring driverless cars out of the realm of science fiction and onto our roads. The potential benefit of automated vehicles to society is enormous - the National Highway Transportation Safety Administration estimates that 90

This technology represents a fundamental change in transportation risk, and the Casualty Actuarial Society has formed an Automated Vehicles Task Force to research the insurance impacts of the implementation of the technology.

This session will provide an overview of the state of automated vehicle development, including the history of the technology, industry progress, and legislative updates. The session will also review and provide updates on the research efforts being made by the CAS Task Force to better prepare its members to address the challenges this technology poses to the insurance industry.

Insurance risk models with reporting delays

ANDREI BADESCU (speaker)

University of Toronto   [badescu@utstat.toronto.edu]

We consider insurance risk models where the time between the accident date and the reporting date is either exponential or Erlang distributed. Furthermore, we assume that when reported, a claim is paid at instant and its size follows a phase-type distribution. By translating the reporting point process into a Markovian Arrival Process (MAP) of a particular structure and by using fluid flows techniques, we derive several ruin related measures. Numerical illustrations and possible future extensions are presented in the end.

Forward Mortality Modelling of Multiple Populations

CRAIG BLACKBURN (speaker)

University of New South Wales, Australia [craigb211@gmail.com]

MICHAEL SHERRIS

University of New South Wales, Australia [M.Sherris@unsw.edu.au]

We present a general framework for jointly estimating the cohort mortality rates of two similar populations using a forward model based on the Heath-Jarrow-Morton (HJM) framework. Using a deterministic volatility function we apply a finite dimensional realisation (FDR) to the HJM model. The affine term structure model is a specific case in the FDR framework. Using this framework is new to mortality modelling and provides greater flexibility to designing suitable multi-population models. Such FDR models would not have a closed-form solution in the term structure model.

The framework includes common factors and dependence between population specific factors, and mortality forecasts are endogenously generated in the real-world measure. Although each population will have some dependence in their mortality forecasts, hedging and the management of longevity risk is performed under an equivalent martingale measure. Without market information we define this measure to represent the best estimate cohort survivor curve. The volatility function, and hence the FDR, define common and dependent state variables between populations under this equivalent martingale measure.

The model is estimated with a standard Kalman filter. We apply the framework to assess the hedging of a portfolio of Australian male annuitants with a survivor swap. The survivor swap is based on a population index; with the index being either the same population as the annuitants, or another similar population. The similar population in our application is Swedish males. The hedge efficiency of the survivor swap and the 1-year 99.5% Value-at-Risk solvency capital requirement is compared for varying portfolio sizes. The annuity portfolio is subject to idiosyncratic longevity risk, which reduces with portfolio size, and in the case of hedging against a different population, the portfolio will also be subject to basis risk. The hedge effectiveness achieved from a survivor swap based on the same population as the annuitants is 92%, while the hedge effectiveness when based on a similar population is 57%. A substantial reduction in the solvency capital requirements is achieved for both survivor swaps for the life of the annuity contract.

Abstract 7
Session A1

Correlation Matrices and the Perron Frobenius theorem

PHELIM BOYLE (speaker)

Wilfrid Laurier University   [pboyle@wlu.ca]

 Recent papers have used the correlation matrix in the construction of a frontier portfolio with all its weights positive. This portfolio is a candidate for the market portfolio of all assets. The portfolio weights are obtained from the dominant eigenvector of the correlation matrix. We are therefore interested in the cases when all the components of this dominant eigenvector are positive. We know something about the conditions under which the dominant eigenvector of the correlation matrix has all its components positive. The classic Perron-Frobenius theorem provides a sufficient condition which is that all the correlations are positive. However this condition is too strong as there are recent extensions to the Perron-Frobenius theorem where some of the correlations can be negative and the dominant eigenvector still has all its components positive. Empirical studies of stock price returns show that some of the correlations can be negative and in some cases the pervasiveness of negative correlations produces negative weights in the dominant eigenvector. In this paper we examine the empirical occurrence of negative elements in the correlation matrix. We investigate the conditions under which a correlation matrix with negative elements has the Perron-Frobenius property. We also use Monte Carlo simulation to explore this issue.

CATL Methods and Robust Credibility: A Study Using Hachemeister's Data

VYTARAS BRAZAUSKAS (speaker)

University of Wisconsin-Milwaukee   [vytaras@uwm.edu]

HARALD DORNHEIM

KPMG Switzerland   [bavaria_harry@gmx.de]

 Two recent papers by Dornheim and Brazauskas (2011a,b) had introduced a new likelihood-based approach for robust-efficient fitting of mixed linear models and showed that it possesses favorable large- and small-sample properties which yield more accurate premiums when extreme outcomes are present in the data. In particular, they had studied regression-type credibility models that can be embedded within the framework of mixed linear models for which heavy-tailed insurance data are approximately log-location-scale distributed. The new methods were called corrected adaptively truncated likelihood (CATL) methods. In this talk, we build upon that work and further explore how CATL methods can be used for pricing risks. For illustrative purposes, we use a well-studied Hachemeister's data of bodily injury claims. The process of outlier identification, the ensuing model inference, and related issues are thoroughly investigated on the featured data set. Performance of CATL methods is compared to that of other robust regression credibility procedures.

Structure of the CAPM Covariance Matrix

JAMES G. BRIDGEMAN (speaker)

University of Connecticut   [bridgeman@math.uconn.edu]

We present a step by step synthesis of all possible covariance matrices in the Capital Asset Pricing Model, illustrating the hidden presence of the market portfolio assumptions within the covariance matrix.

Actuarial Metrics for Monitoring the Sustainability of the US Social Security System

Kenneth G. Buffin (speaker)

The Buffin Foundation   [kenbuffin@buffinfoundation.org]

Social Security systems are the focus of much public policy debate due to concerns over demographic changes and financial sustainability. The actuarial profession can contribute to these public policy issues by informing policymakers and the public about suitable objective actuarial assessments of financial stability, solvency and sustainability. While several countries publish meaningful actuarial metrics for their national Social Security systems, it would appear that many of these countries could enhance the scope of published actuarial metrics for their various Social Security systems so as to provide greater clarity and insight into the reporting and understanding of financial sustainability. Since there is no established or recognized international standard for the actuarial assessment of sustainability for Social Security systems, it is reasonable to explore the types of actuarial metrics that might be useful for this purpose.

This paper will address the issues of the US Social Security system's financial stability, solvency and sustainability as a case study and as a potential role model for other countries. Various suitable actuarial metrics are presented that are derived from the official published data contained in the annual trustees' reports, together with an analysis of historical data relating to long-range actuarial projections of the financial condition of the system.

The paper represents a continuation of previously published research by the author including:

- The US Social Security System: Solvency and Sustainability. Benefits & Compensation International, Volume 32, Number 4, November 2002, London, England.

- Analysis of the Divergence Characteristics of Actuarial Solvency Ratios under the Three Official Deterministic Projection Assumption Sets for the United States Social Security System. 2002 Actuarial Research Conference, University of Waterloo, Canada.

- Stochastic Projection Methods for Social Security Systems. Paper presented at Joint Colloquium of International Actuarial Association and International Social Security Association, Helsinki, Finland, May 2007.

Fed's Ultra-Low Interest Rate Policy and the new Norm in the Catastrophe Space: Implications for Optimum Mix with Catastrophe Reinsurance and Bonds

Jack S.K. Chang (speaker)

Cal State Los Angeles   [jskchangg@gmail.com]

Carolyn W. Chang

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Min-Teh Yu

National Chiao-Tung University   [mtyu@nctu.edu.tw]

 Fed's ultra-low interest policy in recent years has altered the norm in the catastrophe space, with an influx of alternative capital market participation seeking higher returns and exerting an increasingly strong force of demand for catastrophe bonds and supply of collateralized reinsurance, leading to significant downward pressure on traditional reinsurance pricing and Cat bond spreads, and inducing convergence across reinsurance and capital markets in the catastrophe space.

Insurers and reinsurers issue catastrophe bonds in capital markets to supplement their reinsurance deals in the reinsurance market. Reinsurers lay off exposure and extend underwriting capacity; insurers diversify external hedging capital structure and minimize hedging cost; while fund managers diversify into an alternative investment with zero beta and higher bond return. We derive an optimum mix methodology across financial and reinsurance markets, to demonstrate how the new norm in the catastrophe space has altered insurers' and reinsurers' risk capital allocation toward less traditional reinsurance but more collateralized insurance-linked securities such as catastrophe bonds, leading to a fast recovery of the catastrophe bond market, increasing innovation for reinsurers to offer alternative products, and more neutralized underwriting cycle.

Simulation results demonstrate these effects in relation to the reinsurance pricing, attachment and detachment points, the catastrophe bond spread, issuance size and trigger type and point, market interest rate risk, moral hazard and basis risk inherent in the trigger type, the reinsurer's default risk and capital/debt positions, the underwriting cycle, and the extent of Fed's QEs.

Systemic Risk with Jump Diffusion Processes

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We want to establish a mathematical model to characterize the banking system and the effect on the systemic risk when each bank has instantaneous shock or sudden bankrupt. We will first illustrate what a systemic risk is by proposing an inter-bank borrowing and lending model using a stochastic flocking system with jumps. In a fixed time period, a systemic risk is characterized by a large number of banks reaching certain critical level. Here we anticipate a small probability that every bank will bankrupt simultaneously. In order to obtain this probability, we need an explicit formula to calculate the distribution of the first passage time for a stochastic process with jumps. However, such explicit formula is hard to obtain. Therefore, we use the Laplace transform approach and the inversion formula instead to calculate the probability. We anticipate that the systemic risk will rise when instantaneous shocks occur. In other words, the probability that all banks will reach the critical level at the same time would be higher when jumps are taken into consideration. Our model integrates a game feature with jumps where each bank controls its rate of borrowing/lending to a central bank. We use game theory and stochastic optimal control with jump processes to analyze the impact of jumps on our inter-bank borrowing and lending model.

Actuarial Model Outcome Optimal Fit (AMOOF) 3.0: Probability Modeling Tool for Education and Research

Yvonne Chueh (speaker)

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The purposes of this free software designed, engineered, or contributed by the presenters are to assist in the fitting of data sets using single and mixed probability density functions (pdfs), calculate empirical tail statistics (VaR, TVaR) against their comparable measures of the model curves, and investigate the various degrees of small-sample bias correction for the maximum likelihood estimations. Nonlinear Optimization of the log-likelihood function is used to determine the best values for the pdf parameters. The interactive and graphical user interface is innovative and facilitates efficient selection of initial guesses for the distribution parameter value. Percentiles and Conditional Tail Expectations for the resulting pdf functions are found using numeric integration and equations solving. Version 3.0 adds cross-mixed pdfs (22 times 22 pdfs) to allow mixing different density families, increases the speed of improper integral calculus, adds a real-time check on numeric accuracy, and includes a public website for the user to download the program and report testing issues for future improvement. This software is an extension of AMOOF 2.0, which was begun as an undergraduate software engineering project for learning probability model fitting and data-driven actuarial research.

Finite Mixed Erlang Distribution: Moment-Based Approximation And Loss Modeling With Actuarial Applications

Hélène Cossette (speaker)

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In this talk, we assume that a financial entity is subject to a risk X which has known moments, but for which its distribution function is unknown or does not admit a tractable closed-form expression. Based on the recent advances on the mixed Erlang class of distributions, we propose to approximate its distribution function by a member of this class using a moment-matching method. This approximation is mathematically justified and offers a greater level of flexibility. In addition, risk measures such as Value-at-Risk (VaR), tail-Value-at-Risk (TVaR) and stop-loss premium are readily available for any member of the mixed Erlang class which will be of great use to insurers. In the talk, we provide the theoretical ground of the proposed approximation. This approximation method can also be viewed as a moment-matching estimation method for the loss distribution of a given risk X which will be illustrated with an example.

A copula-based risk aggregation model

Marie-Pier Côté (speaker)

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A flexible approach is proposed for risk aggregation. The model consists of a tree structure, bivariate copulas, and marginal distributions. The construction relies on a conditional independence assumption whose implications are studied. A procedure for selecting the tree structure is developed using hierarchical clustering techniques, along with a distance metric based on Kendall's tau. Estimation, simulation, and model validation are also discussed. The approach is illustrated using data from a Canadian property and casualty insurance company.

Stochastic areas of diffusion and applications in risk theory

Zhenyu Cui (speaker)

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In this paper we study the stochastic area swept by a regular time-homogeneous diffusion till a stopping time. Through stochastic time change we establish a link between the stochastic area and the stopping time of another associated time-homogeneous diffusion. Then we characterize the Laplace transform and integer moments of the stochastic area in terms of the eigenfunctions of the associated diffusion.

We show applications of the results to a new structural model of default (Yildirim (2006)), the Omega risk model of bankruptcy in risk analysis (Gerber, Shiu and Yang (2012)), and a diffusion risk model with surplus-dependent tax (Albrecher and Hipp (2007)). We compute the probability of bankruptcy and the expected time of ruin in the Omega risk model for diffusions with a general bankruptcy rate function $\omega(.)$, and extend the previous literature where $\omega(.)$ is assumed to be a constant (Albrecher, Gerber and Shiu (2011), Li and Zhou (2013)). We also explicitly compute the expected time of ruin in a diffusion risk model with a surplus-dependent tax rate (Li, Tang and Zhou (2013)). Preprint is available at: http://arxiv.org/pdf/1312.0283v1.pdf

Member Plan Choice and Migration in Response to Changes in Member Premiums after Massachusetts Health Insurance Reform

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In 2006, Massachusetts implemented a substantial reform of its health insurance market that included a new program for uninsured individuals with income between 100% of Federal Poverty (the upper limit for state Medicaid benefits) and 300% of Federal Poverty. Enrollment was compulsory for all citizens due to a mandate. Consumers who enrolled in this program, which offered generous benefits with low copays received graduated subsidies depending on their income. Five insurers were contracted to underwrite the program and consumers were able to choose their insurer. Insurers bid annually and the member contribution was set according to an affordability schedule for the lowest-bidding insurer. Consumers could choose from the range of insurers but if they chose a plan other than the lowest cost, their contributions reflected the difference. Premiums were changed annually at July 1 and members were eligible to move to a different plan at this date; a number of members migrated each year. This study aims to quantify the effect of this premium-induced switching behavior.

Prior studies of member switching behavior have looked at employer plans and estimated the elasticity* of response to changes in member contributions. The Massachusetts environment is unique in that there is a mandate (so uninsurance is not an option) and members may choose insurer but not benefit plan. Thus a study of migration in Massachusetts is uniquely able to quantify the effect of price (contribution rates) on member switching behavior. We find lower elasticity than previous studies of employer populations:

- Price elasticity of demand for the more heavily-subsidized plans is estimated at -0.14;

- Price elasticity for less-subsidized plans is -0.36; i.e for each 1% increase in price relative to the average of all plans, the plan can expect to lose about 0.36% of its membership.

Prior studies have estimated higher elasticities in the range -0.3 to -0.6. We found that the data contained many outliers both in terms of changes in contributions and percentage of members switching plans. The effect of outliers was moderated by the choice of robust regression models, leading us to question whether other studies may have been affected by outliers, leading to over-estimates of the elasticities.

* Elasticity of response to a change in price is defined as $(\delta y/y)/(\delta p/p)$ or the relative change in enrollment (y) divided by the relative change in price (p).

Nonparametric Curve Estimation with Incomplete Data

SAM EFROMOVICH (speaker)

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Nonparametric curve estimation, which makes no assumptions about shape of estimated functions, is one of the main statistical pillars of the modern actuarial science. It is used when no parametric distribution is available that provides an adequate model. The literature is primarily devoted to the case of direct observations while in actuarial applications data sets may be incomplete. The paper presents new results devoted to nonparametric and adaptive hazard rate estimation with truncated and censored data and nonparametric regression with missing responses or predictors. One of the interesting results is that estimation for censored and truncated data may be done without using Kaplan-Meyer methodology.

On Solvency, Model Uncertainty and Risk Measures

Paul Embrechts (speaker)

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In this talk I will review recent results on the calculation of Min-Max bounds for risk measures of aggregate financial/insurance positions, only assuming information on the marginal risk factor distributions. This will be referred to as Dependence Uncertainty (DU). The risk measures used are mainly Value-at-Risk (VaR) and Expected Shortfall (ES); their use is motivated by recent discussions under the Basel III framework for banks and Solvency 2 for insurance companies. I will discuss both analytic and numerical results in the homogeneous as well as in the inhomogeneous case. Applications will be given to the quantitative modeling of Operational Risk type data and multi-line insurance covers. I will also address the consequences for the ongoing debate on VaR versus ES regulation.

Advancements in Common Shock Modeling

Paul Ferrara (speaker)

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In this paper we rigorously investigate The Common Shock Model for correlating insurance losses. In addition, we develop additional theory which describes how The Common Shock Model, or 'Contagion' model, can be incorporated within a larger set of distributions. We also address the issue of calibrating contagion models to empirical data. To this end, we propose several procedures for calibrating Contagion models using real-world Industry data. Finally, we demonstrate the efficacy, and efficiency, of these calibration procedures by calibrating aggregate loss models, which incorporate Contagion. Further, these case-studies illustrate the power of Contagion modeling by demonstrating how the introduction of Contagion can correct for the short-comings of traditional Collective Risk Modeling.

3 R's - will all enrollees stand up and be counted

JOANN FIFIELD (speaker)

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This technical and informational session will bring to light the current conversations (customers, government, and analysts) and requirements around 3R's reporting. It will include real-world thoughts regarding the impact of 3 R's on healthcare payors as well as the known steps to compliance. A few sample mathematical approaches will be highlighted as well as modeling techniques using Oracle software.

Anatomy of a Slow-Motion Health Insurance Death Spiral

Harry E. Frech III (speaker)

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Adverse selection death spirals in health insurance are dramatic, and so far, exotic economic events. The possibility of death spirals has garnered recent policy and even popular attention because the pricing regulations in the Affordable Care Act of 2010 make health plans more vulnerable to them. Most death spirals tracked in the literature have involved selection against a group health plan that was dropped quickly by the employer. In this paper, we empirically document a death spiral in individual health insurance that was apparently triggered by a block closure in 1981 and developed slowly because the insurer partially subsidized the block. Indeed, we show that premiums rose dramatically from around the time of the block closure to at least 2009 (the last year of available data). By 2009 very few policyholders remained in the block and premiums were roughly 7 times that of a yardstick we developed. The history of this slow-moving event is directly relevant to current policy discussions because of both adverse selection in general and the particular problems induced by closing a block.

Paths and indices of maximal tail dependence

EDWARD FURMAN (speaker)

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We argue that the classical indices of tail dependence quite often underestimate the tail dependence in copulas and thus may not always convey useful information. We illustrate this phenomenon using a number of bivariate copulas and suggest an alternative way for assessing tail dependence.

Full credibility with GLMs and GLMMs

Jose Garrido (speaker)

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Generalized linear mixed models (GLMMs) are an extension of GLMs in which the linear predictor contains random effects in addition to the usual fixed effects. They are popularly for longitudinal data or group. Recently, they have gained popularity as a statistical method for insurance data, for example, in auto insurance where "territory" is seen as a random effect. Insurers use GLMs to estimate premium rates. When the observed data is not "credible" (small risk class, heterogeneous data, changes in risk characteristics) the GLM estimate is replaced by an exogenous value. In this paper we extend the theory of limited fluctuation credibility to GLMMs. Some results for the asymptotic variances of the estimators are presented, both for the marginal mean and the class-specific means. A new full credibility criteria is given for class-specific means. A statistical application is also given for an asymptotic approximation of the unconditional mean square prediction error of GLMMs, based on the conditional variance of class-specific mean estimators. This algorithm turns out to be efficient, both in of computational time and CPU workload.

Modeling Competition: Predator-Prey Dynamics and Agent-Based Modeling

Rick Gorvett (speaker)

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The level and nature of competition in a market is an important indicator of how the market is functioning, and is a critical factor with respect to the regulation of both the overall market and its constituent companies. In the insurance industry, competitive forces and market structure also play a role in determining the supply, demand, and cost of risk and insurance. Thus, the dynamics of the competitive marketplace— which can differ greatly between types and lines of insurance, even in the same geographical area—can help enlighten actuarial functions such as ratemaking, as well as related considerations such as underwriting and marketing.

This research utilizes agent-based techniques and software to model competitive forces in an insurance marketplace. The specific modeling context employed is that of predator-prey dynamics, which is often employed in the planning and management of ecological situations. In this paper, an attempt is made to model the interactions between a few large companies with significant market share (the "predators"), and numerous small companies with low market shares (the "prey") which might be subject of takeover efforts by the larger companies. By varying the predator-prey parameters in order to represent different hypothetical market structures, we examine the potential impact of, and the critical factors associated with, various insurance regulatory policies and competitive circumstances.

The paper also serves as a case study in the application of agent-based modeling techniques, an area with much potential promise for illuminating issues in actuarial science and risk management.

Physiological Age, Health costs and their Interrelation

Maria Govorun (speaker)

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We use a phase-type approach to demonstrate the impact of observable annual health care cost information on the evaluation of individual's physiological age. Specifically, in 2007 Lin and Liu suggested a model for human aging which is a particular Markov chain with phases being unobservable physiological ages of an individual. In this phase-type aging model, an individual of a given age has a defined distribution of his/her physiological age. Many studies indicate that it is is important for health costs projections and for underwriting purposes to take into account the physiological condition of an individual rather than just his/her calendar age.

In this work, we extend the Lin and Liu model in order to use the information on annual health care costs for calendar ages to infer the distribution of the physiological age for an individual of a given chronological age. We also show the impact of the cost information on the net present value of future health care costs.

The finite-time Gerber-Shiu penalty functions for two classes of risk processes

IONICA GROPARU-COJOCARU (speaker)

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JOSE GARRIDO

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We study the Gerber-Shiu penalty functions in a finite time horizon for a risk model involving two independent classes of insurance risks. We assume that the two claim number processes are independent Poisson and generalized Erlang(n) processes, respectively. We derive an expression for the finite-time Gerber-Shiu penalty function through a Maclaurin series expansion. The coefficients of this series are computed using a system of recursive relationships. As a special case, an expression for the finite-time ruin probability is obtained. Numerical examples are considered to show possible applications of our results.

Challenges and opportunities for flood insurance in Canada

FRÉDÉRICK GUILLOT (speaker)

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Following Calgary and Toronto flood events of the summer of 2013, Canadian property and casualty insurers has suffered significant impacts on their balance sheets as a result of paying for water related losses. After these events, some on these insurers started to seek for better understanding of their flood exposure and rapidly discover that Canadian information on water risk such as flood maps are currently inaccurate and outdated to properly assess the insurance costs for water related perils. The intent of the talk is to present a real case example of how one Canadian insurance company is currently reacting to the raises of water related catastrophes in an environment where information is limited. A probabilistic flood model based on creative flood proxies, and incorporating creative solutions for modelling both flood frequency and severity is proposed, along with a discussion on potential wins and limitations in using such model in a pricing context.

Adverse selection and loss coverage in insurance markets

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Insurers hope to make profit through pooling policies from a large number of individuals. Unless the risk in question is similar for all potential customers, an insurer is exposed to the possibility of adverse selection by attracting only high-risk individuals. To counter this, insurers have traditionally employed underwriting principles, to identify suitable risk factors to subdivide their potential customers into homogeneous risk groups, based on which risk-related premiums can be charged.

In reality, however, insurers may not have all the information reflecting individuals' risks due to information asymmetry or restrictions on using certain risk factors in their underwriting process. In either case, conventional wisdom suggests that the absence of risk classification in an insurance market is likely to lead eventually to a collapse of the whole insurance system, i.e. an adverse selection spiral. However, this concept is difficult to reconcile with the successful operation of many insurance markets, even in the presence of some restrictions on risk classification by regulators.

Moreover, arguably from society's viewpoint, the high risks are those who most need insurance. That is, if the social purpose of insurance is to compensate the populations losses, then insuring high risks contributes more to this purpose than insuring low risks. Thus, the traditional insurers risk classification scheme can be considered as contrary to this social purpose.

To highlight this issue, Thomas (2008, 2009) introduced the concept "loss coverage", i.e. the proportion of the whole population's expected losses which is compensated by insurance. The main idea is that a modest degree of adverse selection in insurance can be desirable, as long as loss coverage is increased.

In this paper we model the outcome in an insurance market where a pooled equilibrium premium is charged for two risk-groups when there is an absence of risk-classification. Using an iso-elastic and negative exponential demand functions, we first explore the demand elasticity conditions which ensure a single equilibrium. We find that a single equilibrium will be obtained when either the demand elasticity from the high risk-group is sufficiently greater than that from the low risk-group, or the fraction of the total population represented by the high risk-group is either above or below certain limits. Based on these results, we further analyse the impact of demand elasticity on loss coverage and adverse selection in more general cases. The consolidated results are consistent with ideas proposed by Thomas (2008, 2009) that loss coverage will be increased if a degree of adverse selection is tolerated.

The research findings should add to the wider public policy debate on these issues and provide necessary research insights for informed decision making by actuaries, regulators, policyholders, insurers, policy-makers, capital providers and other stakeholders.

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Pricing Credit Default Swaps with Random Recovery Rates

XUEMIAO HAO (speaker)

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We study the pricing problem of a single-name credit default swap (CDS) under a framework of a structural default model in which the asset value process is of infinite activity but finite variation. This model was proposed by Madan and Schoutens (2008; Journal of Credit Risk) and they gave an efficient algorithm for calculating the CDS spread by assuming a constant recovery rate at default. We extend their work and study under the assumption of random recovery rates. It is more attractive from a practitioner's point of view since in reality recovery rates is closely related with a firm's asset value at default.

Reviewing Target Benefit Pension Plans

MARY HARDY (speaker)

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Target Benefit Pension Plans are in the news regularly, promoted as the future of sustainable employer sponsored pension plans, or as an unfounded attack on workers' retirement rights. Despite their ubiquity, there is no agreed definition of what such a plan looks like, nor of the risks and rewards compared with alternatives. In this talk I will present some different types of Target Benefit plan, and I will explore the costs and benefits for sponsors and members.

A Comparison of Resampling Methods for Bootstrapping Triangle GLMs

Thomas Hartl (speaker)

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Bootstrapping is often employed for quantifying the inherent variability of development triangle GLMs. While easy to implement, bootstrapping approaches frequently break down when dealing with actual data sets. Often this happens because linear rescaling leads to negative values in the resampled incremental development data. We introduce two computationally efficient methods for avoiding this pitfall: split-linear rescaling, and parametric resampling using a limited Pareto distribution. After describing the essential mathematical properties of the techniques, we present a performance comparison based on a concrete bootstrapping application implemented in VBA. The VBA application is available at request from the author.

Extrapolating co-linear payment year trends for development triangle GLMs

Thomas Hartl (speaker)

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In the context of stochastic property and casualty reserving, one of the promises of using GLM techniques is that it becomes possible to include the payment year dimension. Classical non-stochastic loss development methods, by contrast, usually only include the exposure and development period dimensions. It is well known (e.g. Barnett and Zehnwirth, 1999) that one has to deal with two mathematical challenges when trying to realize this promise: the payment year period is functionally dependent on the exposure and development periods, and reserve projections require out of sample extrapolation of future payment period trends. While software packages successfully implement workarounds, we are not aware of an in-depth analysis of how to deal with the functional dependence. Furthermore, the out of sample extrapolation of payment period tends is left to ad-hoc user assumptions. This paper provides a rigorous framework for understanding of how the functional dependence among the three dimensions of analysis affects the parameterization of a GLM. Two subtleties emerge. Firstly the familiar parameter structure with a constant offset variable does not apply here. Secondly, while it is possible to set up a design matrix of maximal rank, it is not possible to interpret the values of model parameters in one dimension in isolation from the other dimensions. The last point complicates the task of extrapolating future payment period trends, which becomes an issue in the context of using bootstrap simulations to determine a confidence interval for reserve outcomes. To deal with this challenge, we propose a class of future payment period trend estimators, which we describe as offset invariant. The paper concludes with a comparison of simulation results based on the new offset invariant estimators vs ad-hoc extrapolation purely based on past payment period trends.

Risk Management of Storm Damage to Overhead Power Lines

Brian Hartman (speaker)

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The past few years, many storms have knocked out the power in Connecticut. With a group in the environmental engineering department and the support of the local utilities, we are building models to predict damage from future storms and help the utilities properly manage their risk. In this presentation I will discuss our current models, storms we predicted well, others where we did poorly, and our current work to improve.

Abstract 35
Session B8

A new approach for studying stochastic ordering of risks

Liang Hong (speaker)

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Stochastic orders have been widely applied in actuarial science, insurance and risk management. Many authors have studied their properties. This paper is part of the ongoing efforts for searching new properties of stochastic orders. In this paper, we introduce a new approach for studying stochastic ordering of risks. This approach has two potential advantages: (1) it may lead to simple proofs of complicated theorems; (2) it provides an opportunity of studying many different stochastic orders under a unified framework. As an illustration, we will apply this approach to prove separation theorems for three commonly-used risk orders: stochastic dominance order, stop-loss order and convex order. In particular, our proof of the separation theorem for convex order is simpler than the one in the existing actuarial literature. Furthermore, we will also show that this approach yields a decomposition theorem as well as a countable approximation property for each of the three risk orders under consideration.

An Optimal Investment Strategy with Multivariate Jump Diffusion Models

Hong-Chih Huang (speaker)

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This article provides an optimal asset allocation strategy to enhance risk management performance in the face of a financial crisis; this strategy entails constructing a good asset model (multivariate jump diffusion (MJD) model which includes idiosyncratic and systematic jumps simultaneously) and choosing suitable asset allocations and objective functions for fund management. This study also provides the dependence structure for the MJD model. The empirical implementation demonstrates that the proposed MJD model provides more detailed information about the financial crisis, allowing fund managers to determine an appropriate asset allocation strategy that enhances investment performance during the crisis.

Model Selection and Averaging of Health Costs in Episode Treatment Groups

Shujuan Huang (speaker)

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Brian M. Hartman

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 Proper model selection is essential to properly price and manage risk in health insurance. The optimal model (or model probabilities) can change depending on the disease. We compare five potential models (lognormal, gamma, folded t, log skew t, and Lomax) using four different metrics (AIC and BIC weights, random forest feature classification, and Bayesian model averaging) on 320 episode treatment groups. We compare the various methods on both speed and precision and also examine the wide range of selected models for the different ETGs. Several case studies are provided for illustration.

Nonparametric Model of Capital Appreciation of Portfolio

Natalia A. Humphreys (speaker)

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Nonparametric model of capital appreciation of portfolio is based on statistical analysis of joint distribution of the portfolio assets. It is explained how the joint distribution is estimated and then used to forecast capital appreciation of the available assets. Theory is complemented by a numerical example.

Forward Mortality Rates: Applications to the risk management of annuities

Andrew Hunt (speaker)

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David Blake

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Modern solvency regimes require us to measure the longevity risk inherent in mortality- and longevity-linked policies on an ongoing basis and in a manner consistent with market information. We propose a new forward mortality rate framework which is derived from more familiar age/period/cohort mortality models. This framework can be easily calibrated from a combination of historic data and market prices to give market-consistent values for life insurance reserves or longevity-linked securities prices. We then use this framework to calculate the Solvency Capital Requirement that would be required for an illustrative annuity portfolio under the Solvency II regime, utilising a stratified sampling technique to avoid performing nested simulations.

Methods of Computing a Large Number of Quantiles from an Aggregate Loss Distribution

Mahesh V. Joshi (speaker)

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A statistical approach to the enterprise risk modeling problem requires estimation of the probability distribution model for the aggregate loss that an organization expects to see in a particular time period. A commonly used method decomposes the aggregate loss into frequency and severity of individual loss events, builds separate distribution models for frequency and severity, and then combines the two distribution models to estimate the distribution of the aggregate loss. The last step requires a convolution operation, and a closed-form analytical expression is rarely available for the distribution of the aggregate loss, making it attractive to use a Monte Carlo simulation method that generates a large sample of the aggregate loss. This sample essentially serves as the nonparametric estimate of the distribution. It is used to compute the empirical estimates of risk measures such as value-at-risk (VaR) and conditional value-at-risk (CVaR).

However, in the enterprise risk modeling context, the process does not stop there. The aggregate loss distribution is estimated for a single risk category or line of business at a time. To compute an estimate of risk across the entire enterprise, it is necessary to add estimates of losses from all the risk categories. For accurate estimates, it is also necessary to account for the dependencies among different risk categories. Copula-based methods are often used. The resulting dependency structure is used to simulate a large number of observations such that each observation provides the probability of loss for each risk category. These probabilities need to be translated into loss estimates in each risk category, requiring computation of a large number of quantiles from the aggregate loss distribution of each risk category. This paper proposes a parametric method that approximates the aggregate loss distribution by using a finite mixture of one or more severity distributions. The parsimony of the parametric method is weighed against the simplicity of the nonparametric method that approximates the quantiles by the percentiles of the simulated aggregate loss sample.

How Well Does Adapt Predict Success?

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Adaptive Dynamic Actuarial Practice Tests (Adapt) is an online testing software designed by Coaching Actuaries to adapt to student's current level of understanding of the material. Adapt generates unique exams from a large database of questions and at the same time allows students to take questions that are not too difficult and not too easy. Students begin taking practice problems at their current level of knowledge. As the questions are mastered, Adapt will provide new questions at a more difficult level. The goal is for students to reach exam level difficulty questions and be able to master these questions.

Adapt uses "Earned level" to help students gauge their level of preparedness for the exam. Past survey results have shown that students who reach an earned level of 7 or higher pass about 90% of the time. Another goal of "earned level" is to provide students with questions at the correct level of difficulty, so that practice exams and questions are not too difficult or too easy. "Earned levels" are adjusted based on the score that is earned on Adapt practice exams. Thresholds are defined on an exam basis that determines whether a score qualifies for the "earned level" to be adjusted. If the score is less than the lower threshold, then the "earned level" will be reduced. If the score is above the higher threshold, then the "earned level" will be increased.

Our presentation will focus on how well Adapt earned level predicts success in the actual exam.

Using Fuzzy Logic to Model Risk – Case Studies

Marie-Claire Koissi (speaker)

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Arnold F. Shapiro

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The risk associated with an event generally involves the likelihood of the occurrence (frequency) of the event and the severity of the consequence of this event. In the risk analysis process, the choice of the distribution for the frequency and severity variables depends on the categories of risk. Common risk categories include financial risk, strategic risk, hazard risk, and operational risk

For operational risk, for example, scenario analysis is one source of data used in computing the regulatory capital. Scenario analysis finds its relevance in cases where the alternative sources of data do not provide robust estimates of the risk. The common approach to compile data from scenario analysis is to combine expert opinions using bootstrapping or Bayesian inference. The first method requires past data on the event and the second requires knowledge of the shape of the empirical distribution of the severity and frequency. Such information often is not available, and fuzzy logic models have been shown to be effective tools in such cases of data limitations.

In this talk, we present examples of risk assessment application of fuzzy logic for the common risk categories mentioned above.

Predictive Modeling in Long-term Care insurance

NATHAN LALLY (speaker)

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The accurate prediction of long-term care insurance (LTCI) mortality, lapse, and claim rates is essential for making informed pricing and risk management decisions. Unfortunately, academic literature on the subject often has too narrow focus to be practical for widespread usage and industry practice often lags behind contemporary statistical research. In this paper we review current LTCI industry modeling methodology (Poisson regression with covariate banding/modification). We contend that the assumptions required for Poisson regression are not appropriate in this case and propose several alternative modeling techniques specifically tailored towards count responses with an overabundance of zeros and exhibiting overdispersion. Using the same data, we evaluate the goodness-of-fit and predictive capacity of generalized linear and additive models with zero-inflated Poisson, negative binomial, and Tweedie errors and compare them to the previously developed Poisson regression models.

Ruin And Risk Measures In A Bivariate Discrete-Time Ruin Model

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Jean-Philippe Le Cavalier (speaker)

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In this talk, we examine the capital assessment for an insurance portfolio within an extension of the classical discrete time risk model assuming two dependent lines of business. We define different bivariate ruin measures. We propose a recursive algorithm to evaluate the finite-time horizon ruin measures. This algorithm is based on a bivariate extension of Lindley's recursive formula. In addition, we examine the computation and the properties of different bivariate dynamic risk measures. Numerical examples are provided in order to illustrate the results.

Predictive Modeling of Healthcare Claims

MICHAEL LUDKOVSKI (speaker)

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IAN DUNCAN

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I will discuss a healthcare predictive modeling project that was carried out at UCSB over the past 3 years. We investigated a dataset of 30,000 insureds containing claims information from the previous year. The dataset contains over a hundred covariates for each insured, including detailed breakdown of past costs and causes encoded via HCC flags. I will discuss statistical models for the relationship between next-year costs and collected medical and cost information in the context of predicting the mean and quantiles future costs, ranking risks and identifying the most predictive covariates. I will go over some of the challenges and basic relationships uncovered. A comparison of multiple models will be presented, including Lasso GLM, multivariate adaptive regression splines (MARS), random forests, boosted trees and generalized additive models.

Applications of GAMLSS in Non-life Insurance Ratemaking Analysis

DINGHAI LV (speaker)

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Starting from the analysis of limitations of generalized linear models (GLMs), we analyze several improved models, especially the generalized additive models for location scale shape (GAMLSS). We can use more kinds of distributions, which are not limited to exponential family and more systemic components in GAMLSS. The essential difference between GAMLSS and GLMs is that we can also construct scale shape models, not only location mean models in GAMLSS. If premium principle is not only related to the mean of distribution, but also related to other parameters, such as kurtosis, skewness, we will get more risk sensitive, though more complicated premium principle. Finally we construct GAMLSS for loss frequency data and loss severity data and compare the results with which given by GLMs. Due to the greater effect of the selected distribution on the estimated parameters, we suggest considering some kind of credibility form in models, into which can combine expert opinions, but will be the subject of another paper. We demonstrate the applications of GAMLSS in non-life insurance ratemaking analysis from different angles, which will enrich the methods of non-life insurance ratemaking analysis.

Fixed and variable payout annuities: how optimal are "optimal strategies"?

Anne MacKay (speaker)

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This paper examines the investment choices of a retiree who must divide his or her wealth at retirement among a fixed annuity, a group self-annuitization scheme and other financial assets. Under the group-self annuitization scheme the retiree absorbs the investment risk but pools the mortality risk with other retirees in the group. We solve the retiree's optimal consumption and investment problem using a standard dynamic programming approach. We find that for plausible parameter values the retiree opts for full annuitization. The trade-off between the fixed annuity and the variable annuity depends on the loading charged by the insurer. We show that the standard model's optimal allocation to the variable payout life annuity does not adequately capture a retiree's strong aversion to downside risk. We suggest additional metrics that could be used.

Infinite-time ruin measures for compound renewal risk models with dependence

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We study infinite-time ruin measures within risk models assuming dependence between interclaim times and claim amounts. We use change of measure techniques to obtain exact expressions for both the infinite-time ruin probability and the Gerber-Shiu discounted penalty function. Two different approaches are considered in the application of these techniques. Based on the expressions for the infinite-time ruin probability and the Gerber-Shiu function, we also derive Lundberg-type inequalities and asymptotic expressions for these two quantities. We investigate an important sampling method based on change of measure techniques. For specific bivariate distributions for the interclaim time and the claim amount, we derive their corresponding bivariate distributions resulting from the change of measure.

Abstract 49
Session A6

Eurekas, Ah has, and Other Epiphanies

Mark Matthew Maxwell (speaker)

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In two of our actuarial studies senior level capstone courses, students are evaluated equally on content mastery, communication, and contribution to class. We will talk about the motivation for this design and ways to evaluate student communication and contribution. We will share painful failures which are called learning experiences. We promise an entertaining presentation with some ideas that participants may borrow to help them develop their best possible class.

Diversity in the Actuarial Profession

BARRY MCKEOWN (speaker)

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The actuarial profession does not have the diversity that it needs or desires. Black, Hispanic and Native American populations are under-represented. 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 Career Encouragement and 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 under-represented minority high school students. West Chester University is starting a program in 2014 and Bentley University is considering a program for 2015. These programs serve an important role in enabling students to make informed decisions about the actuarial profession. While these programs are important, much more needs to be done.

A presentation at the 2013 Actuarial Research Conference described these actuarial summer programs and the role they have in the profession's diversity efforts. At the 2014 Actuarial Research Conference, there will be an update on actuarial diversity activities, including summer programs. There will also be a discussion on possible next steps needed to achieve appropriate levels of diversity. Suggestions from academia and actuarial employers will be an important part of this session.

Abstract 51
Session B4

Introduction to Housing Finance and Mortgage Insurance

Yuchen Mei (speaker)

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Real estate represents 25% of the total household assets in US. More than half of them are financed through mortgages, which makes mortgages one of the most important assets held by financial institutions. In 2006-07 house prices dropped by about 30% and subprime mortgages were substantially devalued. Mortgage investors and insurers suffered from huge losses, leading to the financial crisis. In this talk, I will first introduce the US mortgage market, including popular mortgage instruments, market participants, commonly used risk factors, etc. Then I will briefly discuss how to manage house price risk with a particular focus on mortgage insurance.

Agent Based Modeling of P&C Underwriting Cycles

Gao Niu (speaker)

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The model is designed to simulate and project future Property and Casualty Underwriting Cycles. An Agent-Based Model (ABM) is a computational method to simulate actions and interactions of a group of agents to estimate their effects on the system as a whole. This research has defined each insurance company as an agent and each agent has its own unique decision rules based on its individual characteristic, for example risk appetite, premium volume, surplus levels, etc. The model analyzes how individual insurance company's decisions will affect the industry as a whole. In contrast to traditional predictive models which use historical experience to predict the future, ABM uses a behavioral approach of various agents to predict the future and test the collective impact of changes in individual behavior.

A Model-Based Clustering Approach to Data Reduction for Actuarial Modelling

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In the recent past, actuarial modelling has migrated from deterministic approaches towards the use of stochastic scenarios. Such projections are useful to an insurer who wishes to examine the distribution of emerging earnings across a range of future economic and mortality scenarios. The use of nested stochastic processes dramatically increases required computational time. This is particularly true for products with heavy optionality, which are becoming more popular in the marketplace. Incremental savings can be made as computing power expands and as coding is optimised. However, much more comprehensive savings are possible using a compressed version of the original data in the stochastic model.

This involves the synthesis of "model points": a relatively small number of policies that efficiently represent the data at large. Traditionally this has been achieved using variations on the distance to nearest neighbour and k-means nonparametric clustering approaches. The aim of this paper is to investigate how model-based clustering can be applied to actuarial data to produce high quality model points for stochastic projections. This is feasible since insurance policies typically have a number of associated location variables, allowing them to be modelled spatially.

High quality historical data on a large set of $110,000$ variable annuity policies has been provided by Milliman for the conduct of this research, under the guidance of Mr Craig Reynolds and Mr Avi Freedman, Principal and Consulting Actuaries with Milliman, Seattle. The location variables are a series of net present values for revenue, expense and benefit outcomes across a range of five economic scenarios. The size variable is the total account value in force for each policy.

A large number of policies in the data have location variables taking the value 0, a common feature in actuarial data. Hence the model-based approach is integrated with the nonparametric weighted distance-to-nearest-neighbour approach to produce a hybrid clustering outcome for identification of model points, where necessary. This is achieved using the standard Gaussian mixture model and automated using the freely available R package Mclust. An advantage of the parametric model-based approach is that the resultant clustering has an associated likelihood value. Its determination in this application, using principal component analysis as an initialising step for dimension reduction, avoids the issue of positive correlation among location variables.

The model-based clustering approaches are contrasted with both the weighted distance-to-nearest-neighbour approach and the outcome when the full, uncompressed data is used. The model points produced under each regime are compared for forecast accuracy at a range of compression levels for various stochastically generated scenarios. The results are validated using the Milliman actuarial pricing model.

Optimal Capital Allocation: Mean-Variance Models

Krzysztof Ostaszewski (speaker)

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This paper studies capital allocation problems based on minimizing loss functions. Two capital allocation models based on the Mean-Variance principle are proposed. General formulas for optimal capital allocations for both models are derived according to quadratic distance measure. In particular, we discuss centrally symmetric distributions and gamma distributions. Some numerical examples are given to illustrate the results.

Constrained clustering of territories: a "k-means"-based algorithm aiming to minimize intra-cluster variation in the context of car insurance

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SAMUEL PERREAULT (speaker)

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Geographical location is an important factor used by car insurers to determine the premium associated with a contract. Initially, insurers could divide a state or province in as many territories as wanted. In this framework, a premium can differ from one zip code to another. However, some jurisdictions begin to impose constraints on the definition of these territories. In particular, the Financial Services Commission of Ontario imposes the following conditions :

1. A territory must possess a minimal exposure of 7500 cars over a three-year span;

2. There must be no more than 55 territories in Ontario, of which no more than 10 should cover a fraction of the greater Toronto;

3. All territories must be contiguous.

The challenge is to shrink, as optimally as possible, the number of territories initially used, that is, to group them in such a way that the resulting territories are as homogeneous as possible. The present work aims to provide a method adapted to these three constraints. Given a criteria to minimize (intra-group variation), a common approach is to use a hierarchical clustering algorithm. However, it is very hard with these methods to take into account, first, the fact that initial territories have a weight associated to them (exposure) and, second, the various constraints imposed by the new regulations. That leads to relatively heterogeneous final territories. The method proposed in this work is mostly based on the well-known k-means algorithm, an algorithm specifically designed to minimize intra-group variation. A hierarchical component was added to it in order to overcome some heterogeneity problems caused by the constraints.

Purchasing Term Life Insurance to Reach a Bequest Goal

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We determine how an individual can use life insurance to meet a bequest goal and find the optimal strategy for buying life insurance for two related problems: (1) to maximize the probability of reaching a given bequest goal and (2) to maximize expected (limited) wealth at death. We assume that the individual buys instantaneous term life insurance with a premium payable continuously. We allow the force of mortality to vary with time, and therefore obtain that the optimal strategy varies with time, in addition to varying with wealth.

Pure Premium Trend Analysis for Auto and Home Insurance Coverages

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The underlying question motivating this research was whether or not time series modeling is better at predicting future insurance trends than linear regression modeling. Using Auto and Home insurance state-wide series for a mid-size insurance carrier from 2005Q1 to 2013Q1, we used R programming techniques to compare models in terms of pure premium costs, as well as the frequency and severity of claims. Using the `forecast` package in R we've fit ARIMA models and compared them to linear and exponential trend models across a number of state/different coverages in both the Auto and Home insurance. We broke down our models into trend, seasonality and residual components to determine which model best explains the data. To determine which sufficed as the better model, we removed the two latest quarters and used them to compare the accuracy of our forecasts. The model with the least error was considered the better model. After comparing models, we concluded that ARIMA modeling is indeed a better modeling technique for predicting Pure Premium costs.

Percentile-Matching for Poisson and Zero-Inflated Poisson Models, with Applications to Risk Measurement

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In a recent publication by Wang and Hutson (2011, Journal of Statistical Planning and Inference) the asymptotic non-normality problem of the classical sample quantiles for discrete data was resolved by defining a smooth quantile population function. The estimators based on corresponding sample quantiles are smooth, consistent and asymptotically normal. The smoothing is achieved through a class of weight functions using fractional order statistics. Using those techniques, we aim to: (i) develop the method of percentile-matching (PM) for estimating parameters of claim frequency distributions and (ii) evaluate the risk in claim count variables using the value-at-risk (VaR) type measures.

In this talk, we will first introduce the PM estimator for parameters of Poisson and zero-inflated Poisson models, then study its finite-sample properties using Monte Carlo simulations and illustrate its computation on a claim count data set.In addition, sensitivity of the PM estimator to data contamination is also explored and its effects on risk measurements using the VaR type measures are investigated. Since this estimator is not robust against various kinds of data contamination, we will propose other methods for robust fitting of claim frequency models.

Measurement & Classification of Risk loads for Property Casualty Insurers and its applications to Loss Reserve Margins and Optimal Business Mix

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The rates charged in property casualty insurance have three provisions: permissible loss, risk load (also called profit and contingencies) and expense load. We propose the following regarding risk loads:

1. Instead of underlying loss distributions, we focus on mismatch between actual versus expected losses. This shift is reflected in the dataset itself and thus produces modeling simplicity.

2. Measurement of risk loads using both value at risk (VAR) and conditional value at risk (C-VAR) approaches

3. Classification of risk loads using suitably defined, insured classes.

4. Determining risk margins for loss reserves. This is especially important in light of emerging international accounting standards board (IASB) rules.

5. Determining the optimal new business written premium mix to maximize profit, constrained by fixed held capital (capacity) and inherent volatility in each lines loss experience.

6. Model is practical and rooted in rate reviews of property & casualty insurance companies. Specifically, all data and information is readily available as part of the rate filing process.

The methodology is intended to be for non-catastrophic losses only. It is clear that the paper is most useful to line that has a large risk load: workers compensation, mortgage insurance, excess reinsurance, large deductible etc.

Quantifying Economic Capital for Insurance Risk

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 This paper is about quantifying economic capital pertaining to insurance risk of property casualty insurers. The methodology is particularly relevant for long tailed lines such as general liability, workers compensation, mortgage insurance & auto liability etc. We model the following three risks:

- Risk of rate inadequacy (pricing risk)

- Reserving risk (risk of reserve deficiency)

- Interest rate risk pertaining to equity in unearned premium reserves and loss reserves

Instead of underlying loss distributions, we focus on mismatch between actual versus expected losses. Likewise we focus not on the interest rates themselves but on the mismatch between actual versus expected interest rates. This shift is reflected in the dataset itself and thus produces modeling simplicity.

All risks are modeled simultaneously with correlation effects expected to emerge from the data. To do this, we build insurance risk triangles. Thus the correlation structure is embedded in the data themselves and is captured in the parameters estimated from those data.

The combination of all three risks results in the economic capital for property casualty insurance companies. This paper discusses concepts and measurement of the insurance risk component of the economic capital. It provides a framework for economic capital that accounts for incorporating current/future market conditions as well as internal company reserving/pricing changes.

We relate the model to current actuarial functions of ratemaking and loss reserving in the traditional property casualty environment. The objective is to create a "economic capital review" process similar to reserve reviews.

We also show several applications of the model.

On the use of long term risk measures

JIANDONG REN (speaker)

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Value at risk (VaR) is a widely used risk management. However, as argued in Taleb (2010), "VaR encourages low volatility, high blowup risk taking which can be gamed by the Wall Street bonus structure" It was also argued that one reason for this is the limitation of ability of all quantitative risk measures (including VaR, TVaR and many other modifications) to measure the risk of extreme events (black swans). In this paper, we argue that since VaR and its modifications are short–term risk measures, they necessarily create extreme small probability numbers when used for measuring risk of extreme events. It is well documented in the psychology literature that human tend to make irrational decisions when dealing with extreme small probabilities. Therefore, we propose that long–term risk measures, such as ruin probability in a long time horizon studied in risk theory literature, may be useful to gauge the risk of extreme event and therefore could be considered by risk managers in decision making.

Exploring Copulas

Jacques Rioux (speaker)

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The concept of copula is, at times, misunderstood, or misapplied by risk management practitioners. It is often confused with that of a correlation matrix. Unfortunately, the Solvency II diversification benefit formula, for example, does nothing to clarify the difference and contributes to muddy the waters even more. Most of the crowd in this meeting may be well acquainted with copulas and their applications. Nevertheless, some may have run into situations where a simple and intuitive tool to describe and explain the concept and its ramifications to a client or a student would have been most welcome.

In this presentation, I will introduce a software application, I created, that is called "Copula Explorer". The application allows the user to, as the name suggests, explore various copulas from a very basic point of view. In particular, the application allows one to extract the copula corresponding to a sample of joint random values, and observe the effect of that same copula applied to another pair of random variables. It also allows one to identify statistics being copula properties as opposed to joint sample properties.

The motivation for building the application is the "moto" I coined myself: "Interaction is the mother of intuition". My goal is to provide a simple way to interact with copulas, get feedback from them, and get answers to "what if" question in order to develop one's own intuition about the concept.

The software will be made available for free for all.

Comparison of Imputation Techniques for Missing Data when the Reason for Missingness May be Informative: An Application to Childhood Obesity using the Medical Expenditures Panel Survey

Michael Wurm

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Margie Rosenberg (speaker)

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According to the American Heart Association (2014), one-third of US children and teens are either overweight or obese. The long-term population health impact of childhood obesity are greater prevalence of diseases (type 2 diabetes, heart disease), as well as psychological disorders (depression and low self-esteem). Researchers investigating the impact of obesity turn to nationally representative, publicly available data, such as the Medical Expenditure Panel Survey (MEPS).

The MEPS data are a longitudinal study starting in 1996 that follows households for two-years in an overlapping panel design. One variable in the data set is Body Mass Index (BMI) and is a function of a person's height and weight. Standards for classifying an individual as obese are based on BMI.

If data on BMI are missing, then decisions need to be made as to how to handle the missingness. Observations where BMI is missing could be deleted (called a complete case analysis), but then potentially important other information is removed from the study. If the data are Missing at Random (MAR), then conclusions reached in an analysis are reasonable. However, if the data are Missing Not at Random (MNAR, or informative missingness), then conclusions reached deleting these observations are biased.

In this study we use the MEPS data to focus on children between the ages of 6 and 17 inclusive, where a large proportion of the data are missing. Reasons for missingness are unknown. Our study will compare results of techniques comparing MAR techniques with MNAR.

Comparing the Riskiness of Dependent Portfolios

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Brazauskas, Jones, Puri, and Zitikis (2007) have introduced a nonparametric test based on the nested L-statistics to compare the riskiness of independent portfolios. In this work, we investigate how the power of the test varies when the dependence structure between portfolios is present. To achieve that goal, we perform a Monte Carlo simulation study. We consider three different risk measures: conditional tail expectation, proportional hazards transform, and mean. Further, three portfolios are generated from exponential, Pareto and lognormal distributions, and their interdependence is modeled with a three-dimensional Gaussian copula. It is found that the presence of positive dependence among the portfolios makes the test more conservative for the risk measures under consideration. For the negatively dependent portfolios, the opposite conclusion is reached. We also examine the potential effects of dependence on the real data sets where the risks of interest are those associated with tornado damage in different time periods and different regions of the United States.

Simulating Portfolio Losses from Adverse Events

KENNETH SANFORD (speaker)

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Financial losses due to adverse events are an unfortunate yet inescapable fact of life for many businesses, especially in the financial industry. An insurance company, by the very nature of its business, needs to deal with the losses incurred by its policyholders. Banks and other financial institutions operate in a market economy, where investment losses are an inherent part of the business. It is important not only to identify the factors that cause the losses but also to quantify the expected losses in order to manage risk better and to estimate the risk-based capital requirements that are demanded by regulations such as Basel III (banking industry) and Solvency II (insurance industry). Most modern businesses collect and record information about these losses. Such information often includes the number of loss events that were encountered in a given period of time, the magnitude of each loss, the characteristics of the entity that incurred the loss, and the characteristics of the economic environment in which the loss occurred. Because data about past losses are more readily available, quantitative modeling of losses is becoming an increasingly important task for many businesses. The goal is to estimate the average loss as well as the worst-case loss that you expect to observe in a particular period of time, not only for one entity but also for a group of entities such as a group of policyholders, a group of financial assets, or even a group of operating environments. Several mathematical and statistical approaches are possible, but one of the most commonly used and desirable approaches is to estimate separate loss distribution models for the frequency (number) of loss events and severity (magnitude) of each loss, and then to combine those models to estimate the aggregate loss in a given time period.

This poster demonstrates a practical implementation of a loss distribution approach (LDA) which postulates that the number of losses and the severity of each loss are random variables and builds a probability distribution model for each variable. We extend this loss distribution modeling with a convolution of the two distributions to create a compound distribution model (CDM) to analyze potential aggregate losses.

On the Dependent Structure of Compound Loss Models

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N.D. Shyamalkumar (speaker)

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Classical compound loss models assume the independence between individual losses and occurrence of claims. We study modeling of the dependence between individual losses and the number of claims using copula. Drawing from connections with related problems arising from bio-statistics, and otherwise, we study problems of statistical inference for such models.

On the decomposition of life expectancy and limits to life

LES MAYHEW

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DAVID SMITH (speaker)

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 Life expectancy is a measure of how long people are expected to live and is widely used as a measure of human development. Variations in life expectancy reflect not only the process of ageing but also the impacts of epidemics, wars, economic recessions, etc. Since 1950, the influence of these events in the most developed countries has waned and life expectancy continues to grow unabated. As a result, it has become more difficult to forecast long run trends accurately or identify possible upper limits to life expectancy. This uncertainty impacts greatly on the pensions industry and capital markets and ultimately affects the pricing and valuation of annuities. In this paper we will present new methods for comparing past advancements in life expectancy and also future prospects using data from five developed, low mortality countries. We consider life expectancy in ten-year age intervals rather than over remaining life and show how natural ceilings in life expectancy can be used for extrapolating future trends using a logistic model. We conclude by discussing the significance of our results and compare our approach with other commonly used methods and projections.

Using patient records to investigate mortality and deprivation

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David Smith (speaker)

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It is generally assumed that deprivation has a major impact on mortality rates with mortality rates increasing as the level of deprivation increase. While this has been shown to hold, calculations are often carried out on historical, aggregated data. For this paper we have investigated the impact on mortality of deprivation by using patient data provided by the THIN (The Health Improvement Network) database of patient records from 2005 to 2010. The data base contains around 4 million anonymised patient records including their patient histories. The data are being used to investigate chronic disease pathways over the life course and the consequent burden on the health service. We will begin with a description of the structure of the data base and how it can be used in the specific investigation of mortality. By splitting up the population into deprivation quintiles based on location, we demonstrate that mortality rates support the hypothesis that they increase as the level of deprivation increases. While this general relationship holds for all ages we find that the differences as expressed as relative percentages varies considerable over the age range, with the difference in males peaking around age 45 and females showing a different pattern with two peaks at ages 42 and 65. We also find that the differences reduce at older ages with mortality rates converging when patients reach age 80. We suggest reasons for why these patterns have emerged from this population and hence possible changes in the future.

Fixing a Broken Correlation Matrix

Brian Spector (speaker)

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The correlation matrix is central to risk calculations, whether it is used as part of the definition of a copula or other dependency structure used to generate risk factors, or more directly to combine capital requirements using the "VCV" technique (e.g, in the Standard Formula method of Solvency 2). In this talk we discuss a common problem: a matrix which superficially "looks like" a correlation matrix may not be one mathematically. First we review some theory of correlation matrices before discussing what can go wrong. We then present some ways of constructing valid correlation matrices or "fixing" broken ones. Finally, we will discuss other problems that can occur with numerical computations including overflow/underflow, condition number, and stability.

The relative value of health habits and how best to create them. Two research models: A Dose Value model and a Four Powers model for creating health habits

Andrew Sykes (speaker)

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Two key questions exist in wellness programs: What's worth focusing on (in terms of habits or risks to manage)? And how do we reliably get people to practice these habits, in a way that leaves them satisfied and engaged with their employers?

A dose value model answers the first question and is a research summary (or meta-analysis) across 10 inputs (such as exercise, healthy eating, managing risk factors) and 30 outputs (including productivity, sick care costs, absenteeism, and many more). Over 3,000 pieces of research have been reviewed to extract, where possible, the "dose value" of each input on each output. This allows actuaries to understand which areas in a wellness program might reasonably be expected to produce valuable results for insurers, employers and members. With these answers, the next question is then how best to get people to practice these habits.

The Four Powers model is a framework for collecting together influence techniques that have worked to create new habits in industries as diverse as casinos, food services, online gaming and many more, combined with more traditional research in behavior modification.

The model considers four separate powers: The power to grow capability, the power to inspire motivation, the power to overcome barriers and the power to resist temptation. For each power, the model curates the research in how these powers are best brought to bear in four contexts: Self, Social, Spaces and Systems. The methods developed from this research form the building blocks of effective wellness tools and programs that insurers can use to really drive down health care costs and improve worker productivity.

What's been missing in wellness (perhaps explaining the failure of many wellness programs to date), is an actuarial approach to understanding where to focus efforts for optimal results, combined with the best research and thinking in how to create new habits.

In this presentation, we summarize the research approach, explain the models and share some of the surprising results that have emerged so far.

Claim dependencies in economic capital modeling: The Australian experience

Benjamin Avanzi

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Greg Taylor (speaker)

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An essential component of insurers' reserving for insurance liabilities is the estimation of statutory risk margins by line of business (LoB) and in aggregate. The relation between the aggregate risk margin and its LoB components is a function of the degree of independence (diversification) between the LoBs. The greater this is, the smaller the risk margin the insurer is obliged to carry.

The accurate estimation of the diversification benefits related to the dependence structures between lines of business is crucial for (i) capital efficiency, as one should avoid holding unnecessarily high levels of capital, and (ii) solvency of the insurance company, as an underestimation, on the other hand, may lead to insufficient capitalization and safety.

Over the interval since the introduction, in many countries, of insurance legislation that mandates the quantification of risk margins, capital management and diversification, insurers' methodologies for dealing with these matters have been variable, and progress in relation to the allowance for dependencies between LoBs has been (considering the market as a whole) the most limited. Even in cases where useful progress has been made, methodology has tended to be cumbersome and lacking in consistency and in rigorous estimation of dependencies.

In this paper, we report on some initial findings from a joint research project with three of the four major insurance companies in Australia on claim dependency modeling.

We start by discussing the main forms of dependence insurance companies face, and discuss their impact and (possible) interactions. We then review the most relevant aspects of current practices with respect to modeling dependence, especially in Australia. We analyze the adequacy of those and tease out main advantages and pitfalls. We go on by reviewing the main challenges that require, in our opinion, further development, and discuss possible avenues for improvement.

Variations of the linear logarithm hazard transform for modelling cohort mortality rates

CARY CHI-LIANG TSAI (speaker)

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Observing that there is a linear relationship between two sequences of the logarithm of the forces of mortality (hazard rates of the future lifetime) for two years, two variations of the linear logarithm hazard transform (LLHT) model are proposed in this paper. We first regress the sequence of the logarithm of the forces of mortality for a cohort in year y on that for a base year. Next, we repeat the same procedure a number of times with y increased by one and the base year unchanged each time, and produce two sequences of slope and intercept parameters which both look linear. Then the simple linear regression and random walk with drift model are applied to each of these two parameter sequences. The fitted parameters can be used to forecast cohort mortality rates. Deterministically and stochastically forecasted cohort mortality rates with the two LLHT-based approaches, and the Lee-Carter and CBD models are presented, and their corresponding forecasted errors and associated confidence intervals are calculated for comparing the forecasting performances. Applications in pricing term life insurance and annuities are also given for illustration.

Dynamic Hedge Projection for Variable Annuity Capital Assessment

CRAIG TURNBULL (speaker)

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 In order to obtain recognition for the risk mitigation benefits of hedging in their regulatory capital assessments, variable annuity writers in North America and Europe must perform stochastic projections of the behavior of their dynamic hedging programs over the lifetime of these long-term liabilities. However, the computational difficulties of this calculation result in many firms being either unable to obtain realistic levels of capital relief, or undertaking enormous complex nested stochastic calculations that are expensive, unwieldy and which may involve arbitrary simplifications that undermine confidence in their results.

This presentation introduces an entirely different methodology for addressing the highly demanding modeling required in this area and one which is significantly more efficient, accurate and objective than those applied in industry up until now. We use Least Squares Monte Carlo methods can be used to produce accurate estimates of variables annuity Greeks' behaviour throughout the run-off of the business.

A case study is used to demonstrate the implementation of this method to variable annuity product features, and to show how it can be used to obtain economic capital relief under a CTE run-off basis.

Market-Consistent Valuation of Pension Sponsor Support and its Use in Risk-Based Capital Assessment

CRAIG TURNBULL (speaker)

Fellow of Institute of Actuaries [craig.turnbull@moodys.com]

Most 'Defined Benefit'-style pension funds around the world today have a funding deficit, particularly when market-based valuation of the liabilities is undertaken. These pension funds often, however, have an important 'off-balance-sheet' asset: the value of future additional contributions from the pension fund sponsor. In many jurisdictions, this 'sponsor support' is a legal obligation, and can be viewed as a credit-risky asset. However, the timing and path-dependency of the sponsor contributions and the correlation between sponsor default and pension fund deficit mean that a market-consistent valuation of this sponsor support is technically demanding.

This presentation discusses how the sponsor support valuation can be undertaken using risk-neutral Monte Carlo simulation methods. A case study is used to show how valuation results vary as a function of contribution strategy and investment strategy.

The presentation will also discuss how this valuation approach can then be used to assess economic capital requirements by calculating a 1-year Value-at-Risk for the net assets of the pension fund's market-consistent balance sheet. This market value VaR approach to risk capital could be viewed as an application to pension funds of the economic capital techniques developed in insurance and banking in Solvency II and Basel II/III respectively. Finally, it will discuss how such a framework could influence pension fund risk management and investment strategy.

A paper on this topic was published by the presenter in the British Actuarial Journal in 2013 and it received the 2013 Peter Clark Prize for Best Paper from the Institute and Faculty of Actuaries. The presenter is also a member of the Pension Solvency Work Group of the Actuarial Association of Europe.

On the Interaction between Transfer Restrictions and Crediting Strategies in Guaranteed Funds

Eric Ulm (speaker)

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Guaranteed funds with crediting rates for fixed periods determined by a Pension Provider or Insurance Company are common features of accumulation annuity contracts. Policyholders can transfer money back and forth between these accounts and Money Market accounts which give them features similar to demand deposits and yet they frequently credit a higher rate than the Money Market. Transfer restrictions are commonly employed to prevent arbitrage. In this paper, we model the interaction between company and policyholder as a multiperiod game in which the company maximizes risk-neutral expected present value of profits and the policyholder maximizes his expected discounted utility. We find that the optimal strategy on the part of the company is to credit a rate higher than money market rate in the first period to entice the policyholder to invest in the guaranteed fund. The company then credits the floor in the remaining periods as the policyholder transfers out the maximum amount. This does better for the policyholder in low interest rate environments and worse in high interest rate environments and acts as a type of "interest rate insurance" for the policyholder.

Regulatory risk : is there a danger in reducing the volatility ?

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CHRISTIAN WALTER (speaker)

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Regulatory risk is defined as the exposure to financial loss arising from the probability that regulatory agencies will make changes in the current rules (or will impose new rules) that will negatively affect the already-taken trading positions. In the post-financial crisis environment, the US and EU are each pursuing modernization of their regulatory frameworks. Hence, the regulatory landscape is inherently more complex, and the recent regulations aiming at reducing the risk to all financial institutions lead to a fundamental redesign of the conceptual frameworks. The paths taken by the US and EU are each impacted by these conceptual frameworks. Nevertheless, the feeling of a large number of professional practitioners is ambiguous: if these rules achieve to reduce the volatility, they seem to rigidify the financial structure of the economic system and, consequently, tend to increase the probability of large moves, i.e. the probability of large jumps. The side effect of these rules seems to swap the volatility for the intensity of jumps, in the sense that the aimed reduction of volatility is accompanied by the increase of the intensity of jumps. In other words, the volatility risk seemed to be swapped for a jump risk. In this situation, the new rules of regulators seem create a new regulatory risk. This paper discusses this idea in two ways. First, after having precisely defined two kinds of risk (volatility and intensity of jumps), we document this swap effect by analyzing a daily time series of the S&P500. We find that the recent evolution of the index indicates simultaneously a reduction in the volatility and an increase of the intensity of jumps, a result that validates the intuition of professional practitioners. Second, we propose a model which can simulate a practical consequence of this swap of risk on the risk measures : for a given level of Value-at-Risk (VaR), the Tail Conditional Expectation (TCE) increases with the risk swap. We simulate this effect by using an alpha-stable motion (Lévy process) to exhibit the approximately linear relation between VaR and TCE in order to give an example of the swap risk. We assume that a new set of regulation rules tend to decrease the volatility by a reduction of alpha, decreasing from 1.75 to 1.4, and we examine the impact of this reduction to the VaR and TCE. We find that, for a given constant level of VaR, the TCE is multiplied by a 1.5 factor. In other words, even with a constant level of VaR, the TCE increases due to the swap of risk effect. We conclude by challenging the main objective of regulators : we argue that to reduce the sole volatility can increase the potential losses, creating a new type of regulatory risk.

The Effects of Urbanization on Insurance Consumption- The experience of China

PING WANG (speaker)

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JI ZHANG

University of International Business and Economics, China   []

The effects of urbanization on the insurance consumption are studied in this article examining the experience of China from 1997 to 2011. The insurance market of China grows at average speed of higher than 20% annually since 1980s. During the same period, the percentage of the country's population who work and live in urban areas also rises rapidly. This article studies the relationship between urbanization and consumption of both life-health insurance and property-liability insurance, while controlling for factors identified in the literature. The effects of China's WTO accession in 2001 on insurance consumption are also examined. Using provincial-level data, the authors find evidence that both urbanization and WTO entry are important in explaining the variation in the consumption of both lines of insurance. Specifically the coefficient estimates are positive and statistically significant.

Valuing Guaranteed Minimum Death Benefits in Variable Annuities with Knock-Out Options

Xiao Wang (speaker)

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This research is motivated by the problem of valuing Guaranteed Minimum Death Benefits (GMDB) in variable annuities. The proper valuation of GMDB needs to take into account of lapses and surrenders. This talk will show that, in the presence of lapses and surrenders, such guarantees can be viewed as a portfolio of barrier options, in particular, knock-out options. Because the distribution of the time-of-death random variable can be approximated by linear combinations of exponential distributions, the problem becomes the valuation of barrier options with an exponentially distributed exercise date. Due to the memoryless property of an exponential random variable, there is a simple method to value such barrier options when the underlying stock fund is modeled as a geometric Brownian motion. We shall also show that our approach can lead to a new derivation of the classical formula for pricing European barrier options.

Applications of Price Elasticities in Auto Insurance

Philip Wong (speaker)

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We estimate the effects of premium changes on retention/renewals on existing policies based on discrete choice models. Modeled elasticities vary by segments and depend on the amount of premium change. We give one useful business application – estimating expected renewal rates and aggregate premium changes due to rate or system changes. We also discuss issues in applying these models such as the timing of data and the presence of 6 and 12 month policies.

Using Monte Carlo Simulation to Predict Captive Insurance Solvency

Lu Xiong (speaker)

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The solvency of captive insurance fund is a main thing captive managers care. We built a solvency prediction model for captive insurance fund using Monte Carlo simulation with the fund's current financial data and setups. This model will tell captive managers the solvency score of current fund using the fund survival probability in the next several years as a measurement of solvency. Standard financial reports will also be generated in each year including income statement, balance sheet and summary of financial ratios. This model is developed from a general casualty insurance actuarial model. We add random numbers follow the distribution of loss scenarios to simulate future losses. If the solvency ratios broke the red line in a simulated case, we count it as a insolvency case; otherwise, it's a survival case. After large sampling, we can approximate the future survival probability of current captive fund. We use a heat map to visualize the solvency score of each setup choice so that it will be easier for captive insurance managers compare their decision choices.

Pricing Joint-Life Reverse Mortgages and Non-Recourse Provisions Considering Mortality Dependence: a Copula Approach

Sharon S. Yang (speaker)

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The continuing global increase in life expectancy demands urgent consideration of the ways in which the retirement incomes of the elderly can be increased in order to ensure the maintenance of an acceptable standard of living. Aging populations and increases in longevity on a global scale have put pension and annuity providers in untenable positions, such that the response by many providers has been unavoidable reductions in pension benefits or extended the retirement age (Antolin, 2007). About 75 per cent of the increasingly elderly populations around the world are now considered to have inadequate income upon their retirement. Many elderly people are considered to be "cash poor and equity rich" (Shan, 2011). Home equity therefore offers a potential alternative financial resource capable of meeting current shortfalls in retirement income.

In the US, the department of Housing and Urban Development (HUD) first introduced the Home Equity Conversion Mortgage (HECM) program in 1989 (Shiller and Weiss, 2000). Current demographic trends indicate that the number of potential purchasers will continue to rise. In addition, most of reverse mortgages in the U.S. were purchased by couples, which is account for 40% of the total sales in 2008. Under the joint-life reverse mortgage, the couples receiving a lump sum and/or annuity in exchange for the transfer of some, or all, of the value of their house to a financial institution upon the last death. The loan value is ultimately determined by the age of the couples, the interest rate and the value of the property. Therefore, the mortality dependence between couples should be considered into the valuation for joint-life reverse mortgages. The purpose of this paper is to build a pricing framework for joint-life reverse mortgage and investigate the non-recourse provision. Particularly, we take into account the mortality dependence between couples. Thus, we adopt the copula approach to capture the mortality dependence between couples. The mortality dynamics and house price return dynamic are examined according to the empirical study on the model fitting. As a result, we suggest that the mortality dynamic follows Renshaw and Haberman (2006) Lee-Carter cohort model and house price return dynamic follows the ARMA-GARCH model. We fit the actual mortality data. Numerical analysis shows that the price of reverse mortgage would be overestimated if we ignore the mortality dependence between the joint-life mortality.

Using Population Census and Actuarial Analytics to Price for Individual Products

Yan Yang (speaker)

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Health care has been experiencing tremendous changes in recent years. The health law has reshaped the way insurers do business. Not only do health insurance carriers need to take all risks, but also are becoming very retail-oriented and customer-focused. This presentation will review our application of public data and consumer census in our rate setting, and continuous monitoring of the markets for pricing needs to adapt to the new normal. Many other business implications similarly using the external data, such as marketing and care management, will be recognized but not addressed in the presentation.

The Affordable Care Act (ACA) set the new market rules. New policy requirements, restrictions, and regulations from the law have forced actuaries to look for additional tools in the toolkits in order to better understand current and future risks. Due to uninsured uptake, population shift from group business to individual customers, the traditional pricing approach based on analyzing the existing enrollments and projecting the medical trend is simply of little value in the new competitive landscape. Leveraging external databases and advanced statistic analytics, we set up our 2014 premium rates from projecting the uninsured risk, modeling market shift and simulating consumer purchasing decisions under different product and pricing strategies. In order to do it all, we employed Lifestyle Based Analytics on consumer survey data, and built price elasticity in the health care reform forecasting model. The sophistication of the last year's rate setting for the post ACA environment not only guided business planning in preparing for the reform, but also resulted in very competitive rates. Our individual business membership has almost doubled during the open enrollment period. Now, it also serves the foundation for monitoring the risk on early enrollment and continues to inform the 2015 bids.

Medicare Advantage has utilized the population data for even longer time. Numerous studies on the FFS population by CMS and academic research institutions have been leveraged by actuaries, to understand the risks associated with Medicare Advantage members for improving the revenue and better managing care. Given the critical linkage between star rating and CMS funding levels, there are more consumer focused studies for the purpose of improving quality of care to seniors and customer satisfaction.

The market disruption from the regulations only exacerbates the need for more lens and innovative thinking in setting up the premium rates, as the competition has always been a catalyst for new crossovers from multiple disciplines in problem solving for years. The importance of this trend is that the actuaries can take advantage of new opportunities in our future pricing for better educated guess.

Model Uncertainty in Operational Risk Modeling

Vytaras Brazauskas

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Daoping Yu (speaker)

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The treatment of the data collection threshold in operational risk modeling has been actively debated by practitioners and regulators in the United States and around the world. Several recent papers have shown that different approaches lead to different probability models, risk measurements and hence different capital allocations. In this work, we further investigate such model uncertainty through simulated case studies, with the true data generating model being lognormal. We use the Value-at-Risk measure to determine the capital charge against operational risk. We consider several approaches: the "naive" lognormal, the truncated lognormal, the shifted lognormal and the log-folded normal models. It is found that the naive approach, which completely ignores the presence of the threshold, consistently underestimates the capital charge. All other methods do take the threshold into account (as data shifting, truncation or scaling) and may be equally valid or invalid approaches. We also note that model validation tools such as quantile-quantile plots or goodness-of-fit tests sometimes help but often they are inconclusive. Finally, we attempt to classify all the approaches as conservative or liberal based on the capital allocations they produce.

Interplay of Asymptotically Dependent Insurance and Financial Risks

Zhongyi Yuan (speaker)

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We consider a discrete time model for an insurer who is exposed to both insurance risks and financial risks. The two kinds of risks stem from insurance claims and potential losses due to financial investments, respectively, and are usually assumed to be independent or asymptotically independent in the literature. We propose that in some cases asymptotically dependent models are more appropriate. Under asymptotic dependence given by a multivariate regular variation structure, we obtain asymptotic approximations for both the finite-time and the infinite-time ruin probabilities. We observe that the asymptotic dependence introduces additional risk to the insurer, and demonstrate that the two kinds of risks may exhibit a different way of interplay from the cases where they are independent.

Extreme behaviour for bivariate skew-elliptical distributions

Jinyuan Zhang (speaker)

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 It is widely reported that symmetric distributions cannot well describe returns on financial assets. Accounting for the asymmetric extremal dependence is essential in risk management and portfolio selection. The aim of the paper is to estimate the conditional distribution of the loss on one asset given a large movement in another. This can, in particular, be used to quantify the effect of financial contagion in the markets. Estimation is based on an asymptotic result of Abdous et al. [Canad. J. Statist. 33 (2005)] for elliptical distributions, but extended to a more general class of skew-elliptical distributions. Assuming heavy-tailed risks, we propose a novel way to estimate asymmetry parameters by deriving the limiting shape for the level sets of a multivariate skew-t density. A good performance of the procedure is demonstrated using simulations and financial data.

Portfolio Choice with Life Annuities under Probability Distortion

Wenyuan Zheng (speaker)

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One key assumption from Behavior Economics that people tend to overweight small probabilities and underweight large probabilities applies well in Insurance Industry. In our work, optimal investment, consumption and annuitization strategies are compared between models with and without such probability distortion. The critical points of buy/ surrender annuity behavior are obtained as wealth gradually increases or decreases.

By introducing the probability distortion, we revisited the optimal portfolio model in a financial market with a riskless bond, a risky asset , and commutable life annuities. Under the stochastic control framework, a new reverse S-shape probability distortion function is proposed to obtain an explicit distorted diffusion process. We then established a dynamic utility-optimization problem with control processes, and solved it via HJB-equation.

Valuing equity-linked death benefits

Zhenhao Zhou (speaker)

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Motivated by Guaranteed Minimum Death Benefits (GMDB) in variable annuities, we are interested in evaluating the expected discounted value of a payment at the time of death, where the payment depends on the price of a stock at that time and possibly also on the history of the stock price. The stock price is modeled as the exponential of a Brownian motion plus an independent compound Poisson process whose jumps are linear combinations of exponentials. Thus our stock-price model contains the classical geometric Brownian motion model as a special case. Because the time-until-death distribution can be approximated by a linear combination of exponential distributions, the analysis can be reduced to the case where the time-until-death distribution is exponential, and hence the Wiener-Hopf factorization is applicable. Our results will be illustrated by numerical examples.

Valuing Variable Annuity Guarantees on Multiple Assets

JONATHAN ZIVEYI (speaker)

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JOSE DA FONSECA

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Guarantees embedded variable annuity contracts exhibit option-like payoff features and the pricing of such instruments naturally leads to risk neutral valuation techniques. This paper considers the pricing of two types of guarantees; namely, the Guaranteed Minimum Maturity Benefit and the Guaranteed Minimum Death Benefit riders written on several underlying assets whose dynamics evolve under the influence of affine stochastic volatility processes. Within the standard affine framework for the underlying mortality risk, stochastic volatility and correlation risk, we develop the key ingredients to perform pricing of such guarantees. The affine nature of the model implies that the corresponding characteristic function for the state variables is known in a closed form. We illustrate the methodology for two possible payoffs for the guarantees whose Fourier transforms are computed and combined with the characteristic functions so that resulting prices can be obtained through numerical integration. Using typical values for the parameters, an implementation of the model is provided and underlines the significant impact of the assets correlation structure on the guarantee prices.

Speaker Index

The number after the name of the speaker refers to the page number.

Author Index

The number after the name of the author refers to the page number.

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