Abstract Booklet for the 2017 Actuarial Research Conference at Georgia State University in Atlanta

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Program Outline

Wednesday, July 26  6:30-8:30pm  **Welcome Reception**  
Center for Civil and Human Rights, 100 Ivan Allen Jr Blvd NW

Thursday, July 27  **Conference Day 1**  
8:00-9:00am  Breakfast & Registration  
9:00-9:30am  Opening Remarks  
9:30-10:30am  Plenary Session I  
Christian Gollier, Toulouse School of Economics  
10:30-11:00am  Coffee Break  
11:00-noon  Plenary Session II  
Damir Filipovic, EPFL and Swiss Finance Institute  
noon-1:15pm  Lunch  
1:15-2:45pm  Parallel Sessions A1-E1 (3 Presentations)  
2:45-3:15pm  Coffee Break  
3:15-4:45pm  Parallel Sessions A2-E2 (3 Presentations)  
6:00-7:30pm  **ARC 2017 Basketball game (with hot dogs and burgers)**  
GSU Sports Arena, 125 Decatur St

Friday, July 28  **Conference Day 2**  
8:00-9:00am  Breakfast & Registration  
9:00-9:15am  Welcome & Logistics,  
9:15-10:15am  Plenary Session III  
James Guszcza, Deloitte  
10:15-10:45am  Coffee Break  
10:45-12:15pm  Parallel Sessions A3-E3 (3 Presentations)  
12:15-1:45pm  Lunch with Presentations and Invitation to ARC 2018  
Nancy A Braithwaite, Travelers, CAS President  
Craig Reynolds, Milliman, SOA Past President  
Bruce L Jones, Western University  
1:45-3:15pm  Panel Discussion on Analytics in Actuarial Science  
Edward W Frees, U Wisconsin Madison  
James Guszcza, Deloitte  
Rodrigo C Martinez, Georgia State University  
3:15-3:45pm  Coffee Break  
3:45-5:15pm  Parallel Sessions A4-E4 (3 Presentations)  
6:00-9:30pm  **Conference Dinner**  
Georgia Aquarium, 225 Baker St NW

Saturday, July 29  **Conference Day 3**  
8:00-9:00am  Breakfast  
9:00-10:30am  Parallel Sessions A5-D5 (3 Presentations)  
10:30-11:00am  Coffee Break  
11:00-12:30pm  Parallel Sessions A6-D6 (3 Presentations)  
12:30-1:30pm  Closing and Boxed Lunch
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Saturday, July 29

Breakfast: 8:00am - 9:00am
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   A5 – DIFFICULTIES IN INSURANCE ESTIMATION
   B5 – NEW APPROACHES IN INSURANCE MODELING
   C5 – VALUATION OF UNIT-LINKED INSURANCE
   D5 – TOPICS IN PENSIONS
Coffee Break: 10:30am - 11:00am
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   A6 – CAS: Best University Practices
   B6 – CAT AND SYSTEMIC RISK
   C6 – OBJECTIVES IN INSURANCE
   D6 – TOPICS IN MORTALITY RISK
Closing and Lunch: 12:45pm - 1:45pm

Presenter and Chair Names and Sessions
Presenter Names and Sessions
Session Chairs Names and Sessions

Welcome

Wednesday, July 26

Welcome Reception: 6:30pm - 8:30pm
   Location: Center for Civil and Human Rights, 100 Ivan Allen Jr Blvd

Thursday, July 27

Registration and Breakfast: 8:00am - 9:00am
   Location: Georgia State University; Student Center East (SCE) – Court & House Salons; 55 Gilmer St NE, Atlanta GA 30303

Plenary Session I: 9:00am - 10:30am
   Location: SCE Auditorium / SCE 120; Chair: George Zanjani, Georgia State University
   Opening Remarks by Richard Phillips, Dean of the Robinson College of Business
   Title: Evaluation of very long-dated assets, interest rates and climate change
   Presenting Author: Christian Gollier, Toulouse School of Economics
   Abstract: The evaluation of assets and liabilities of insurance companies requires a model of
the term structure of interest rates that is compatible with collective beliefs about the long-term prosperity of our economy, which also affects their solvency. In a very different arena, the question of which rate should be used to discount future climate damages in order to estimate the optimal price of carbon raises similar challenges. I will expand the classical consumption-based capital asset pricing model to maturities extended to many decades or even centuries to explore the determinants of what EIOPA calls the ultimate forward rate.

Coffee Break: 10:30am - 11:00am
Location: Court & House Salons

Plenary Session II: 11:00am - noon
Location: SCE Auditorium / SCE 120; Chair: Liang Peng, Georgia State University

Title: Replicating Portfolio Approach to Capital Calculation
Presenting Author: Damir Filipović, Ecole Polytechnique Fédérale de Lausanne (EPFL) and Swiss Finance Institute (with Mathieu Cambou)
Abstract: The replicating portfolio (RP) approach to the calculation of capital for life insurance portfolios is an industry standard. The RP is obtained from projecting the terminal loss of discounted asset-liability cash flows on a set of factors generated by a family of financial instruments that can be efficiently simulated. We provide the mathematical foundations and a novel dynamic and path-dependent RP approach for real-world and risk-neutral sampling. We show that our RP approach yields asymptotically consistent capital estimators if the chaotic representation property holds. We illustrate the tractability of the RP approach by two numerical examples.

Lunch: noon - 1:15pm
Location: Court & House Salons

Parallel Sessions 1: 1:15pm - 2:45pm (A1-E1)

A1 – TOPICS IN CLAIMS MODELING (Location: SCE Auditorium / SCE 120; Chair: Edward (Jed) Frees, University of Wisconsin)

1:15-1:45
Title: A Comparison: Some Approximations for the Aggregate Claims Distribution
Presenting Author: Ranee Thiagarajah, Illinois State University
Abstract: In this paper, we compare several approximations for the aggregate claims distribution in the context of insurance theory. For most combinations of distributions of claim counts and individual claim amounts, the exact distribution of aggregate claims is not available analytically. In this situation, one often prefers to use an approximate distribution for the aggregate claims. Several approximations for the distribution of aggregate claims have been proposed in the literature. In this paper, we have developed saddlepoint approximation for the aggregate claims distribution, and compared with some existing approximations
such as NP$^2$, Gamma, IG, and Gamma-IG mixture. We considered several distributions for the aggregate claims to examine the performance of these approximations. It seems that the saddlepoint approximation generally outperforms the other four in terms of relative errors.

1:45-2:15

**Title:** Generalized linear mixed models (GLMMs) for dependent compound risk models  
**Presenting Author:** Emiliano Valdez, University of Connecticut (with H. Jeong, J. Ahn, and S. Park)  
**Abstract:** The calculation of a pure premium in general insurance ratemaking has traditionally been based on modeling both frequency and severity in an aggregated claims model. It has been a standard practice to assume the independence of claim frequency and claim severity, but there has been a sporadic interest in the actuarial literature exploring models that depart from this independence. We extend the work of Garrido, et al. (2016) which uses generalized linear models (GLMs) that accounted for dependence between claim frequency and severity and simultaneously incorporated rating factors to capture policyholder heterogeneity. In addition to rating factors, we quantify and explain the contribution of the variability of claims among policyholders through the use of random effects using generalized linear mixed models (GLMMs). We calibrated our proposed GLMM model using a portfolio of auto insurance contracts from a Singapore insurer where we observed claim counts and amounts from individual policyholders for a period of nine years. We compared our results with the dependent GLM model considered by Garrido, et al. (2016), Tweedie models, and the case of independence. Using out-of-sample validation procedures, we find that the statistical results demonstrate a more superior model when random effects are considered within a GLMM framework.

2:15-2:45  

**Title:** Conditional, Non-Homogeneous and Doubly Stochastic Compound Poisson Processes with Stochastic Discounted Claims  
**Presenting Author:** Emmanuel Hamel, Université Laval (with Ghislain Léveillé)  
**Abstract:** In this talk, we study the conditional, non-homogeneous and doubly stochastic compound Poisson process with stochastic discounted claims. We derive the moment generating functions of these risk processes and find their inverses, numerically or analytically, by using their corresponding characteristic functions. We then compare their distributions and some risk measures as the VaR and TVaR, and we examine the case where there is a possible dependence between the occurrence time and the severity of the claim. Numerical examples and an application to medical/professional liabilities will also be presented.

B1 – EDUCATION UPDATES (Location: Senate Salon / SCE 110C)

1:15-2:45

**Title:** Education Updates  
**Presenters:** Steven Armstrong, Allstate for the CAS and Christophe Groendyke, Robert Morris University for the SOA
C1 – TOPICS IN LOSS RESERVING (Location: Lucerne / SCE 218; Chair: Liang Peng, Georgia State University)

1:15-1:45

**Title:** Inflation in Loss Reserving  
**Presenting Author:** James Ely, Independent Consultant  
**Abstract:** Motivation: The paper will explain the role of inflation in casualty loss reserving using convolution equations.  
Methodology: Loss data is arranged in two-way tables by calendar year and age of claim, so that all payments in each cell occur at the same time. Once the data has been modeled by calendar year and age, a linear transformation is used to change the basis of the model to the more conventional cumulative accident year basis.  
Results: The paper will show that the linear transformation is a convolution. In particular, it will be shown that cumulative accident year development pattern can be expressed as the convolution of the incremental calendar year pattern and a corresponding inflation index.  
Conclusions: Actuaries should be familiar with convolutions in a statistical sense, as the sum of two independent random variables. From this point of view we can say that reserve risk is the sum of insurance risk and inflation risk. Readers should also become familiar with the algebraic meaning of convolutions; they are linear transformations that map basis vectors to diagonals and vice-versa.

1:45-2:15

**Title:** Individual Loss Reserving with Multivariate Tweedie Models  
**Presenting Author:** Mathieu Pigeon, Université du Québec à Montréal (with Juan Sebastian Yanez)  
**Abstract:** Traditional approaches in non-life loss reserving such as Chain-Ladder, Bornhuetter-Ferguson, London Chain, etc. are constructed for aggregated data. Over the past decades, the progress achieved in computing resources and the wider availability of expanded information have resulted in the development of new models for individual dataset. In this talk, we propose a parametric multivariate model for individual loss reserving built on the Tweedie family of distributions. This model uses detailed information about each of the payments made for each of the claims in the portfolio. Moreover, the model has been constructed to capture dependence between subportfolios (lines of business, geographic regions, etc.), as well as between amounts paid for one claim. We consider several estimation techniques and present the main properties of the model. We illustrate theoretical results using a micro-level dataset from a property and casualty insurance company. Finally, we compare the results obtained using this new individual model with those obtained using conventional collective models.

2:15-2:45

**Title:** Generalized Linear Models in Loss Reserving  
**Presenting Author:** Zhihan Zhang, Arizona State University  
**Abstract:** The use of generalized linear models in loss reserving is not new; many statistical models have been developed to fit the loss data gathered by various insurance companies.
The most popular models belong to what Glen Barnett and Ben Zehnwirth in "Best Estimates for Reserves" call the "extended link ratio family (ELRF)," as they are developed from the chain ladder algorithm used by actuaries to estimate unpaid claims. Although these models are intuitive and easy to implement, they are nevertheless flawed because many of the assumptions behind the models do not hold true when fitted with real-world data. Even more problematically, the ELRF cannot account for environmental changes like inflation which are often observed in the status quo. Barnett and Zehnwirth conclude that a new set of models that contain parameters for not only accident year and development period trends but also payment year trends would be a more accurately predictor of loss development. This research applied the paper's ideas to loss information gathered from a real-world source. The data was fitted with both an ELRF model and an adapted version of Barnett and Zehnwirth's new model, and the forecasts were compared to the observed losses to determine the differences in predictive power between the two models. Though they require more analyses in terms of parameter selection, these models have the potential to improve traditional reserving algorithms as they rely on statistically determined parameters. Lastly, this research investigated various models for optimal parameter selection as well as the ease of implementation of such techniques in the company's current environment.

D1 – FINANCIAL MODELING (Location: Lanier / SCE 216; Chair: Nan Zhu, Penn State University)

1:15-1:45

Title: Extracting Latent States from High-Frequency Option Prices
Presenting Author: Jean-François Bégin, Simon Fraser University (with Diego Amaya and Geneviève Gauthier)

Abstract: Stochastic modelling is an important component in measuring and managing risks. Commonly, financial models are used in the design, the pricing and the hedging of many insurance products, among other things. Yet, these models often require estimates of model parameters and latent factors, which might be hard to identify. Fortunately, the increasing availability of high-frequency data has paved the way for a better understanding of asset prices and their underlying risks. The fine granularity of intraday prices and recent advances in econometrics provide new evidence regarding the importance of stochastic variance and jumps as sources of risk. These findings seem to indicate that more precise estimates could be obtained by using the full set of observed intraday prices. Nonetheless, estimating models directly from high-frequency prices is a daunting task since it would require not only the computation and storage of large option panels, but also explicit assumptions about the microstructure effects that govern these prices.

In this spirit, we propose a parsimonious framework to incorporate intraday prices in the estimation of jump-diffusion option pricing models. Rather than using the time series directly of these prices, we summarize this information with realized measures of variance—the realized option variance—that can be used as observable variables at lower frequencies. Our results show that the information contained in the realized option variance improves the inference of model variables such as the instantaneous variance and variance jumps of the S&P 500 index.

1:45-2:15
Title: Bayesian multivariate regime-switching models: an application in correlated assets  
Presenting Author: Brian Hartman, Brigham Young University (with Chris Groendyke and David Engler)  
Abstract: Accurate modeling of financial time series is important in many applications. For example, complex insurance guarantees often have no closed-form pricing solution and must be priced through stochastic simulation of the underlying asset(s) so that the quality of the pricing of these instruments depends on the ability to accurately model the underlying assets. Regime-switching models are an intuitive way to incorporate stochastic volatility into asset pricing models and have been shown to accurately describe single asset streams (e.g., stock index data). However, when considering multiple assets, ignoring between-asset correlation can lead to poor results, especially in the tail of the distribution. Using a Bayesian approach, we compared three ways to define the structure of the correlation matrix. A brief analysis of stock return data from nine stocks across two sectors found that incorporating a more flexible structure provides both superior performance and interesting insights into the data. In particular, for this data, we found that the assignment of data points to regimes differs by model and is often driven by correlation structure rather than the mean and variance parameters. A simulation study confirmed the results of the data analysis and demonstrated that the advantages of the more flexible models are particularly notable when the true underlying correlation structure is more complex.

2:15-2:45

Title: A new approach to model financial data: The Factorial Hidden Markov Volatility Model  
Presenting Author: Maciej Augustyniak, University of Montreal (with Luc Bauwens and Arnaud Dufays)  
Abstract: A new model – the Factorial Hidden Markov Volatility (FHMV) model – is proposed for financial returns and their latent volatilities. This model corresponds to a hidden Markov model (or regime-switching process), but its distinctive features allow for a better representation of volatility persistence in financial data. Volatility is modeled as a product of three components: a Markov chain, a jump process and a data-driven component. An economic interpretation is attached to each component and the statistical properties of the model are discussed. Empirical results on financial time series indicate that the FHMV model compares favorably to the main existing econometric models and offers a better representation of return and volatility dynamics over long-term periods.

E1 – TOPICS IN INSURANCE CONTRACTING (Location: Capital / SCE 203; Chair: George Zanjani, Georgia State University)

1:15-1:45

Title: Pareto-optimal reinsurance policies in the presence of individual risk constraints  
Presenting Author: Zhaofeng Tang, University of Iowa  
Abstract: The notion of Pareto optimality is commonly employed to forge decisions that reconcile the conflicting interests of multiple agents with possibly different risk preferences. In the context of a one-period distortion-risk-measure-based reinsurance model, we characterize the set of Pareto-optimal reinsurance policies analytically and expeditiously. The resulting
solutions not only cast light on the structure of the Pareto-optimal contracts, but also allow us to portray the trade-offs between the insurer and reinsurer geometrically. A strikingly simple graphical search of Pareto-optimal policies in the presence of the insurer’s and reinsurer’s individual rationality constraints is illustrated in the special cases of Value-at-Risk and Tail Value-at-Risk.

1:45-2:15

Title: On Optimal Reinsurance Treaties in Non-symmetric Cooperative Game
Presenting Author: Wenjun Jiang, University of Western Ontario (with Chen Yang and Jian-dong Ren)
Abstract: In this paper, we consider the negotiation of reinsurance policies as a non-symmetric cooperative game. In such a situation, as shown in Nash (1950), optimal reinsurance policies are reached when the product of the increases in expected utilities of the insurer and the reinsurer is maximized. Under this criterion, we derive analytical results for the optimal reinsurance policies. Examples with exponential utility and power utility are studied in detail. A numerical example is provided to show the practical implications of the analytical results.

2:15-2:45

Title: Comparison of Insurance Contracts with Background Risks in High-order Risk Attitudes
Presenting Author: Wei Wei, University of Wisconsin-Milwaukee (with Yichun Chi)
Abstract: In this paper, we compare insurance contracts with background risks. In single-risk models, it is clear that excess-of-loss contract is optimal in many senses. However, complications arise when background risks are introduced. Dependence structures between insurable risks and background risks play an essential role in determining optimal insurance form. In the existing literature, several positive dependence notions have been used and demonstrated the optimality of the excess-of-loss insurance contract. The downside of these notions, however, is that these positive dependence notions are too restrictive. In this paper, we propose a series of new dependence notions based on high-degree stochastic orders and use them to restudy the optimal insurance problems. The excess-of-loss insurance contract proves its optimality in many cases under the proposed framework.

Coffee Break: 2:45pm - 3:15pm
Location: Court & House Salons

Parallel Sessions 2: 3:15pm - 4:45pm (A2-E2)

A2 – TOPICS IN CLIMATE RISK (Location: SCE Auditorium / SCE 120; Chair: Nathaniel Newlands, Government of Canada)

3:15-3:45

Title: Modeling Impact of Natural Disasters on Income Distribution in the United States
Presenting Author: Lin Fang, Miami University (with Jiayu Wu and Tatjana Miljkovic)
Abstract: Prior research showed that economic damage due to hurricane activities impacts
income inequality in the coastal states of the United States. The findings were based on the period 1916-2005 including several shorter periods. An increase in number and severity of catastrophic events lead to an increase in risk mitigation, risk perception, and demand for insurance. We developed a state-by-year fixed effects model to be used to quantify the relationship between income inequality and economic/ and demographic variables, including crop and property losses from all natural disasters for period 1970-2013. Additionally, a region-specific fixed effects model is developed using the same explanatory variables for the climate regions defined by National Climatic Data Center of the National Oceanic and Atmospheric Administration (NOAA). Our findings show that the damages caused by all natural perils further impact income distribution across the United States, not only in the hurricane affected areas, but also in non-hurricane states. The results of our study have important implications for the insurance industry and government policy makers.

3:45-4:15

**Title:** A virtual climate library of surface temperature over North America for 1979–2015

**Presenting Author:** Vytaras Brazauskas, University of Wisconsin-Milwaukee (with Sergey Kravtsov and Paul Roebber)

**Abstract:** The most comprehensive continuous-coverage modern climatic data sets, known as reanalyses, come from combining state-of-the-art numerical weather prediction (NWP) models with diverse available observations. These reanalysis products describe the path of climate evolution that actually happened, and their use in a probabilistic context – for example, to document trends in extreme events in response to climate change – is, therefore, limited. Free runs of NWP models without data assimilation can in principle be used for the latter purpose, but such simulations are computationally expensive and are prone to systematic biases. Here we produce a high-resolution, 100-member ensemble simulation of surface atmospheric temperature over North America for the 1979–2015 period using a comprehensive spatially extended non-stationary statistical model derived from the data based on the North American Regional Reanalysis. The surrogate climate realizations generated by this model are independent from, yet nearly statistically congruent with reality. This data set provides unique opportunities for the analysis of weather-related risk, with applications in agriculture, energy development, and protection of human life.

4:15-4:45

**Title:** Climate, Weather, and Environmental Sources for Actuaries

**Presenting Author:** Robert Erhardt, Wake Forest University

**Abstract:** This report was prepared for the Society of Actuaries in 2016, following its request for a set of data, analysis and discussion sources pertaining to climate change, environmental risks and weather. As both an actuary and environmental statistician, two broad research questions have interested me for years: how do scientists know, and what could actuaries do? This report is a collection of sources that deal with these two questions.
Title: Open Actuarial Textbooks  
Presenting Author: Edward (Jed) Frees, University of Wisconsin-Madison  
Abstract: In this talk, I outline a project designed to develop open actuarial textbooks. Many will remember the days before open statistical software such as "R" was available. The availability of free open software has transformed the way that we teach and do research. Will the same be said of textbooks in the future? Currently available authoring tools allow us to produce not only aesthetically pleasing pdf formatted files but also other media including web-based (e.g., html) and EPUB versions (for mobile readers). In particular, web-based versions promote active learning by allowing authors to introduce interactive features that will allow a student to actively explore the content. The talk will provide an overview of the project. Additional background materials are available at https://sites.google.com/a/wisc.edu/loss-data-analytics/.

3:45-4:15

Title: Designing Exams to Test Higher Levels of Learning  
Presenting Author: Diana Skrzydlo, University of Waterloo  
Abstract: Bloom’s taxonomy includes several levels of learning: remember, understand, apply, analyze, evaluate, and create. We want our students to be able to apply tools to solve new problems, evaluate different approaches critically, and create predictions and new ideas, not only memorize formulas. But how can we design the assessments we give them so that these higher levels are tested? In this session, we will explore examples of how to elevate questions to test all levels of learning. Guidance will be provided on choosing topics to target and preparing students for these types of questions, as well as some practical hints on grading them.

C2 – RUIN AND DEPENDENCE MODELING (Location: Lucerne / SCE 218; Chair: Emiliano Valdez, University of Connecticut)

3:15-3:45

Title: Full-range tail dependence copulas  
Presenting Author: Lei Hua, Northern Illinois University  
Abstract: In this talk, I will introduce some flexible new bivariate copulas, the R package CopulaOne, and a few applications for data analytics in insurance and finance. Popular multivariate copulas such as vine copulas and factor copulas are constructed based on bivariate copulas. In order to provide more flexible building blocks for multivariate dependence modeling, an ideal bivariate copula should have the following features: First, both upper and lower tails are able to explain full-range tail dependence. That is, the dependence in each tail can range among quadrant tail independence, intermediate tail dependence, and usual tail dependence. Second, it can capture upper and lower tail dependence patterns that are either the same or different. In this talk, I will discuss a general approach for constructing copulas that have the above features. Some promising parametric copula families will be presented, and both the ideal features and the computational speeds were considered when constructing the copulas. Finally, a few applications using the full-range tail dependence copulas will be demonstrated.
Title: A Bivariate Extension of the Beta-Generated Distribution Derived from Copulas
Presenting Author: Ranadeera Samanthi, Central Michigan University (with Jungsywan Sepanski)

Abstract: There have been extensive studies on families of univariate distribution functions constructed based on beta distribution. These beta-generated distributions allow for more flexibility of modality and skewness in fitting data. In this talk, we introduce a new class of bivariate distributions whose marginals can be beta-generated. Copulas are employed to construct this bivariate extension of the beta-generated distributions. It is shown that when Archimedean copulas and convex beta generators are used in generating bivariate distributions, the copulas of the resulting distributions also belong to the Archimedean family. The coefficients of upper and lower tail dependence of the proposed bivariate distribution are examined. Further, the parameter estimation and simulation results are presented for beta generators.

Title: Double barrier problem for double exponential jump diffusion
Presenting Author: Dean Teneng and Julius Esunge, University of Mary Washington (with Kalev Pärna)

Abstract: We consider a perturbed double exponential jump diffusion process which starts at a fixed level \( u > 0 \). We derive integral, integro-differential equation and a general form for the probability that the double exponential jump diffusion process reaches a fixed level \( b > u \) before it ruins. Our obtained analytic solution can easily be implemented with any mathematical software.

D2 – TOPICS IN VARIABLE ANNUITIES (Location: Lanier / SCE 216; Chair: Maciej Augustyniak, University of Montreal)

Title: A Neural Network Monte Carlo Evaluation of Withdrawal Benefits in Variable Annuities
Presenting Author: Hongjun Ha, Saint Joseph’s University (with Daniel Bauer)

Abstract: Advanced life insurance products with exercise-dependent financial guarantees present challenging problems in view of pricing and risk management. In particular, due to the complexity of the guarantees and since practical valuation frameworks include a variety of stochastic risk factors, conventional methods that are based on the discretization of the underlying (Markov) state space may not be feasible.

As a practical alternative, this paper explores the applicability of the Neural Network Monte Carlo (NNM) method familiar from machine learning community for predictions in this context. Unlike previous literature of American option pricing, we consider optionality beyond surrendering the contract, where we focus on popular withdrawal benefits – so-called GMWBs – within Variable Annuities. We introduce an approximation method for a value function via the neural network with a single layer and focus on how to train coefficients of
a neural network based on sample paths generated from Monte Carlo simulation. We commence our numerical analysis in a basic Black-Scholes framework, where we compare the NNM results to those from a discretization approach. We then extend the model to include various relevant risk factors and compare the results to those from the basic framework.

3:45-4:45

Title: Pricing Bounds and Bang-bang Analysis of the Polaris Variable Annuities
Presenting Author: Zhiyi Shen, University of Waterloo (with Chengguo Weng)
Abstract: I will present our research results on the pricing and hedging of the Polaris Income Plus Daily income benefit structured in the Polaris Choice IV variable annuities recently issued by the American International Group. Distinguishing from most withdrawal benefits in the existing literature, the Polaris allows the income base to "lock in" the running maximum of investment account over certain monitoring period depending on the policyholder’s first withdrawal. By assuming the rider charge is proportional to the investment account, we establish a bang-bang solution for the optimal withdrawal strategies and show that they can only be among a few choices. We consequently design an innovative efficient numerical algorithm for the optimal solution based on a Monte Carlo method combined with nonparametric sieve regression technique. We show that the resulting value function is an upper bound of the hedging cost for a contract which charges insurance fees on the income base. Extensive numerical studies show that this upper bound performs very well.

4:15-4:45

Title: Where Less Is More: Reducing Variable Annuity Fees to Benefit Policyholder and Insurer
Presenting Author: Thorsten Moenig, Temple University (with Carole Bernard)
Abstract: After two decades of increasing popularity, sales of variable annuities (VAs) began to dwindle in 2013. Financial advisors have long argued against investing in VAs due to the products’ high fees. VA providers charge these fees—typically at a constant rate throughout the policy period—to cover their expenses and the costs of the embedded guarantees, and lowering this constant fee rate could make the VA unprofitable. Instead, we propose and analyze a simple change to the fee structure that would lower overall fees (and thus make the product more attractive to investors) without reducing the insurer’s profit. In fact, this time-dependent fee structure—whereby the fee rate is reduced significantly only after a specified number of policy years—can be Pareto-improving for both parties. The key insight is that the new fee structure discourages policy exchanges, which reduces the insurer’s policy acquisition expenses. Taking into account financially optimal lapse (and reentry) decisions, we determine the optimal timing and rate of the fee reduction for a competitive as well as for an innovative VA provider. An important characteristic of this feature is that it can be implemented easily and effectively to both new and existing VA policies.

E2 – TOPICS IN HEALTH INSURANCE (Location: Capital / SCE 203; Chair: Ian Duncan, UC Santa Barbara)
3:15-3:45
Title: Combining both Financial and Clinic Data into Decision Making under Health Care Reform

Presenting Author: Yan Yang, Blue Cross and Blue Shield of Michigan

Abstract: Health care has been experiencing tremendous changes in recent years. The Affordable Care Act (ACA) set the new market rules and the American Health Care Act (AHCA) continues to bring in considerable uncertainty when it means to repeal and replace the bill. New policy requirements, restrictions, and regulations from the law have reshaped the way insurers do business and pressured actuaries to look for new tools and innovations in order to better understand current and future risks. The competition has always been a catalyst for new crossovers from multiple disciplines in problem solving while the market disruption from the regulations further increases this trend.

This presentation will review the latest AHCA update and its impact on market stability from both short term and long term point of view. It will also showcase our application of financial and clinic data to identify the drivers of current Medicare Advantage and Individual financial performance, and opportunities for future cost reduction or revenue improvement initiatives. Under the uncertainties surrounding the health care reform, setting up the robust monitoring system and leveraging financial and clinic expertise to manage both cost and revenue are even more critical in the current health care arena.

3:45-4:15

Title: A Predictive Modeling Approach to Fraud Management in Medicare Claims

Presenting Author: Robert Lieberthal, The University of Tennessee (with Jing Ai and Patrick L. Brockett)

Abstract: Fraudulent activities are a pressing concern in the healthcare system due to the financial costs of such activities. However, our understanding of these fraudulent activities is very limited. The wide range of available estimates also implies a high degree of uncertainty as to the extent of healthcare fraud and limited evidence for the effectiveness of available methodologies to detect healthcare fraud and estimate the rate of fraud. In this paper, we propose a predictive modeling approach to developing methodologies for healthcare fraud management. Our modeling approaches are based on the following economic framework: fraud is a rational response by certain providers to misrepresent their effort on behalf of patients in order to reap monetary incentives when the probability of detection is low. Given this framework, we describe how predictive modeling models can be used in combination with previously identified fraud predictors. We then use the Medicare 5% sample file to show how these methodologies are applied and discuss the design of empirical analysis using Medicare claims data. We also explore the implications of our study for healthcare practitioners and public policy makers in reducing fraud in public programs. We conclude by commenting on the validation of fraud detection methodologies.

4:15-4:45

Title: Examining Predictive Modeling Based Approaches to Characterizing Healthcare Fraud

Presenting Author: Skyla Smith, University of Tennessee (with Jing Ai and Robert Lieberthal)

Abstract: Background: Healthcare fraud can represent upwards of hundreds of billions of  

1Interim Results
dollars in spending that could be better spent on patient care. There is often not sufficient detail on the underlying methodologies and data samples that lead to fraud estimates, which may be due to different purposes of these reports or the need to obscure the details of fraud detection methods to prevent fraudulent operators from responding to existing methods.

Objectives: The objective of this study was to provide a systematic synthesis of the methodologies and data samples used in current peer-reviewed studies for characterizing healthcare fraud.

Data Sources: The academic databases searched were Academic Search Complete, Business Source Complete, EconLit, Medline (EBSCO), OneSearch, ProQuest Business Collection, ScienceDirect, and Web of Science. Governmental and commercial sources were used for background.

Synthesis of Methods: This examination was conducted by using systematic review methodology to identify studies and determine relevance. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to guide the performance of reviewing the literature. Study criteria for eligibility were collected by applying specific search terms: healthcare, health insurance, Medicare, Medicaid, Obamacare, Affordable Care Act, or health services; fraud, cheat, falsification, corruption, or kickback; detect, detection, prevent, prevention, deterrence, audit, or auditing. Results were restricted to scholarly journals, academic journals, working papers, and conference proceedings. Study selection occurred through independent reviews of each study for inclusion or exclusion.

Results: Our search terms resulted in 450 articles that were potentially appropriate for inclusion in our review. The results of these reviews ended with 27 studies considered as relevant to include after the application of our inclusion criteria. Variables are identified from the literature to synthesize each method of fraud detection used.

Limitations: One limitation of this study is that the strength of the evidence is reliant on the quality and number of studies previously performed regarding the topic. Another limitation is the quality of studies in terms of applying the evidence to different types of insurers.

Conclusions: Limited number of validated methods are used to detect healthcare fraud. The literature on the topic is spread among several academic fields. The majority of available studies utilize public or social health insurance systems such as Medicare or Medicaid in order to study fraud. The main gaps we identified are validation of existing methods and proof of intent to commit fraud in the studies analyzed.

Implication of Key Findings: Our insurer agnostic approach examines the use and reliability of healthcare fraud analytic methods across different types of health insurers, posing great value for members of the health sectors. The tools identified may be of value to health actuaries. Actuaries that are working for Medicare or surrounding insurance products will be able to use the results as a benchmark for fraud and an indicator of best practices. Those considering or currently involved in work that could be considered as "nontraditional" would benefit from the educational material produced in the project.

ARC 2017 Basketball game (with hot dogs and burgers): 6:00pm - 7:30pm
Location: GSU Sports Arena, 125 Decatur St
Friday, July 28

**Breakfast: 8:00am - 9:00am**

Location: Georgia State University; Student Center East (SCE) – Court & House Salons; 55 Gilmer St NE, Atlanta GA 30303

**Plenary Session III: 9:00am - 10:15am**

Location: SCE Auditorium / SCE 120; Chair: Eric Ulm, Victoria University of Wellington

Welcome & Logistics

**Title:** Actuarial Science in the Age of AI  
**Presenting Author:** James Guszcza, Deloitte  
**Abstract:** Jim will discuss ideas for the role of the actuarial profession in the coming age of Artificial Intelligence [AI]. The rapidly increasing availability of data about nearly every aspect of our lives is giving rise to an AI renaissance that is set to reshape both business and societal landscapes. In insurance, big data and AI enables smarter decisions, improved customer-centricity, and even new business models. To seize the moment, the actuarial profession must view the possibilities through a suitably wide aperture, focusing both on traditional strengths and needed developments. In this talk, Jim will survey the landscape and discuss opportunities for the actuarial profession.

**Coffee Break: 10:15am - 10:45am**

Location: Court & House Salons

**Parallel Sessions 3: 10:45am - 12:15pm (A3-E3)**

**A3 – TOPICS ON SURVIVAL DATA (Location: SCE Auditorium / SCE 120; Chair: Ian Duncan, UC Santa Barbara)**

10:45-11:15

**Title:** CSAC_EIA Workers Compensation Survival Analysis  
**Presenting Author:** Shannon Nicponski, UC Santa Barbara (with Liz Riedell and Jerrick Zhang)  
**Abstract:** The CSAC-EIA currently reserves for disabled worker Workers Compensation (WC) claims using an OSIP-prescribed methodology based on US population mortality. Using a sample of WC claims, we tested the accuracy of this method, estimated claim closure rates using actuarial methods, and compared these to the OSIP-prescribed closure rates. OSIP’s reserving methodology was found to overestimate the time WC claims are open, thus implying an overestimation of the reserves needed for WC claims. To approximate the closure rate, we created multiple models such as Kaplan-Meier, polynomial, and Cox Proportional Hazard models, all of which more accurately fit the WC experience than OSIP’s model.

11:15-11:45
Title: Identification of Persistent High-Utilizers and the Role of Multiple Unhealthy Behaviors  
Presenting Author: Margie Rosenberg University of Wisconsin – Madison (with Kyeonghee Kim)  
Abstract: At the 2016 Actuarial Research Conference, we presented our work linking unhealthy behaviors to one’s perceived health status. The premise of our prior work was that an individual’s perceived health status is a function of their history of unhealthy behaviors. Our current work extends the prior study to link these unhealthy behaviors to health care utilization while controlling for perceived health status and other appropriate covariates. We know that an individual who has high expenditures in one year may have high expenditures in the following year but not necessarily so. The purpose of our work is to identify those who are consistently high-utilizers from one year to the next whom we label as “persistent high-utilizers”. Identification of those who are persistent high-utilizers would benefit both the individual to receive any needed care and the provider and insurer to properly manage the care and control costs.  
We use five years of National Health Interview Survey (NHIS) data linked with the two-year longitudinal follow-up data from the Medical Expenditures Panel survey (MEPS). Our sample population consists of adults between ages 30 and 59 inclusive who completed the NHIS Sample Adult Questionnaire and who completed all five rounds of the MEPS survey. We define a high-utilizer as one who exceeds $10 (2012 dollars) of total health expenditures in a year. We chose this absolute threshold as it approximately represents the top 10% of total annual health expenditures in the U.S. civilian non-institutionalized population.  
We define one-time high-utilizers as those who exceeded $10 in only one of the two MEPS data years; persistent high-utilizers are those who exceeded $10 in both years of MEPS; low-utilizers are neither one-time high-utilizers nor persistent high-utilizers. The dependent variable is this categorical utilization group variable that is the classification of individuals into one of these three categories.  
A partial proportional ordinal logistic model is used to estimate the effects of multiple unhealthy behaviors. The partial proportional logistic model assumes that some of the covariates violate the proportional odds assumption and has separate parameters for those variables. Our main variable of interest in this study is the impact of the number of unhealthy behaviors on utilization group. We include four unhealthy behaviors: physical inactivity smoking heavy drinking and inadequate sleeping. All of our results are adjusted for the complex sampling designs of NHIS and MEPS.

Title: Evaluating Life Expectancy Evaluations  
Presenting Author: Nan Zhu, Penn State University (with Daniel Bauer, Michael V. Fasano, and Jochen Russ)  
Abstract: The quality of life expectancy estimates is one key consideration for an investor in life settlements. The predominant metric for assessing this quality is the so-called A-To-E Ratio, which relies on a comparison of the actual to the predicted number of deaths. In this paper, we explain key issues with this metric: In the short run, it is subject to estimation uncertainty even for a moderately-sized portfolio; and, in the long run, it converges to 100% even if the underwriting is systematically biased. As an alternative, we propose and discuss a set of new metrics based on the Difference in (Temporary) Life Expectancies. We examine the
underwriting quality of a leading US life expectancy provider based on this new methodology.

B3 – NOVEL ACTUARIAL APPLICATIONS (Location: Sinclair / SCE 217; Chair: Vytautas Brazauskas, University of Wisconsin-Milwaukee)

10:45-11:15

Title: Firearm Risk: An Insurance Perspective
Presenting Author: Kristen Moore, University of Michigan
Abstract: Firearm deaths and injuries are a significant public health issue in the United States. Indeed, the American Medical Association recently called firearm violence "a public health crisis" and called for a comprehensive public health response and solution. In 2013, there were 33,636 deaths from firearm injuries. Of these, 63% were suicides and 33% were homicides. Firearms were the third leading cause of injury-related death overall, just behind motor vehicle accidents, which accounted for 33,804 deaths. In fact, firearm fatalities now exceed automobile fatalities as the leading cause of injury-related death in 21 states. Moreover, in 2013, there were 84,258 nonfatal firearm injuries. Estimates of the cost of gun violence vary. The most recent evaluation of firearm related injury costs found that the annual direct and indirect costs of firearm violence is as high as $230 billion annually, equivalent to the annual revenue of Apple Computers and nearly as much money as is spent nationwide for Medicaid expenditures on an annual basis. It is clear that gun violence in America exacts a staggering toll on our society in both human and economic terms. Some argue that we have a moral obligation to address this issue, but even from a more concrete perspective, the cost of gun violence directly impacts the financial health of life, health, disability, workers’ compensation, homeowners, and liability insurers, as well as taxpayers. Actuaries are well positioned to study the financial risk related to firearms, both to quantify the risk and to inform state and public health interventions to mitigate the risk associated with firearms. There is evidence that some insurers are recognizing firearm-related risk in an ad hoc way through product offerings, pricing, and underwriting decisions. However, there is little on the topic in the actuarial and insurance literature. In this talk, I will present data to introduce actuaries to the scope, frequency, and severity of firearm-related losses as well as a quantitative comparison of firearms to risk factors that are used for underwriting life and homeowners insurance. In addition, I will describe some existing insurance products related to firearm risk as well as proposed legislation regarding gun liability insurance. Finally, I will describe some of the many open questions related to firearm risk.

11:15-11:45

Title: Predicting Ticket Sales for Air Shows
Presenting Author: Stephen Henderson, Middle Tennessee State University (with Ye Fang)
Abstract: Companies want to know the success of their event as their tickets are on sale. Prediction and good estimation of ticket sales will allow for companies to see if they need to plan for things such as advertisement for their event beforehand and arrangements of services for the event. The purpose of this study is to predict the ticket sales for air shows put on by a ticket-selling company. This study uses the ticket sales data of the 4 past events of the Great
Tennessee Air Show. Three of the events are used as a train set, while the other event is used as a test set. The study used a timing model with a three-segment Latent Class Weibull Model on the train set. The parameters of the model were found by computing each of the maximum likelihood estimators. The results show that the first segment has a small scale parameter and a small shape parameter. The second segment has a smaller scale parameter but has a larger shape parameter. The results of the model approach were used on the only event in the test set as well as on other previous air shows. This model will be used as a metric for predicting ticket sales on future air shows.

11:45-12:15

Title: What about Park Factors? – Park Factors and their Impact on Minor League Baseball

Presenting Author: Kim Page, Middle Tennessee State University & SIGMA Actuarial Consulting (with Al Rhodes)

Abstract: At ARC 2015, developmental data on using predictive analytics in Minor League Baseball was presented. Pitchers were evaluated using the Bill James game score statistic, and this data was used to build developmental linear predictive models for the performance of pitchers as they transitioned from Minor League Baseball to Major League Baseball. As a part of the question and answer session that followed, a new research question was proposed: What about park factors?

A newer discussion in the world of baseball analytics is that of park factors, also referred to as park effects or park adjustments. Often we have heard "Yankee Stadium is a home run park", but what does that really mean? There are no set regulations on the outfield dimensions of baseball parks. Due to the lack of regulations on dimensions and the differing atmospheric conditions of parks, the park factor is calculated to account for these differences. In this presentation, a brief summary of the 2015 data will be presented along with new data that accounts for the confounding park factor variable. It will be eye-opening to enthusiasts of baseball and actuarial practitioners to see the difference that one confounding variable can make in the analysis of a data set. Practical implications for accounting for confounding will also be discussed.

C3 – TOPICS IN RISK MEASUREMENT (Location: Lucerne / SCE 218; Chair: Shaun S. Wang, Nanyang Technological University)

10:45-11:15

Title: Mixture modeling of left-truncated insurance losses with the application in risk management

Presenting Author: Tatjana Miljkovic, Miami University (with Martin Blostein and Petar Jevtić)

Abstract: An adequate assessment of risk measures is critical to the pricing of individual contracts as well as to determining the solvency capital levels. We use finite mixture models in model fitting. We propose a new approach in risk management that evaluates models based on model selection criterion in concert with tail risk measures. With this, we inform a risk manager to consider tradeoffs between the best model selected using common criteria such as negative log-likelihood (NLL), Akaike Information Criterion (AIC), or Bayesian
Information Criterion (BIC) and frequently used risk measures such as value-at-risk (VaR) and conditional-tail-expectation (CTE). For illustration purposes, we develop a new grid map which considers model selection criterion and the risk measures jointly.

Motivated by recent popularity of finite mixture models in the area of loss modeling, we consider the application of the proposed approach in finite mixture modeling of the left-truncated losses. This is an extension of the work done on finite mixture modeling of insurance losses using non-Gaussian distributions. Here, we developed a new finite mixture model based on Gamma, Lognormal, and Weibull distributions. The EM algorithm is utilized to find the optimum number of the mixture components. In addition to fitting the mixture models using components from the same parametric family, we also considered the finite mixture models based on any combination of Gamma, Lognormal, and Weibull distributions. The EM algorithm is initialized using the Euclidian distance-based stochastic initialization strategy, known as emEM in the computational statistics. In addition to performing a simulation study, we also illustrated our proposed approach on two real data sets.

11:15-11:45

Title: Inference and Sensitivity Analysis of Haezendonck-Goovaerts Risk Measure for a Portfolio
Presenting Author: Xing Wang, Georgia State University (with Qing Liu, Yanxi Hou, and Liang Peng)
Abstract: When Haezendonck-Goovaerts (H-G) risk measure is applied to a portfolio with many asset returns, sensitivity analysis becomes useful in managing the portfolio, and the assumption of independent observations is no longer valid. This paper first derives an expression for computing the sensitivity of the H-G risk measure for a portfolio return, which enables us to estimate the sensitivity nonparametrically via the H-G risk measure. Further, we derive the asymptotic limits of the nonparametric estimators for the H-G risk measure and the sensitivity by assuming that returns in the portfolio follow from a strictly stationary α-mixing sequence. A simulation study is provided to examine the finite sample performance of the proposed non-parametric estimators. Finally, the method is applied to some real data sets in finance.

11:45-12:15

Title: On Tail Dependence Matrices
Presenting Author: Nariankadu D. Shyamalkumar, University of Iowa
Abstract: Modelling dependence has recently gained a lot of interest in actuarial science, especially with focus on inter-relatedness when one or more variable assumes extreme values. The latter is referred to in the literature as tail-dependence, and as for dependence there are many ways of measuring tail dependence. For a d-dimensional vector, an analogue of the correlation matrix is the tail dependence matrix, and recently Embrechts, Hofert and Wang gave a characterization for such matrices. Nevertheless, as pointed out by them, an algorithm to determine whether a given matrix equals the tail dependence matrix of a distribution has been lacking. In this talk we discuss an algorithm and present the computational complexity of this problem.
D3 – HEDGING VARIABLE ANNUITIES (Location: Lanier / SCE 216; Chair: Thorsten Moenig, Temple University)

10:45-11:15

Title: Weighted Fund Style Analysis of Variable Annuity
Presenting Author: Guangwei Fan, Maryville University (with Ethan Edens, Thomas Green, Kris Nilsson, and Yuanjin Liu)
Abstract: In this presentation, we propose weighted fund mapping as a better method to hedge market risks of variable annuities. We also provide models that can be easily implemented by insurance and reinsurance companies. Several types of weights – geometric, arithmetic, logarithmic, and trigonometric – are all considered. The optimal weight parameter, rolling window size, and benchmark indices are selected based on the rolling window cross validation method. We conclude with a real-world example which demonstrates that the algorithm significantly reduces the fund basis risks.

11:15-11:45

Title: A local approach based on risk measures for the hedging of variable annuities
Presenting Author: Frédéric Godin, Concordia University
Abstract: We present a simple local hedging approach based on risk measures for the hedging of variable annuities in the presence of equity risk and basis risk. The hedging strategy is obtained by minimizing risk with respect to next period’s cash flow injection within the hedging portfolio by the insurer. Taylor expansion based approximations are used to improve the tractability of the approach by reducing the problem’s dimensionality. The impact of basis risk on capital requirements is quantified. The hedging performance of our approach is compared to industry benchmarks such as Fund Mapping Regressions.

11:45-12:15

Title: A Tale of Two Risk Management Strategies: Risk Measure Based Reserving and Net Liability Hedging of Variable Annuity Guaranteed Benefits
Presenting Author: Bingji Yi, University of Illinois at Urbana-Champaign (with Runhuan Feng)
Abstract: Variable annuity guaranteed benefits are enhanced life insurance products that offer policyholders participation in equity investment with minimum return guarantees. There have been two well-established risk management strategies for variable annuity guaranteed benefits in the insurance industry, namely, (1) stochastic reserving based on risk measures such as Value-at-Risk (VaR) and Tail-Value-at-Risk (TVaR), etc; (2) dynamic hedging. The latter is increasingly more popular than the former, as the latter is believed to be less costly than the former. While both have been extensively used in practice, scarce academic literatures have been written on the comparison of the two approaches. The present paper provides a quantitative framework in which two risk management strategies are mathematically formulated and their objectives can be computed analytically. In addition, the paper proposes managing net liabilities as a more effective and cost-saving alternative to the common practice of dynamic hedging of gross liabilities. The finding of this paper does not support the general perception that dynamic hedging is always more affordable than stochastic reserving, although in many cases it is with the TVaR risk measure.
Title: Agricultural Insurance, Farmer Security, and Food Security  
Presenting Author: Akshi Jain, University of Nebraska-Lincoln (with Colin M. Ramsay, Victor I. Oguledo, Donna Morrison, John K. Osiri, and Janvier Degbedji)  
Abstract: According to the 1996 World Food Summit definition: food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This uncompromising definition of food security requires the physical availability of adequate supplies of food at affordable prices. Agriculture is one of the most important economic sectors in most developing countries. Yet the agricultural sector is, perhaps, the most vulnerable. Farmers everywhere are exposed to extreme events such as drought, excessive rains and floods, early rains, late rains, hurricanes, and pests and diseases, to name a few. Even when such events are absent, farmers have to face uncertain commodity prices at the time of harvest. In developed countries, however, farmers have access to government subsidized agricultural insurance that makes their income somewhat predictable. In contrast, farmers in developing countries seldom have access or can afford agricultural insurance. The main argument of this paper is that food security is predicated on farmer security, i.e., a necessary condition for food security is farmer security. Our concomitant argument is that agricultural insurance can provide security and protection against losses from many of the extreme events described above and can cover many different types of crops and/or livestock. As a result, agricultural insurance can stabilize a farmer’s income as well as make the insured farmer more credit worthy. A credit worthy farmer can borrow to invest in plants, animals, fertilizer, and machinery to make the farming enterprise more efficient and more productive thus contributing to the stable supply of food.

Title: Weather index-based crop insurance: Exploring the benefits of Bayesian and Deep Learning models in crop yield prediction  
Presenting Author: Nathaniel Newlands, Agriculture and Agri-Food Canada, Science and Technology Branch (with Yulia R. Gel, Vyacheslav Lyubchich, and Weixun Lu)  
Abstract: The agricultural sector is highly vulnerable to a wide range of weather- and climate-induced risks. Challenges with modeling the complex weather and climate dynamics bring to the forefront statistical issues linked with analyzing massive multi-resolution, multi-source data with a non-stationary space-time structure, a nonlinear relationship of weather events and crop yields, and the respective actuarial implications due to imprecise estimation of risk. Conventional parametric statistical and actuarial approaches are constrained in being able to address these problems. However, state-of-the-art machine learning (ML) and artificial intelligence (AI) methods provide fast, automatic learning of hidden nonlinear dependencies and nonstationary structures within large complex datasets and are proving to outperform other methods across a wide variety of applications, from credit card fraud detection to the next best product offer and customer segmentation. Yet, their potential in actuarial sciences and, particularly, agricultural insurance, remains largely untapped. In this project, we investigate
the utility of a novel methodology for evaluation of basis risk in agricultural index-based insurance, using a flexible framework of Deep Belief Nets (DBNs) and Copula Bayesian Networks (CBNs) ML methods. This study aims to provide a better understanding of nonlinear relationship of crop yields and weather events at disparate space-time scales, identify optimal indicators that reliably track future risks of climate and weather to crop production and better identification, quantification and propagation of uncertainty to improve crop production basic risk estimation for more reliable index-based insurance rate-making.

Lunch: 12:15pm - 1:45pm
Location: Court & House Salons
Presentations by Nancy A Braithwaite, Travelers, CAS President and Craig Reynolds, Milliman, SOA Past President
Invitation to ARC 2018, Bruce L Jones, Western University
Invitation to ICA 2018 (Video)

Plenary Session IV: 1:45pm - 3:15pm
Location: SCE Auditorium / SCE 120; Chair: Daniel Bauer
Title: Panel Discussion on Analytics in Actuarial Science
Panelists: Edward W Frees, University of Wisconsin – Madison; James Guszcza, Deloitte; Rodrigo C Martinez, Georgia State University

Coffee Break: 3:15pm - 3:45am
Location: Court & House Salons

Parallel Sessions 4: 3:45pm - 5:15pm (A4-E4)
A4 – ASSET ALLOCATION (Location: SCE Auditorium / SCE 120; Chair: Frédéric Godin, Concordia University)

3:45-4:15
Title: Short Positions and Negative Correlations
Presenting Author: Phelim Boyle, Wilfrid Laurier University (with Thierno Bocar N’Diaye)
Abstract: Empirical portfolios constructed from the dominant eigenvector of the covariance (or correlation) matrix have attractive risk return properties and typically outperform optimized mean variance strategies. These portfolios sometimes contain short positions, which arise from negative entries in the correlation matrix. The signs of the dominant eigenvector are determined by the properties of the correlation matrix. We know from the Perron Frobenius theorem that if all the correlations are positive, the dominant eigenvector has positive weights. In practice some of the correlations can be negative and in this case the weights on the first principal component may or may not contain negative values. We identify the characteristics of the correlation matrix that govern the sign patterns of the dominant eigenvector.
4:15-4:45

Title: Investment and Reinsurance Options with Dynamic Financial Analysis

Presenting Author: Betül Zehra Karagül, Hacettepe University (with Samet Gençgönül)

Abstract: Dynamic financial analysis (DFA) is a financial modeling approach and used for performance measurement, capital allocation, pricing decisions, product designing and valuation, analysis of major risks such as inflation risks, interest rate risks, and reserving risks. DFA is based on large-scale computer simulations. Financial results are projected under a variety of possible scenarios by changing internal or external conditions with DFA. For non-life insurance companies DFA is an important tool for asset management and risk management. In this study, two different simulation studies are made with 100,000 iterations in MATLAB programming language via a DFA model that includes basic components for a non-life insurance company to minimize the probability of ruin and maximize the company’s profit.

In the first study investment option is discussed. The investment option can be divided in high-risk investments, such as stocks or high-yield bonds and low-risk investments, such as government bonds or money market instruments. We try to find the best portions invested in high-risk investments and in low-risk investments.

In the second study the reinsurance option is discussed; we try to find the optimal retention limit under stop-loss, excess-of-loss and quota-share reinsurance arrangements.

4:45-5:15

Title: Evaluating Multivariate GARCH model for optimal asset allocation purposes

Presenting Author: Nor Syahilla Abdul Aziz, University of Essex (with Spyridon Vrontos and Haslifah Hashim)

Abstract: This study presents a plethora of advanced multivariate econometric models, which forecast the mean and variance-covariance of the asset returns in order to create optimal asset allocation models. Most existing studies compare the performance of a limited number of Generalised Autoregressive Conditional Heteroscedasticity (GARCH) models, and they are only based on specific optimisation models. In this study, we consider large asset modelling and optimisation strategies for solving a portfolio selection problem. Specifically, we use symmetric GARCH model and an asymmetric version of it (GJR-GARCH) such that the models are implemented with the multivariate Normal and Student distributions. Several studies have tried to examine the effectiveness of using parametric copula in estimating portfolio risk measures but their results have been inconclusive. We are interested in evaluating if copula-GARCH could be an optimal model in assessing the performance of a portfolio. This study, therefore, implemented various copula-GARCH based models using the static and dynamic (DCC) estimation of the correlation. By employing different model specifications, we are able to explore the empirical applicability of the multivariate GARCH model when estimating large conditional covariance matrices. In constructing the optimal portfolios, we evaluate the minimum variance, mean-variance, maximising sharpe ratio, mean-CVaR and minimisation of Sortino ratio. We compare the out-of-sample performance for each of the models based on the risk-adjusted performance for portfolio with and without short sales. The methodology proposed could be useful to pension managers and asset allocation purposes in pension schemes to ensure that enough assets are available to support pension liabilities.
B4 – CAS: Case Studies and Competitions (Location: Sinclair / SCE 217; Chair: Rick Gorvett, CAS)

3:45-5:15

Title: Case Studies and Case Competitions: Tools to Provide Real World Property/Casualty Examples In Your Classes

Presenting Author: Alisa Havens Walch, University of Texas at Austin; and Jelena Milovanovic, Arizona State University

Abstract: Are you looking for more ways to bring real world property and casualty insurance examples to your students? Attend this session to learn about off-the-shelf resources available through the Casualty Actuarial Society (CAS) to incorporate case studies and case competitions both inside and outside of the classroom. Teams of academics and practicing CAS actuaries have put together materials that universities can use to expose students to property and casualty concepts in unique and exciting ways! The five CAS case studies cover the following topics – Auto Safety, Catastrophe Modeling, Liabilities, Probability, and Warranties – and are geared toward classroom instruction. The case competition materials, packaged as a toolkit, present challenges around Auto Safety Features, Workers Compensation, Warranties, and Excel. This session will provide practical tips for including the case studies as part of your course curriculum, and will provide ideas for running case competitions for your students.

C4 – CYBER RISK AND NEW INSURANCE FORMATS (Location: SCE Auditorium / SCE 120; Chair: Hongjun Ha, St. Joseph's University)

3:45-4:15

Title: Actuarial Implications of Peer-To-Peer (P2P) Insurance

Presenting Author: Tatiana Margulies, Universidad de Buenos Aires (with Colin Ramsay and Victor I. Oguledo)

Abstract: Peer-to-peer (P2P) insurance is based on the application of new technologies to the approach used in beginning of modern insurance when insurance was obtained through membership in fraternal orders, guilds, and/or friendly societies. Under P2P insurance, a group of individuals typically pool their resources in order to insure similar goods or services. These individuals determine which risks associated with their goods are covered, the premiums to be charged, and the events that constitute a claim. Compared to traditional insurance, P2P insurance is informal nature and is technologically based. The main vehicle for the propagation of P2P insurance is social networking and the "peers" within the social network insure each other. It is anticipated that P2P insurance will use technology to simplify the insurance process and eliminate many of the intermediaries between the insured and the insurer, thus reducing costs associated with procurement of policies and settlement of claims. P2P insurance is generally viewed as having the potential to radically change and "disrupt" the insurance landscape if P2P insurance becomes the dominant form of risk transfer among low-risk segments of the population-at-large. Those who share this view expect that P2P insurance can be as disruptive to insurance companies as Uber is to taxis, Airbnb is to hotels, Netflix is to cinemas, and Amazon and Alibaba are to retailing. The objective of this paper is to explore the strengths, weaknesses, and limitations of P2P insurance. We are especially...
interested in determining if P2P insurance is an actuarially viable form of insurance or if it is just a passing trend that will fade away in the future.

4:15-4:45

**Title:** Optimal Level of Information Security Investment: Model and Formula  
**Presenting Author:** Shaun S. Wang, Nanyang Technological University  
**Abstract:** What is an optimal level of information security spending by a firm? Such a decision requires an economic model to facilitate cost-benefit analysis of additional information security spending and its benefit in reducing loss exposures to cyber breaches. This paper presents a proportional hazard model to quantify the effect of information security spending on the firm’s vulnerability to cyber breaches, and derives formula for optimal information security spending. This paper shows that the optimal level of information security investment can be significantly higher than the 1/e rule (37%) as indicated by the Gordon-Loeb (2002) model. The economic model has applications in guiding firms in optimizing information security spending.

D₄ – NUMERICAL ISSUES IN ACTUARIAL AND FINANCIAL MODELING (Location: Lanier / SCE 216; Chair: Jean-François Bégin, Simon Fraser University)

3:45-4:15

**Title:** Actuarial Approaches to modeling F/X and Commodity risk  
**Presenting Author:** James P. McNichols, Clemson University Risk Engineering and System Analytics Center  
**Abstract:** Motivation. Insurance companies and corporations require credible methods in order to measure and manage risk exposures that derive from market price fluctuations. Examples include foreign currency exchange, commodity prices and stock indices.  
Method. This paper will apply Geometric Brownian Motion (GBM) models to simulate future market prices. The Cox-Ingersoll-Ross approach is used to derive the integral interest rate generator.  
Results. Through stochastic simulations, with the key location and shape parameters derived from options market forward curves, the approach yields the full array of price outcomes along with their respective probabilities.  
Conclusions. The method generates the requisite distributions and their parameters to efficiently measure capital risk levels as well as fair value premiums and best estimate loss reserves. The modeled results provide credible estimators for risk based and/or economic capital valuation purposes. Armed with the se distributions of price outcomes, analysts can readily measure inherent portfolio leverage and more effectively manage these types of financial risk exposures.  
Availability. An Excel version of this stochastic GBM method is available from the CAS website, E-Forum section under filename MPiR.xlsm.

4:15-4:45

**Title:** Numerical approximations of optimal portfolios in mispriced asymmetric Levy markets
**Presenting Author:** Winston Buckley, Bentley University (with Hongwei Long and Mario Marshall)

**Abstract:** We present numerical approximations of optimal portfolios in mispriced Levy markets under asymmetric information for informed and uninformed investors having logarithmic preference. We apply our numerical scheme to Kou (2002) jump-diffusion markets by deriving analytic formulas for the first two derivatives of the underlying portfolio objective function which depend only on the Levy measure of the jump-generating process. Optimal portfolios are then simulated using the Box-Mueller algorithm, Newton’s method and incomplete Beta functions. Convergence dynamics and trajectories of sample paths of optimal portfolios for both investors are presented at different levels of information asymmetry, mispricing, investment horizon, asymmetry in the Kou density, jump intensity, volatility, mean-reversion speed, and Sharpe ratios. We also apply the proposed Newton’s algorithm to compute optimal portfolios for investors in Variance Gamma markets via instantaneous centralized moments of returns.

**4:45-5:15**

**Title:** Maximum likelihood estimation for phase-type aging models  
**Presenting Author:** Boquan Cheng, University of Western Ontario (with Bruce Jones, Xiaoming Liu, and Jiandong Ren)

**Abstract:** In this talk, we would like to explore the estimation of Phase-type aging and mortality (PTAM) model (Lin and Liu, 2007). PTAM approach makes use of a continuous time finite state Markov model to build the connection between the age-specific mortality pattern with an underlying physiological process of individuals; more specifically, each transient state of the Markov model is used to represent a physiological age of an individual. While the model has nice biological interpretation, it is difficult to effectively estimate the model parameters due to the time-consuming calculation in matrix exponentials and non-uniqueness property of the phase-type distribution. This work explores the use of uniformization method to achieve much faster yet accurate MLE estimates for the structured PTAM model. We also discuss the issue of finding globe optimization. We apply our method to fit the Swedish population cohort data. The results show that our approach has greatly improved the speed of convergence and the fitted results are satisfactory.

**E4 – NEW INSIGHTS TO RETIREMENT PLANING** (Location: Capital / SCE 203; Chair: Barbara Sanders, Simon Fraser University)

**3:45-4:15**

**Title:** Gilded Pastures  
**Presenting Author:** Julie Tang, Arizona State University (with Jelena Milovanovic and Matthew J. Hassett)

**Abstract:** This presentation explores one particular option for seniors, guardians, or children of seniors, seeking stability and security in their golden years: the continuing care retirement community. The continuing care retirement community (CCRC) industry offers a hefty promise to retiring seniors, offering comprehensive well-being in exchange for a pretty penny, thus serving only the wealthiest of seniors. With such a financial and social impact on its inhabitants, investors, and surrounding communities, most states regulate CCRC operations to
help prevent potential mismanagement and control risk to residents. In addition to providing a solution to a mounting issue facing everyone in coming decades, the CCRC industry commands our attention in its impressive growth over the last two decades. In 1991, about 800 CCRCs were tallied in the United States; as of 2009, about 1900 individual CCRCs were registered (Sanders; United States). Today, over half a million seniors, or roughly 2% of the senior population, live in these residential complexes, (“Continuing Care Retirement Community – Definition and History”). In this presentation, an overview the industry will be presented, followed by an survey of experts with respect to current regulations governing the industry and how adequately they address risks of the CCRC.

4:15-4:45

**Title**: The Annuity Puzzle and an Outline of Its Solution  
**Presenting Author**: Colin Ramsay, University of Nebraska-Lincoln (with Victor I. Oguledo) 
**Abstract**: In his seminal paper, Yaari (1965) showed that, assuming actuarially fair annuity prices, uncertain lifetimes, and no bequest motives, utility maximizing retirees should annuitize all of their wealth upon retirement. Nevertheless, the markets for individual life annuities in the U.S., the U.K., and several other developed countries have been small relative to other financial investment outlets competing for retirement savings. Researchers have found this situation puzzling hence the so-called “annuity puzzle.” There are many possible explanations for the annuity puzzle including “rational” explanations such as adverse selection, bequest motives, and incomplete markets; and “behavioral” explanations such as mental accounting, cumulative prospect theory, and mortality salience. We will review the literature on the various plausible explanations given for the existence of the annuity puzzle and we will suggest a few of the ingredients needed for possible solutions.

**Conference Dinner at the Georgia Aquarium: 6:00pm - 9:30pm**

Location: Georgia Aquarium; 225 Baker St. NW; Atlanta, GA 30313. Aquarium Admission and Seated Dinner

**Saturday, July 29**

**Breakfast**: 8:00am - 9:00am  
Location: Georgia State University; Student Center East (SCE) – Court & House Salons; 55 Gilmer St NE, Atlanta GA 30303

**Parallel Sessions 5: 9:00am - 10:30pm (A5-D5)**

**A5 – DIFFICULTIES IN INSURANCE ESTIMATION** (Location: Sinclair / SCE 217; Chair: Edward (Jed) Frees, University of Wisconsin)

9:00-9:30  
**Title**: T-Estimation for Insurance Loss Data  
**Presenting Author**: Chudamani Poudyal, University of Wisconsin-Milwaukee (with Vytaras
Brazauskas)

Abstract: Parametric statistical models for insurance claims severity are continuous, right-skewed, and frequently heavy-tailed. The data sets that such models are usually fitted to contain outliers that are difficult to identify and separate from genuine data. Moreover, due to commonly used actuarial "loss control schemes", the random variables we observe and wish to model are affected by truncation (due to deductibles), censoring (due to policy limits), scaling (due to coinsurance proportions) and other transformations. In the current practice, statistical inference for loss models is almost exclusively likelihood based, which typically results in non-robust parameter estimators, pricing models, and risk measures. In this talk, we redesign the method of trimmed moments (Brazauskas, Jones, Zitikis, 2009) to accommodate the loss variable transformations, establish its asymptotic and small-sample properties, and study its practical performance in applications. For numerical illustrations, we use the SOA 1991-92 Grouped Medical Insurance Large Claims Data Set.

9:30-10:00

Title: Model Uncertainty and Selection in Operational Risk Modeling
Presenting Author: Daoping Yu, University of Central Missouri (with Vytaras Brazauskas)
Abstract: Model uncertainty arising from different ways treating the operational loss data collection threshold is investigated. Asymptotic normality of Value-at-Risk (VaR) estimates is established using the Delta method and asymptotic normality of Maximum-Likelihood-Estimation parameter estimates. Evaluating the probability of overestimation/underestimation of the true target VaR in exponential and Lomax models, the truncated modeling approach turns out to be theoretically sound, while the shifted and naive approaches are fundamentally flawed. Using industry data of the external fraud type of event in the retail banking business line across major commercial banks in China for case study, the truncated lognormal, Lomax and Champernowne models are compared. They all pass visual inspection of Quantile-Quantile plots as well as model validation by the Kolmogorov-Smirnov test and the Anderson-Darling test. However, they produce quite different VaR estimates. In the model selection procedure, those models are compared using Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), and Information Complexity (ICOMP).

10:00-10:30

Title: Implementing Probabilistic Fuzzy Systems
Presenting Author: Arnold F. Shapiro, Penn State University
Abstract: The two major sources of uncertainty are randomness and fuzziness, and they are complementary. This talk extends this perspective to an integrated model where both types of uncertainty exist concurrently, and where each of the randomness and fuzziness components, while necessary, is not sufficient, in and of itself, to formulate the model. Many actuarial applications are of this sort.
Such integrated models have come to be known as probabilistic fuzzy systems (PFSs). Essentially, the PFS is a methodology that is built on a fuzzy inference system, which has been modified to accommodate a probabilistic fuzzy rule base. This provides a stochastic input-output mapping between the input fuzzy sets associated with the antecedent part of the rule base and the output fuzzy sets associated with the consequent part. The purpose of this talk is to discuss the implementation of PFSs. The talk begins with an
introduction to PFSs and a discussion of their architecture. Next, we explain the key features of their methodology. Given this background, we present some examples of application. The talk concludes with a comment on the findings and suggestions for further studies.

B5 – NEW APPROACHES IN INSURANCE MODELING (Location: Lucerne / SCE 218; Chair: Brian Hartman, Brigham Young University)

9:00-9:30

Title: Spatial Statistical Tools to Assess the Old-Age Mortality Risk in the US
Presenting Author: Tatjana Miljkovic, Miami University (with Patricia Carracedo and Ana Debón)
Abstract: Modeling longevity risk in the USA has gained much attention in recent years in the area of insurance risk management and securitization of mortality based products. Many studies of the US mortality rates over time are based on the macro level data and do not consider spatial dependence. Some of these studies established the relationship between mortality rates, economic variables, and climate change for the USA, focusing on state-by-year or region-by-year fixed effects models in various insurance applications. There is also an evidence in the literature that climate change impacts mortality rates. However, these studies have not considered a spatial dependence of significant clusters through a spatial panel data model.

We propose a spatial panel econometrics model for modeling the Comparative Mortality Figure (CMF) for the age group of 65 and older for the continental USA using the population structure for subgroups 65-75, 75-85, and 85+. The objective of this project is to explain the pattern of the mortality for age 65+, by gender and by state for period 1970-2013, depending on demographic and economic variables. A spatial lag model with temporal and spatial fixed effects is proposed. The methodology takes into account the neighboring relationships between the states. The performance of the model is assessed using the methods of goodness of fit, residual analysis, and the coefficient of determination.

Our analysis uses a rich data set that includes: 1) death and population records from the USA National Center for Health Statistics provided with a signed Data Use Agreement, 2) Gini coefficient obtained from the US Internal Revenue Service, 3) GDP provided by the US Bureau of Labor, 4) Population projections from the US Census, and 5) property damages from the natural disasters obtained from the Hazard & Vulnerability Research Institute, University of South Carolina. We identified spatial-temporal mortality relations between states, which in turn can be considered in modeling of longevity risk and insurance risk management practice.

9:30-10:00

Title: Regression Tree Credibility Model
Presenting Author: Chengguo Weng, University of Waterloo (with Liqun Diao)
Abstract: Credibility theory is viewed as cornerstone in actuarial science. This paper brings machine learning techniques into the area and proposes a novel credibility model and a credibility premium formula based on regression trees, which is called regression tree credibility (RTC) premium. The proposed RTC method first recursively binary partitions a collective of individual risks into exclusive sub-collectives using a new credibility regression tree algorithm based on credibility loss, and then applies the classical Bühlmann-Straub credibility
formula to predict individual net premiums within each sub-collective. The proposed method effectively predicts individual net premiums by incorporating covariate information, and it is particularly appealing to capture various non-linear covariates effects and/or interaction effects because no specific regression form needs to be pre-specified in the method. Our proposed RTC method automatically selects influential covariate variables for premium prediction with no additional ex ante variable selection procedure required. The superiority in prediction accuracy of the proposed RTC model is demonstrated by extensive simulation studies.

10:00-10:30

**Title:** General Insurance Claims Modelling with Factor Collapsing and Bayesian Model Averaging

**Presenting Author:** Sen Hu, University College Dublin (with Adrian O’Hagan and Brendan Murphy)

**Abstract:** Insurance product pricing involves analysis of past insurance claims data as well as different properties of the insured objects and the corresponding policy holders, and generalised linear models (GLMs) have become the industry’s standard approach for pricing and modelling risks of this nature. However, as typically implemented, the GLM approach utilises a single “best” model on which pricing outcomes and loss predictions are based, which can involve subjective decisions as to the inclusion or exclusion of variables that are borderline significant. An additional characteristic of most general insurance datasets is the presence of many categorical variables, each with multiple levels, which can adversely affect the parsimony of the model and the interpretability and communicability of its results. Particularly, not all levels of each factor variable may be required or statistically significant, and rather some subsets of the factor levels may be merged to give a smaller overall number of levels. This problem is more obvious when the number of levels within the factor is high. We propose a method for assessing the optimal manner to collapse a factor with many levels into one with a smaller number of levels, then using BMA to blend model parameters or predictions from all reasonably good models arising under every possible collapsed form of the factor in question. In this way, the parsimony of the models and the interpretability of their results will also be improved. This method will be particularly computationally intensive considering the number of factors being collapsed as well as the possibly large number of levels within factors. Hence a stochastic optimisation search is proposed to find the best few collapsing cases across the model space before BMA is used.

C5 – VALUATION OF UNIT-LINKED INSURANCE (Location: Lanier / SCE 216; Chair: Phelim Boyle, Wilfrid Laurier University)

9:00-9:30

**Title:** A two-decrement model for the valuation and risk measurement of a guaranteed annuity option

**Presenting Author:** Yixing Zhao, University of Western Ontario (with Rogenar S. Mamon and Huan Gao)

**Abstract:** The lapse risk arising from the termination of policies, due to a variety of causes
and reasons, has significant influence on the prices of contracts, liquidity of an insurer and the reserves necessary to meet regulatory capital. In this paper, we address the problem of pricing and determining the capital requirements for a guaranteed annuity option when lapse risk is specifically embedded in the modelling framework. In particular, we consider two decrements, which are death and lapse occurrences and their correlations to the financial risk are explicitly modelled. A series of probability measure changes is employed and the corresponding forward, survival, and risk-endowment measures are constructed. This approach superbly circumvents the rather slow "simulation-within-simulation" pricing procedure under a stochastic setting. Our implementation illustrates that our proposed approach cuts down the Monte-Carlo technique’s average computing time by 99%. Risk measures are determined using the moment-based density method and benchmarked with the Monte-Carlo simulation. Our numerical results also demonstrate that depending on the risk metric used (e.g., VaR, CVaR, various forms of distortion risk measures) and the correlation between the interest and lapse rates, the capital requirement may substantially change, which could be either an increase up to 50% or a decrease up to 50%.

9:30-10:00

Title: Analytical Valuation and Hedging of Variable Annuity Guaranteed Lifetime Withdrawal Benefits

Presenting Author: Xiaochen Jing, Georgia State University (with Runhuan Feng)

Abstract: Variable annuity is a retirement planning product that allows policyholders to invest their premiums in equity funds. In addition to the participation in equity investments, the majority of variable annuity products in today’s market over various types of investment guarantees, protecting policyholders from the downside risk of their investments. One of the most popular investment guarantees is known as the guaranteed lifetime withdrawal benefit (GLWB). In current market practice, the development of hedging portfolios for such a product relies heavily on Monte Carlo simulations, as there were no known closed-form formulas available in the existing actuarial literature. In this paper, we show that such analytical solutions can in fact be determined for the risk-neutral valuation and delta-hedging of the plain-vanilla GLWB. As we demonstrate by numerical examples, this approach drastically reduces run time as compared to Monte Carlo simulations. The paper also presents a novel technique of fitting exponential sums to a mortality density function, which is numerically more efficient and accurate than the existing methods in the literature.

10:00-10:30

Title: Experience Studies: The Linear Force Distribution

Presenting Author: John McGarry, Insight Decision Solutions

Abstract: The linear force distribution was introduced in the SOA Experience Study Calculations Educational Tool, Atkinson & McGarry, Oct 2016. It was initially developed as a generalized distribution in order to test the different study methods across a range of realistic distributions derived from industry standard tables. It was then used to derive an error estimate formula for the partial years that arise in a calendar year study for the different study methods, and showed that the linear force distribution can be used to approximate each of the standard distributions. The standard distribution assumptions for continuous decrements are the Balducci hypothesis, with rates decreasing over the year for the traditional study method,
the uniform distribution of decrements, with rates increasing over the year for the distributed method, and the constant rate or force over the year for the fractional and daily methods. These assumptions are rarely met in practise. In this paper, the linear model is derived assuming that the force increases linearly over the year, centered on the average force, and identifying the force "gradient", i.e. the increase in force divided by the average force, as the key distribution parameter, followed by a review of the error formula. Then, realistic ranges of gradients and errors are investigated by applying the formula to industry standard tables for several types of experience study.

D5 – TOPICS IN PENSIONS (Location: Capital / SCE 203; Chair: Margie Rosenberg, University of Wisconsin)

9:00-9:30

Title: Optimal investment strategies and intergenerational risk sharing for target benefit pension plans
Presenting Author: Barbara Sanders, Simon Fraser University (with Suxin Wang and Yi Lu)
Abstract: We consider a stochastic model for a target benefit pension fund in continuous time, where the plan members’ contributions are set in advance while the pension payments depend on the financial situation of the plan, with risk sharing between different generations. The pension fund is invested in both a risk-free asset and a risky asset. In particular, stochastic salary rates and the correlation between salary movements and financial market fluctuations are considered. Using the stochastic optimal control approach, we derive closed-form solutions for optimal investment strategies as well as optimal benefit payment adjustments, which minimize the combination of benefit risk (in terms of deviating from the target) and intergenerational transfers. Numerical analysis is presented to illustrate the sensitivity of the optimal strategies to parameters of the financial market and salary rates. We also consider how the optimal benefit changes with respect to different target levels.

9:30-10:00

Title: Quantifying inter-generational equity under different target benefit plan designs
Presenting Author: Lu Yi, Simon Fraser University
Abstract: We investigate the impact of various affordability tests, actions, and triggers in a target benefit plan on intergenerational equity. We use the value-based asset liability management framework to compare the risk-adjusted value of the benefits payable to each cohort under different plan designs. The return dynamics are generated from a first-order vector autoregressive (VAR) model augmented by an affine term structure model which is arbitrage free. We demonstrate our results visually through a Shiny app.

10:00-10:30

Title: Efficient Retirement Portfolios: Using Life Insurance to Meet Income and Bequest Goals in Retirement
Presenting Author: Qinglai Zeng, University of Michigan (with Fangyuan Dong, Kristen Moore, and Nick Halen)
Abstract: Life Insurance Retirement Plans (LIRPs) offer tax-deferred cash value accumulation,
tax-free withdrawals (if properly structured), and a tax-free death benefit to beneficiaries. Thus, LIRPs share many of the tax advantages of a Roth IRA, but they do not have the limitations on income and contributions. Opinions are mixed about the effectiveness of LIRPs; some financial advisers recommend them enthusiastically while others are more skeptical.

In this paper, we examine the potential of LIRPs to meet both income and bequest needs in retirement. We contrast retirement portfolios that include a LIRP with those that include only investment products with no life insurance. We consider different issue ages, face amounts, and withdrawal patterns. We simulate market scenarios and, using the Efficient Income Frontier (EIF) of Milevsky (2009) and Pfau (2013), we demonstrate that portfolios that include LIRPs yield higher legacy potential and smaller income risk than those that exclude it. Thus, we conclude that inclusion of a LIRP can improve financial outcomes in retirement.

Coffee Break: 10:30am - 11:00am
Location: Court & House Salons

Parallel Sessions 6: 11:00am - 12:30pm (A6-D6)

A6 – CAS: Best University Practices (Location: Sinclair / SCE 217; Chair: Rick Gorvett, CAS)
11:00-12:30

Title: Best Practices in Exposing Actuarial Students to Property and Casualty Insurance, Featuring the CAS University Award Winners

Presenting Author: Representatives of the 2017 award-winning schools

Abstract: The CAS has honored three universities in 2017 for doing exemplary work preparing students for a career in the property-casualty insurance industry. The 2017 honorees are Ball State University, St. John’s University, and the University of Wisconsin-Madison. These schools were selected for the award based on their efforts in the areas of curriculum, research, industry engagement, and innovation. The goal of the award program is to facilitate the promotion and sharing of ideas within academic communities, and this session will focus on how these schools, in their own words, have been incorporating property-casualty research, content, and experiences for students into their actuarial programs. Prepare to come away from this session with new ideas to add property-casualty research and topics into your program.

B6 – CAT AND SYSTEMIC RISK (Location: Lucerne / SCE 218; Chair: Chengguo Weng, University of Waterloo)
11:00-11:30

Title: An Exploration of Systemic Risk in Random Financial Networks

Presenting Author: Dalton Turner, University of California Santa Barbara

Abstract: Since the financial crisis of 2008, regulators have become increasingly concerned about systemic risk of both banks and insurance companies. We study the probability of a systemic event occurring within a financial network through different levels of connectivity between institutions and the probability of multiple institutions defaulting. We accomplish this using a mathematical model that connects the structure of financial networks to systemic
risk. In particular, we are interested in the non-negligible tail of the loss distribution and how this tail is impacted by changes in the model parameters. We begin by interpreting a stochastic model that calculates the effects of a small change in the wealth of each institution and we advance the model to include an additional element of randomness to capture the variability of lending and borrowing in a financial system.

11:30-12:00
Title: CAT bond spreads via HARA utility and nonparametric tests
Presenting Author: Van Son Lai, Laval University (with Denis-Alexandre Trottier and Anne-Sophie Charest)
Abstract: Previous empirical studies on catastrophe (CAT) bond premiums rely mostly on actuarial models, and usually compare their accuracy in terms of in-sample fit and out-of-sample predictive power. After deriving a utility-based specification for pricing CAT bonds under Hyperbolic Absolute Risk Aversion (HARA), we propose two specification tests that use nonparametric estimation techniques to test simultaneously for all possible mis-specifications. Existing pricing models with our new one are then estimated and tested with data from the primary market for CAT bonds. Our results suggest that the utility-based model we propose not only is well-suited for explaining the risk-return relationship observed in the CAT bond market but also delivers the best performance among the tested models. We also provide new empirical evidence that the aggregate utility function of CAT investors exhibits decreasing absolute risk aversion.

12:00-12:30
Title: Valuation of Home Equity Conversion Mortgages with Default Risk Models
Presenting Author: Junsen Tang, University of Waterloo
Abstract: Reverse mortgages are designed to allow elder homeowners aged 62 or over to convert the equity in their homes to regular revenues or a line of credit and retain full ownership of their property for the whole life of the loan. Unlike a traditional mortgage, reverse mortgage loans do not need to be paid off as long as the borrowers remain in their home and pay due obligations such as home insurance and property tax. Home Equity Conversion Mortgages (HECM) are non-recourse reverse mortgage loans insured by the Federal Housing Administration (FHA). Recently, HECM reverse mortgages confront a rising default risk in the wake of the financial crisis, jeopardising the financial soundness of FHA’s Mutual Mortgage Insurance Fund. The fairness of the HECM insurance premium has therefore been challenged. In this paper, we propose a pricing scheme based on default risk models for HECM reverse mortgages. The methodology is initiated to customize fair mortgage payments according to borrowers’ individual credit and default risk. The proposed method achieves a closed-form valuation with mortality risk, interest rate risk, housing price risk, and default risk. The impact on fair HECM insurance premiums of these risks is then investigated. Our work demonstrates that the proposed pricing solution and the corresponding newly-designed rating system will provide HECM lenders a better payment arrangement for the risk management and also support the effectiveness of recent policy changes in the HECM program.
C6 – OBJECTIVES IN INSURANCE (Location: Lucerne / SCE 218; Chair: Arnold F. Shapiro, Penn State University)

11:00-11:30

Title: The Marginal Cost of Risk and Capital Allocation in a Property and Casualty Insurance Company

Presenting Author: Qiheng Guo, Georgia State University (with Daniel Bauer and George Zanjani)

Abstract: We develop a multi-period profit maximization model for a property and casualty (P&C) insurance company, and use it for determining the marginal cost of risk and resulting economic capital allocations. In contrast to previous literature, our model features a loss structure that matches the characteristics of a P&C company, comprising short-tailed and long-tailed business lines. In particular, we take into account loss history and loss development years. As an example application, we implement the model using two P&C insurance business lines and two development years on the long-tailed line, and using NAIC loss data for calibration. Our numerical results demonstrate how loss history affects the marginal cost and capital allocations.

11:30-12:00

Title: Stochastic Profit Testing of Life Insurance Companies

Presenting Author: Li Shen, Emlyon Business School (with Olivier Le Courtois)

Abstract: This paper discusses the profit testing for a life insurance company that issues modern life insurance contracts, which are participating contracts, universal life contracts and variable annuities with guarantees. Modern life insurance contracts are closely linked to the performance of investments. We use Gaussian and non-Gaussian assumptions to model the performance. Using the stochastic profit testing techniques introduced in Dickson, Hardy, and Waters (2013), we examine the influence of each parameter of the financial models and of the financial models themselves on the profit testing indexes. The Variance Gamma model results in more conservative predictions: it predicts lower expected values but larger standard deviations for net present values and it also predicts larger probabilities of negative net present values.

12:00-12:30

Title: A goal programming model for non-life insurance sector’s technical analysis

Presenting Author: Betül Karagül, Hacettepe University

Abstract: In today’s business environment, management decision making in many insurance agencies and banks has become a complex task. Maximizing the profit or minimizing the risks are not always the only objects that a firm sets for. For these firms a variety of goals influence the decisions. Goal programming is an important technique that has been developed to handle decision problems involving multiple goals. In this study a goal programming model is constructed for analysis of a non-life insurance sector to find an optimal solution with different goals for technical analysis. The real data is used for the numerical example. All goals are fully achieved by using the LINGO Software. This model can be used as a guideline for insurance companies in their agency management and financial modeling. The same
model also will be helpful for life insurance sector and can be used by regulatory and rating agencies in any country.

D6 – TOPICS IN MORTALITY RISK (Location: Lanier / SCE 216; Chair: John McGarry, Insight Decision Solutions)

11:00-11:30

Title: Bivariate Stochastic Lifetime Modeling of Married Couples and Joint-life Longevity Risk
Presenting Author: Min Ji, Towson University (with Rui Zhou)
Abstract: Joint-life annuities with high last survivor benefit play an important role in the optimal annuity portfolio for a retired couple. The dependence between coupled lifetimes is crucial for valuing joint-life annuities. Existing bivariate modeling of coupled lifetimes is based on outdated data with limited observation periods and does not take into account mortality improvement. In this paper, we propose a general framework for transparent and asymmetric modeling of both dependence due to marital status and dependence due to common mortality improvement between coupled lifetimes. Dependence due to marital status is captured by a semi-Markov joint-life model. Dependence due to common mortality improvement, which represents the correlation between mortality improvement patterns of coupled lives, is incorporated by a two-population mortality improvement model. The proposed model is applied to price the longevity risk in last survivor annuities sold in the US and the UK.

11:30-12:00

Title: Optimal Dynamic Longevity Hedge with Basis Risk
Presenting Author: Jingong Zhang, University of Waterloo (with Ken Seng Tan and Chengguo Weng)
Abstract: From a pension plan sponsor’s perspective, we study dynamic hedging strategies for longevity risk using standardized securities in a discrete-time setting. The hedging securities are linked to a population which may differ from the underlying population of the pension plan, and thus basis risk arises. Drawing from the technique of dynamic programming, we develop a framework which allows us to obtain analytical optimal dynamic hedging strategies to achieve the minimum variance of hedging error. For the first time in the literature, analytical optimal solutions are obtained for such a hedging problem. The most striking advantage of the method lies in its flexibility. While q-forwards are considered in the specific implementation in the paper, our method is readily applicable to many other securities such as longevity swaps. Further, our method is implementable for a variety of longevity models including Lee-Carter, Cairns-Blake-Dowd (CBD) and their variants. Extensive numerical experiments show that our hedging method significantly outperforms the standard "delta" hedging strategy which is commonly studied in the literature.

12:00-12:30

Title: Mortality Forecasting using Temporal Regularized Matrix Factorization Method
Presenting Author: Fei Huang, Australian National University
Abstract: In this paper, Temporal Regularized Matrix Factorization (TRMF) method is used
to forecast age-sex-specific mortality rates. It extends the classical Matrix Factorization methods by adding temporal and shrinkage regularizers, see Yu et al. (2016). Different from Lee-Carter model and its variants, which estimate model parameters by doing the Singular Value Decomposition (SVD) and fitting an ARIMA model step by step, TRMF reduces data dimension and fits temporal AR model simultaneously. Experiments using empirical mortality data show that TRMF outperforms many existing mortality models in terms of out-of-sample performance. This method can also naturally handle missing data, which is important for developing countries with sparse data sets.

Closing and Lunch: 12:30pm - 1:30pm

Location: Court & House Salons
Presenter and Chair Names and Sessions

Presenter Names and Sessions

Akshi Jain – E3
Alisa Havens Walch – B4
Arnold F. Shapiro – A5
Barbara Sanders – D5
Betül Zehra Karagül – A4, C6
Bingji Yi – D3
Boquan Cheng – D4
Brian Hartman – D1
Chengguo Weng – B5
Christian Gollier – Plen I
Christophe Groendyke – B1
Chudamani Poudyal – A5
Colin Ramsay – E4
Dalton Turner – B6
Damir Filipović – Plen II
Daoping Yu – A5
David Smith – E4
Diana Skrzydło – B2
Edward (Jed) Frees – B2, Plen IV
Emiliano Valdez – A1
Emmanuel Hamel – A1
Fei Huang – D6
Frédéric Godin – D3
Guangwei Fan – D3
Hongjun Ha – D2
James Ely – C1
James Guszcza – Plen III, IV
James P. McNichols – D4
Jean-François Bégin – D1
Jelena Milovanovic – B4
Jingong Zhang – D6
John McGarry – C5
Julie Tang – E4
Julius Esunge – C2
Junsen Tang – B6
Kim Page – B3
Kristen Moore – B3
Lei Hua – C2
Li Shen – C6
Lin Fang – A2
Lu Yi – D5
Maciej Augustyniak – D1
Margie Rosenberg – A3
Mathieu Pigeon – C1
Min Ji – D6
Nan Zhu – A3
Nariankadu D. Shyamalkumar – C3
Nathaniel Newlands – E3
Nor Syahilla Abdul Aziz – A4
Phelim Boyle – A4
Qiheng Guo – C6
Qinglai Zeng – D5
Ranadeera Samanthi – C2
Ranee Thiagarajah – A1
Rick Gorvett – A6, B4
Robert Erhardt – A2
Robert Lieberthal – E2
Rodrigo C Martinez – Plen IV
Sen Hu – B5
Shannon Nicponski – A3
Shaun S. Wang – C4
Skyla Smith – E2
Stephen Henderson – B3
Steven Armstrong – B1
Tatjana Miljkovic – B5, C3
Thorsten Moenig – D2
Van Son Lai – B6
Vytautas Brazauskas – A2
Wei Wei – E1
Wenjun Jiang – E1
Winston Buckley – D4
Xiaochen Jing – C5
Xing Wang – C3
Yan Yang – E2
Yixing Zhao – C5
Zhaofeng Tang – E1
Zhihan Zhang – C1
Zhiyi Shen – D2
Session Chairs Names and Sessions

Arnold F. Shapiro – C6
Barbara Sanders – E4
Brian Hartman – B5
Chengguo Weng – B6
Colin Ramsay – E3
Daniel Bauer – B5, Plen IV
Edward (Jed) Frees – A1, A5
Emiliano Valdez – C2
Eric Ulm – Plen III
Frédéric Godin – A4
George Zanjani – E1, Plen I
Hongjun Ha – C4
Ian Duncan – E2, A3
Jean-François Bégin – D4
John McGarry – D6
Kristen Moore – B2
Liang Peng – C1, Plen II
Maciej Augustyniak – D2
Margie Rosenberg – D5
Nan Zhu – D1
Nathaniel Newlands – A2
Phelim Boyle – C5
Rick Gorvett – B4, A6
Shaun S. Wang – C3
Thorsten Moenig – D3
Vytaras Brazauskas – B3