Abstracts for the
54th Actuarial Research Conference
August 14-17, 2019 Indianapolis, IN

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Thursday, August 15, 2019

Session 1A: Plenary Session I
Time: 8:45 am - 10:00 am Location: Auditorium - Room 152

8:45 AM - 8:50 AM
Announcements and Introduction of the Dean of Science
Jeff Beckley, Planning Committee

8:50 AM - 9:00 AM
Welcome to Indianapolis and IUPUI Campus
Shiaofen Feng, Interim Dean of Science

9:00 AM - 10:00 AM Keynote Presentation

Title: US Mortality: Underlying Trends by Socioeconomic Group and Cause of Death
Presenter: Andrew Cairns, Professor of Financial Mathematics at Heriot-Watt University, Edinburg, and Director of the Actuarial Research Centre of the Institute and Faculty of Actuaries
Abstract: This presentation will focus on a new mortality dataset that subdivides the US population by education level. As might be expected, lower educated people experience higher mortality. We will discuss how large these mortality inequalities are and how they have changed over time. The data allow more detailed analysis by cause of death. For some causes of death socioeconomic inequalities are very large, for other causes inequalities are quite small. Lastly, we will demonstrate how cause of death data allows us to filter out cohort effects that are linked to specific risk factors.

Thursday, August 15, 2019

Parallel Sessions 2A-2E
Time: 10:30 am - 12:00 pm

2A: Invited Session 1: Education Updates from CAS, CIA, and SOA
Location: Auditorium - Room 152
Casualty Actuarial Society Update by Ken Williams, CAS Staff Actuary
Canadian Institute of Actuaries Update by Bruce Jones, University of Western Ontario
Society of Actuaries Update by Stuart Klugman, SOA Staff Actuary
Title: Variable selection on telematic data using SHAP and gradient boosting machine algorithm  
Presenter: Noureddine Meraihi, Université du Québec à Montréal  
Abstract: Gradient boosting machine algorithm could be a powerful method to predict insurance claim frequency. It provides a high transparency to users when it's time to choose a loss function, and we can review the marginal influence of variables through relative importance charts and partial dependence plots (PDPs). However, in the presence of substantial interaction effects, the partial response relationship can be heterogeneous. Thus, an average curve, such as the PDP, can obfuscate the complexity of the modeled relationship. Tree SHAP allows for the exact computation of SHAP values for tree ensemble methods. We used GBM with a Poisson loss function to predict the frequency of claims on a telematic database, then we used SHAP to select and segment our variables. We then measured the performance of the classical models using proper scoring rules for count data on the selected/segmented variables.

Title: Model error in the current CMS evaluation method  
Presenter: Elise Bonfiglio, University of California, Santa Barbara  
Abstract: CMS established the Medicare Shared Saving Program to reduce Medicare spending. Accountable Care Organizations (ACOs) are risk-taking provider groups. We assessed the model error in the current CMS evaluation method. We compared baseline samples to condition samples comprised of specific diseases such as diabetes, cancer, chronic heart failure and overall cardiac problems. The relative risk factors for these condition samples over-compensate for the average disease cost, implying model risk. Smaller ACOs are likely to share in gains (False Positives). We found that inefficient ACOs with high prevalence of high cost conditions are also likely to share in gains.

Title: Non-homogeneous loss models applied to unearned premium risk  
Presenter: Sébastien Jessup, Université du Québec à Montréal  
Abstract: Unearned premium, more specifically the risk associated to it, has received little attention until the last few years. Unearned losses are losses occurring after the valuation date from policies written before the valuation date. The risk linked to these losses is that the remaining premium to earn from those contracts will not be enough to cover unearned losses. Indeed, insurers usually use a uniform premium acquisition, which can potentially create discrepancy in the proportion of outstanding risk linked to unearned premium. This talk will explore an individual model based on non-homogeneous arrival rates to model losses linked to unearned premium with real data examples. In this study, we consider a non-homogeneous individual loss model for losses connected to unearned premium and evaluate the risk arising from using uniform acquisition of premium. We demonstrate the possible modeling accuracy gained by isolating losses linked to unearned premium through simulation. We discuss possible extensions considering dependence between different coverages and between accident years.
**Title:** Comparing the Riskiness of Dependent Portfolios via Nested L-Statistics  
**Presenter:** Vytaras Brazauskas, University of Wisconsin-Milwaukee  
**Abstract:** A nonparametric test based on nested L-statistics and designed to compare the riskiness of portfolios was introduced by Brazauskas, Jones, Puri, and Zitikis (2007). Its asymptotic and small-sample properties were primarily explored for independent portfolios, though independence is not a required condition for the test to work. In this paper, we investigate how performance of the test changes when insurance portfolios are dependent. To achieve that goal, we perform a simulation study where we consider three different risk measures: conditional tail expectation, proportional hazards transform, and mean. Further, three portfolios are generated from exponential, Pareto, and lognormal distributions, and their interdependence is modeled with the three-dimensional t and Gaussian copulas. It is found that the presence of strong positive dependence (comonotonicity) makes the test very liberal for all the risk measures under consideration. For types of dependence that are more common in an insurance environment, the effect of dependence is less dramatic but the results are mixed, i.e., they depend on the chosen risk measure, sample size, and even on the test's significance level. Finally, we illustrate how to incorporate such findings into sensitivity analysis of the decisions. The risks we analyze represent tornado damages in different regions of the United States from 1890 to 1999.

**Title:** Assessing the Performance of Confidence Intervals for High Quantiles of Burr XII and Inverse Burr Mixtures  
**Presenter:** Tatjana Miljkovic, Miami University  
**Abstract:** Recent research in the area of univariate mixture modeling indicated that the finite mixture models based on Burr and Inverse Burr component distributions perform well in the modeling of heavy-tail insurance data. Mixture models are able to capture the multimodality which is quite a common characteristic of insurance losses. Through an extensive simulation study, we assess the performance of three different methods in building the confidence intervals for high quantiles of the mixtures of Burr and Inverse Burr distributions. First, we prove that \(k\)-Burr and \(k\)-Inverse Burr mixtures belong to the maximum domain of attraction of the Fréchet distribution which allows us to employ the Generalized Pareto Distribution (GPD) in the estimation of high quantiles and their corresponding confidence intervals. Then, we compare these results to those obtained using order statistics and the bootstrap methods. A real data set on Danish Fire Losses is used to illustrate the application of these methods in practice.

**Title:** Small-Sample Performance of the MTM and MWM Estimators for the Parameters of Log-Location-Scale Families  
**Presenter:** Qian Zhao, Robert Morris University  
**Abstract:** Outliers are common in real data sets, it is therefore important to use estimators that are robust. It was recently shown that for estimating parameters of the log-location-scale families, two methods - Method of Trimmed Moments (MTM) and Method of Winsorized Moments (MWM) – offer reasonable trade-offs between robustness and efficiency when sample size is large. In this talk, we will present their performance in the simulation study with samples as small as \(n = 10\). For specific numerical examples, we consider the lognormal and log-logistic distributions and their \(\varepsilon\)-contaminated neighborhoods, as well as the Student’s \(t_{10}\) and a recently proposed log-Pareto-tailed-normal distribution (in a context of location-scale families). We also demonstrate how the formulas of MTM and MWM estimators can be easily adjusted to fit many other log-location-scale families and their variants. Comparisons of estimators are made on the basis of three criteria: relative efficiency with respect to the maximum likelihood estimator (MLE), breakdown points, and premium-protection plots.
Title: An application of survival models to estimate the expected future lifetime of hospice patients
Presenter: Ian Duncan, University of California Santa Barbara
Abstract: Healthcare actuaries are increasingly responsible for advising their employers and clients in areas of managed care. Managed care links traditional health actuarial financial work to areas of medical practice, to address the fundamental question: what works? These relatively new responsibilities have required an expansion of actuarial techniques into non-traditional areas, and in particular, epidemiology and biostatistics. This study is about a specific area of statistics, survival analysis, of great potential application in non-traditional managed care practice. Survival analysis is used frequently in biostatistics to evaluate the efficacy of treatments and to identify factors that contribute to patient survival. In this study, we illustrate an application of survival models to solve a real-world problem: the estimation of survival, using a time-dependent model incorporating drug dosage information, the expected future lifetime of hospice patients.

Title: Profiles of US Adults Based on Social Determinants and their Impact on Oral Health Outcomes and Health Expenditures
Presenter: Margie Rosenberg, University of Wisconsin- Madison
Abstract: The purpose of this research is to apply a novel way of grouping similar individuals involving only social determinants to examine the profiles with respect to insurance coverage, medical and dental expenditures, and oral health need. The data used are the three-year linked National Health Expenditure Study (NHIS) and the Medical Expenditure Panel Study (MEPS) for people aged 20 - 59. Unsupervised clustering is used to group similar individuals from the NHIS study. This study explores the relationship between cluster compositions to expenditures in MEPS, as well as outcomes such as oral health need/problems/expenditures in NHIS and MEPS. The results indicate the highest two expenditure clusters are mostly public insurance with no dental insurance or private insurance with a majority having dental insurance. Those in the highest expenditure cluster have fair to poor oral health with problems of the teeth/gums/mouth.

Title: Diagnostics for Regression Models with Mixed Insurance Claim Data
Presenter: Lu Yang, University of Amsterdam
Abstract: Modeling losses from insurance contracts is a central task for a variety of actuarial applications including ratemaking, loss reserving, and claim management, among others. At policyholder level, insurance claim outcomes usually follow a mixed distribution with a large point mass at zero corresponding to the cases of no claims, while some customers report positive claims. Regression models (e.g., Tweedie and frequency-severity models) have been widely employed for understanding the distribution of claim amount. Given the potential detrimental consequences of model misspecification in insurance practice, having fit a regression model, it is of prime importance to check the adequacy of the model. However, due to the zero inflation, standard diagnostic tools for regression models (e.g. deviance and Pearson residuals) are not informative for insurance claim data. To fill this gap, we propose a partial empirical residual distribution function for mixed data. Under the correctly specified model, the proposed function converges uniformly to the identity function, and significantly departs from this pattern with model misspecification, and is thus an informative diagnostic tool. We demonstrate the effectiveness of the proposed tool using health expenditure data from the US Medical Expenditure Panel Survey (MEPS). Besides in-sample validation, the proposed tool can also be employed to evaluate the policyholder level predictive distribution.
Title: Importance-Allocated Nested Simulation (IANS) for tail risk estimation  
Presenter: Jessica Dang, University of Waterloo  
Abstract: Tail risk estimation for portfolios of complex financial instruments is an important enterprise risk management task. Time consuming nested simulations are usually required for such tasks: The outer loop simulates the evolution of risk factors, or the scenarios. Inner simulations are then conducted in each scenario to estimate the corresponding portfolio losses, whose distribution entails the tail risk of interest. We propose an iterative procedure, called Importance-Allocated Nested Simulation (IANS), for tail risk estimation. In this talk, we focus on multiple-period nested simulations of tail risk measures in Variable Annuities with Guaranteed Minimum Withdrawal Benefit (GMWB). Our numerical results show that IANS can be an order of magnitude more accurate than a standard nested simulation procedure.

Title: Valuations of Guaranteed Lifetime Withdrawal Benefit with New Performance Fee Structure  
Presenter: Chongda Liu, University of Illinois at Urbana-Champaign  
Abstract: Guaranteed lifetime withdrawal benefit (GLWB) with the step-up feature (a.k.a ratchet option) is among the most popular riders for variable annuity contracts. While there has been pioneering work on the subject, most literature on the valuation problem are based on numerical solutions. This paper offers a unique perspective to formulate the valuation problem through the application of the local time. Consequently, we obtain analytical solutions to risk-neutral value of the GLWB rider with roll-up feature and the step-up feature, which lead to highly efficient algorithms for pricing and dynamic hedging of GLWB riders. Besides, this paper also introduces a new performance fee structure originally from hedge fund industry and compare it with the constant percentage fee structure. With new performance fee structure, there is no big difference for the policyholders to initiate the withdrawals during first several years, which would not be the case for constant percentage fee structure.

Title: Outcome analysis of Indexed Universal Life Insurance based on Monte Carlo Simulation  
Presenter: Songyu Yan, University of Minnesota--Twin City  
Abstract: Indexed Universal Life (IUL) Insurance was developed to harness the power of equity market returns with downside protection. However IUL is currently illustrated using a static credited rate which masks market return volatility inherent in its structure. As a result, what policyholders see as expected performance maybe far from reality in many cases. In our research, we modeled the pricing algorithms of major IUL products and applied scenario testing using Monte Carlo simulation of indices used in IUL products. The statistical variance of indices leads to vastly different results than what is currently demonstrated in many cases, and this variance may cause the failure of the policy. Our research indicates a better method for demonstrating policy performance would be based on an outcome analysis rather than the static method currently in use.
3A: **Invited Session 2:** Actuarial Professionalism
   James Miles – Consulting Actuary for the SOA
   David Brentlinger – Sr VP, Chief Actuary and Chief Risk Officer at OneAmerica
   Donna Megregian – Vice President and Actuary at RGA

3B: **Chair:** Sue Vagts
   **Location:** Room 157
   **Title:** Actuarial education: critical thinking and history of science
   **Presenter:** Christian Walter, Fondation Maison des sciences de l’homme
   **Abstract:** If the actuaries should challenge existing ways of thinking and foster their critical thinking, my proposed presentation aims to show how history of science can contribute to this objective. The objective of the paper is twofold: (1) to explain why history of science is useful for developing critical thinking of actuaries and (2) to show how history of science can enrich syllabi of actuarial science. As an illustration, the example of the “discontinuous turn” in risk modelling will be given. It is well known that financial crises are of extreme importance to understand the nature of financial risk. The fundamental role of financial crises has been emphasized by Benoît Mandelbrot in his work on the mathematical modelling of stock market dynamics with fractals, a new approach which characterized heterodox modelling in financial economics. Fractal modelling challenged a very important representation of the dominant paradigm of neoclassical finance, the continuity of stock market fluctuations. With this assumption, whose mathematical translation is the Brownian representation of market dynamics, finance refrained from thinking about crises. This finance “empty of crisis” has produced the illusion of a taming of the risks of which we understand now how it was associated with the continuity assumption. For example, it is possible to consider the 2008 crisis as a cognitive unexpected consequence of the continuity assumption in risk modelling. I propose to focus on one aspect of these debates, the “leptokurtic crisis” and its consequences in challenging the dominant paradigm of risk modelling. Leptokurtic (leptos, peaked, and kurtosis, curvature) means that the empirical distributions are more peaked than the Gaussian bell, the theoretical distribution expected in Brownian representation of the neoclassical finance, with the result that extreme events like financial crises are more likely than under a Gaussian distribution. The Mandelbrot solution to solve the leptokurtic puzzle with fractals exploded the field of risk modelling and launched violent controversies dividing the academic community into two opposite camps: pro and cons the discontinuity, which became the hinge of the debates. After presenting the main hinges of these debates, I will argue that, for solving the leptokurtic problem, Mandelbrot has introduced what I name the “discontinuous turn” in risk modelling: a discontinuity principle which clashes with the empirical grounding of neoclassical finance.
Title: Open Actuarial Textbooks
Presenter: Jed Frees, University of Wisconsin-Madison
Abstract: In this talk, I outline a process for creating online actuarial texts. These texts will cut across traditional boundaries by being available freely, have interactive capabilities, and be translatable for use internationally. Analogous to the case of open-source statistical software (e.g., "R"), the goal is to develop an actuarial community that will work collaboratively in developing actuarial textbooks of the future. Our pilot project, a book entitled "Loss Data Analytics", is well underway. The current draft is crafted by 19 authors from 7 countries, over 40 enthusiasts have contributed reviews. The book, and underpinning source code, is freely available at Github at https://openacttexts.github.io/; the online (and interactive) version is available at https://openacttexts.github.io/Loss-Data-Analytics/index.html.

Title: Pedagogic excellence in terms of executive function and goal-setting
Presenter: Russell Hendel, Towson University
Abstract: The (SOA) formulates pedagogic excellence in terms of the Marzano Taxonomy. For example, the "analysis level" consisting of generalization, specification, classification, contrast, matching, and error detection, is superior to the "retrieval level" consisting of rote memorization. In this presentation, we first show that pedagogic excellence can be equivalently, but more simply, formulated in terms of executive function and goal-setting. Executive function refers to problems requiring simultaneous use of multiple mental "spaces" for their solution: either multiple modalities - such as, formal, verbal, computational, and graphical - or several similar subproblems. Goal-setting refers to the skillful breakup of a complex problem into a sequence of subgoals each of which is clearly formulated, challenging, but achievable timely. The literature is cited to illustrate these concepts and their utility and importance in improving student performance. Using these concepts, we focus on the teaching of distributions for the SOA Exam P. Distributions are an important topic: a third of the SOA Sample Probability problems are distribution questions. Distributions also pose unique pedagogic challenges since they are naturally representable as a "database" that is a rectangular array whose rows are particular distributions and whose columns are attributes common to all or most distributions. Examples of categories of distribution-database attributes include: i) statistics, such as moments and percentiles; ii) functions, such as density, survival, and cumulative distribution; iii) linear combinations of random variables, for example, for the normal, and Poisson but also for the exponential, iv) assistive functions, such as, the various moment generating functions; v) distribution relationships, such as binomial-normal-Poisson, geometric-negative binomial, but also Poisson-exponential; vi) computational facilitation, such as, the quick evaluation of integrals using known integrals for total-probability or means. The presentation shows how skillful construction of the distribution database facilitates quick and efficient solutions to otherwise difficult problems.
Title: On the dual Lévy risk model with a dividend threshold under Parisian ruin  
Presenter: Zhong Li, University of International Business & Economics  
Abstract: We consider the threshold dividend strategy where a company's surplus process is described by the dual Lévy risk model. Namely, the company chooses to pay dividends at a constant rate only when the surplus is above some threshold. Classically, such a company is referred to be ruined immediately when the surplus level becomes negative. More recently, researchers investigate the Parisian ruin problem where the company is allowed to operate under negative surplus for a predetermined period known as the Parisian delay. By introducing the fluctuation identities of spectrally negative Lévy processes, we obtain explicit expression of the expected discounted dividends until Parisian ruin in terms of the relevant scale functions and some probabilities that need to be evaluated for each specific Lévy process. Moreover, we provide an optimal threshold level under such a threshold dividend strategy. Finally, applications and numerical examples are given to illustrate the theoretical results and examine how the expected discounted aggregate dividends and the optimal threshold change in response to different Parisian delays.

Title: On central branch/reinsurance risk networks: exact results and Heuristics  
Presenter: Sooie-Hoe Loke, Central Washington University  
Abstract: Modeling the interactions between a reinsurer and several insurers, or between a central management branch (CB) and several subsidiary business branches, or between a coalition and its members, are fascinating problems, which suggest many interesting questions. Beyond two dimensions, one cannot expect exact answers. However, reductions to one dimension or heuristic simplifications allow occasionally getting explicit approximations, which may be useful for getting qualitative insights. Here, we consider a ruin problem for a two-dimensional CB network, under a new mathematical model which combines a bail-out model with an older model involving proportional reinsurance. The motivation is to investigate how a CB should combine distress bail-outs with continuous risk-sharing of the type used in reinsurance, and in particular with the simplest proportional reinsurance, which leads sometimes to exact solutions. This is joint work with Florin Avram.

Title: A note on stochastic dominance and bounds on probability of ruin  
Presenter: Mostafa Mashayekhi, University of Nebraska - Lincoln  
Abstract: Let $S_1(t)$ and $S_2(t)$ be two compound Poisson aggregate claim processes with equal claim count parameters and generic claim amount random variables $X$ and $Y$ respectively. We show that when losing $X$ dominates losing $Y$ by $n$th degree stochastic dominance for some positive integer $n$, and the premiums are collected at the same constant rate, the standard upper bound on the probability of ruin in a collective continuous time risk model with $S_1(t)$ is lower than the standard upper bound on the probability of ruin in a model with $S_2(t)$. The inequality is also obtained for the case when $Y$ dominates $X$ by $\varepsilon$-almost first-degree stochastic dominance with a sufficiently small $\varepsilon$. Similar results are also obtained for discrete time models.
Title: The impact of unmet oral health needs on hospital emergency department utilization  
Presenter: Lisa Gao, University of Wisconsin-Madison  
Abstract: There has been growing recognition of the integral role of oral health in overall health, as well as the adverse consequences of poor oral health on quality of life. Common oral health issues are pervasive yet preventable, and lack of access to dental care can lead to undiagnosed or untreated conditions that evolve into more severe and costly problems. The purpose of this study is to examine the effect of unmet oral health needs on hospital emergency department (ED) visits in the United States. We extend prior research by estimating the causal effect of delayed or forgone preventive and necessary dental care on ED utilization using a longitudinal, nationally representative data set created by linking the National Health Interview Survey (NHIS) to the Medical Expenditure Panel Survey (MEPS). To address the complex relationships between the social determinants of health and health care service utilization, we incorporate the temporal structure of the data into a two-part model with a predictive component and an inferential component. In the first stage, we predict propensity scores for unmet oral health needs using generalized boosted models (GBM), a nonparametric ensemble tree method that accommodates the nonlinearities and multi-way interactions present in the interrelated social determinants. In the second stage, we combine inverse probability weighting from the first part of the model with the complex survey design in a regression that produces nationally representative estimates. We find that the GBM effectively balances the underlying social determinants and results in a positive causal relationship between unmet oral health needs and ED utilization. Our results have implications for patients, actuaries, policymakers, and the general public as the use of ED services for preventable medical conditions is a growing public health concern in the United States.

Title: Using Asymmetric Cost Matrices to Optimize Wellness Intervention  
Presenter: Zoe Gibbs, Brigham Young University  
Abstract: The majority of healthcare expenditures are incurred by a small portion of the population. Care management or intervention programs may help reduce medical costs, especially those of extremely high-cost members. For these programs to be effective, however, the insurer must identify and select potential high-cost members to be assigned to an intervention before they incur those costs. Because high medical costs are often connected to an accident or traumatic event that cannot be anticipated, it can be difficult to predict who will be high-cost in the future. In this paper, we explore the use of machine learning in predicting high-cost members. Specifically, we use the extreme gradient boosting algorithm to develop risk scores for members based on demographic, medical, and financial histories. To select members for intervention, we develop asymmetric cost matrices that account for potentially unequal savings or losses for assigning interventions to members. We show how these matrices can be reduced to a function of the expected savings per dollar of intervention, which is easily used to optimize the risk score threshold at which members are assigned an intervention. These techniques, which can be tailored to the specific needs of an insurer, may help insurers select the optimal members for intervention programs, reduce overall costs, and improve member health outcomes.
Title: Alternative Predictive Modeling for Medicare Patient Costs  
Presenter: Samuel O'Neill, University of California, Santa Barbara  
Abstract: As health care expenditures increase, patient cost mitigation becomes more essential. Cost mitigation programs such as Accountable Care Organizations rely on the ability to accurately predict patient risk, which is difficult because of highly-skewed data. We examine Medicare public use data that includes demographics, costs, and health conditions. We first consider the Centers for Medicare and Medicaid Services' currently-used linear model and then implement more complex generalized linear and additive models to predict patient costs in a future year based on current year data. We find that the latter models more accurately predict the entire distribution of Medicare patient costs and, thus, can improve the existing cost mitigation frameworks. This research was partially supported by Santa Barbara Actuaries Inc. and the Society of Actuaries Centers of Actuarial Excellence 2015 Education Grant Project-Based Research Training in Actuarial Science.

3E: Chair: Peter Douglas  
Location: Room 162  
Title: Using auto insurance claim adjuster notes to improve the structured model to predict the severity of bodily injury claims  
Presenter: Isaac Golberg, University of California, Santa Barbara  
Abstract: The purpose of this study was to organize auto insurance claim adjuster notes into useful data for actuarial analyses and find useful variables that will improve the structured model to predict the severity of bodily injury claims. After preprocessing adjuster notes, Latent Dirichlet Allocation (LDA) and Non-Negative Matrix Factorization (NMF) were used to find the structure and topics of the given notes. Then, these notes were used to predict the severity of such claims using a variety of different predictive models. After comparing each model, LDA demonstrated better topics while Random Forest and Naïve Bayes had better model performance.

Title: I Know How You Drive! - Profiling via phone telematics  
Presenter: Sak Lee, University of Iowa  
Abstract: Increased accessibility to telematics data is changing the way that auto insurance is priced. Usage-based insurance (UBI), started in the mid-to-late 2000’s, differs from traditional auto insurance in that it takes into account driving habits for pricing. These include the frequency of hard braking and sharp accelerations, as well as the times of day one drives. Prior actuarial research on the use of telematics in auto insurance has focused solely on GPS data. Data acquired by GPS sensors suffers from limited accuracy, slow update rate (1-10Hz) and more importantly is error prone in urban areas due to signal interference. Our focus is on the use of complementary data from Inertial Measurement Units (IMU) within phones that are relevant to vehicle kinematics. Such vehicle borne sensors do not suffer from the issues delineated above for GPS receivers. Interestingly, such data require careful modeling as they can be easily biased by road conditions and driver behavior. In this talk we discuss these issues and present models for discerning driver behavior that use both GPS and IMUs based data.

Title: Professionalism in Actuarial Science: Teaching Our Students to Be Actuaries, Not Just Test Takers – Part II  
Presenter: Alisa Walch, University of Texas – Austin  
Abstract: This is a follow-up/continuation of my presentation on professionalism at last year’s Actuarial Research Conference. While passing actuarial exams is essential for our students to land a full-time job, there is a lot more to being an actuary. It is important that we prepare them to be successful in their actuarial career and not just in the exam room. These are some ideas of how to incorporate professionalism into existing actuarial courses.
Parallel Sessions 4A-4E
Time: 3:30 pm - 5:00 pm
Location: Auditorium - Room 152

4A: Invited Session 3: Actuarial Society Sponsored Research
Dale Hall, FSA, MAAA – Managing Director of Research at Society of Actuaries
Brian Fannin, ACAS, CSPA – Research Actuary at Casualty Actuarial Society
Shlomit Jacobson, PhD, MBA – Manager, Research at Canadian Institute of Actuaries
Steve Jackson, PhD – Assistant Director for Research at American Academy of Actuaries
Sarah Mathieson – Head of Research and Knowledge at Institute and Faculty of Actuaries

4B: Chair: Zhixin Wu
Location: Room 157
Title: What I Learned about Pedagogy from Magic School
Presenter: Diana Skrzydlo, University of Waterloo
Abstract: Immediately after ARC 2018, I attended a role-playing game of a magic school in a castle in England. While the primary purpose was to have fun, I also came away with lots of insights from the way the “professors” structured and designed their lessons. It turned out that nine people from all over the world, without collaborating beforehand and mostly without formal teaching experience, had many of the same ideas about what makes an effective class. In this session, I will tease out some of these similarities and glean what strategies and attributes we can take into our own (albeit slightly less magical) actuarial classrooms. Attendees will see specific examples of techniques they can use in a wide variety of actuarial and statistical courses, and get inspired to bring some magic to their teaching.

Title: Case Studies and Case Competitions: Tools to Provide Real World Property/Casualty Examples In Your Classes
Presenter: Ken Williams, Casualty Actuarial Society and Alisa Walsh, University of Texas-Austin
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 Data Visualization. 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.
Title: What I Tried That Was New
Presenter: Mark Maxwell, University of Texas – Austin
Abstract: While in colleague’s office last semester, she asked “May I share what I am excited to try that is new this semester?” What a great question. I immediately thought, yes please, I might be able to steal a good idea. Then I began to wonder what I was going to try that is new. In this presentation I will discuss two new-for-me techniques:
1) All student grades were based upon z-scores instead of traditional scores of 0-100.
2) Calculus-based probability students had some freedom selecting the weights/percentages for all their work: in-class collected quizzes/team questions/homework, three exams, an individual project with the TA, and the comprehensive final exam.
Summary results will be shared. I plan to continue versions of these ideas in future semesters and will share a couple useful outcomes as well as several opportunities for improvement (formerly referred to as failures). Participant pre-talk homework: Attendees will be asked to describe something that they are excited to try that is new in their teaching or profession or life.

4C: Chair: Tatjana Miljkovic
Location: Room 159
Title: Regression Model for Data Breach Counts
Presenter: Yangho Choi, Hanyang University
Abstract: Leak of private information has significantly increased in recent years and insurers face rising necessity for managing its risk. Quantitative assessment of the data breach risk has not been extensively studied yet, and its pandemic nature due to high autocorrelation hinders the approach. In this study, we investigate what characteristics the count of data breach accidents has and we show that the most appropriate exposure unit for data breach accidents is the number of individual establishments. It is also revealed via a regression model that that the expected frequency of data breach accidents depends on the establishment’s business sector and the capital market performance level such as the S&P500 index. Then, we show an evidence that there is no spatial autocorrelation but do exists medium temporal autocorrelation even in the residuals of the model, and adopting such an evidence as a residual covariance structure, we finally construct our Poisson regression model for the count data with explanatory variables of the weight of business sectors, the S&P500 index with residual temporal autocorrelation.

Title: A Convex Method for Minimizing Ruin Probability
Presenter: Huan Zhang, University of St. Thomas
Abstract: We aim at finding the optimal investment strategy that minimizes the insurer's one-year ruin probability (RP) subject to a constrain on the expected portfolio return. We propose an asymptotic estimate of the RP, which is infinitely differentiable and convex. Theoretically, we show that the optimal investment strategy that minimizes the asymptotic estimator of the RP and the optimal investment strategy that minimizes the RP are close. Empirically, the stability and out-of-sample performance of our optimal solutions and computational efficiency of the novel asymptotic RP risk management method are tested.
Title: T- and W- Estimation for Insurance Loss Severity Models  
Presenter: Chudamani Poudyal, Tennessee Technological University  
Abstract: By nature insurance loss severity are continuous, right-skewed, and frequently heavy-tailed. Further, due to different loss control mechanism, such data are truncated on the left (due to deductibles), fixed right censored (due to policy limits), and scaling (due to coinsurance). The primary objective of this presentation is to redesign the methods of trimmed moments and winsorized moments for insurance loss data. In this presentation, we demonstrate that, when properly redesigned, T - and W -estimators can be a robust and computationally efficient alternative to the likelihood-based (MLE) inference for claim severity models that are affected by data truncation, censoring and scaling. The asymptotic properties of T - and W -estimators are derived. The practical performance of the estimators is illustrated by fitting a single-parameter Pareto model to the well-known Norwegian fire claims data using MLE, T - and W -estimators, and applying the fitted models to price an insurance contract.

4D: Chair: Rasitha Jayasekare  
Location: Room 160  
Title: Asymptotic Approximation of Aggregate Health Claims for a Large Population  
Presenter: Xuemiao Hao, University of Manitoba  
Abstract: Health insurance has become an essential component in our society. The traditional principle of quantitative risk management in health insurance industry relies on the assumption that individual's health is independent to each other. We study in this research the effects of systemic and systematic risks on population health for a large population. In particular, we derive the asymptotic approximation of the aggregate health claims for the population with the existence of both systemic and systematic risk factors. The idea is motivated by a newly proposed credit risk model for large portfolio.

Title: Treatment Level and Store Level Analyses of Healthcare Data  
Presenter: Gee Y. Lee, Michigan State University  
Abstract: This talk will discuss general approaches to analyze and model healthcare data at the treatment level and at the store level using GLMs and GAMs. The talk will consist of two parts: (1) a general analysis method for store level product sales of an organization, and (2) a treatment level analysis method of healthcare expenditures. In the first part, our goal is to develop a modeling framework to help understand the factors influencing the sales volume of stores maintained by a healthcare organization. In the second part of the paper, we demonstrate a treatment level approach to modeling healthcare expenditures. In this part, we aim to improve the operational level management of a healthcare provider by predicting the total cost of medical services. From this perspective, treatment level analyses of medical expenditures may help provide a micro-level approach to predicting the total amount of expenditures for a healthcare provider. We present a model for analyzing a specific type of medical data, which may arise commonly in a healthcare provider's standardized database. We do this by using an extension of the frequency-severity approach to modeling insurance expenditures from the actuarial science literature.
Title: Bayesian Nonparametric Regression
Presenter: Robert Richardson, Brigham Young University
Abstract: Standard regression models are often insufficient to describe the complex relationships that exist in healthcare claims. A Bayesian nonparametric regression approach is presented as a flexible regression model that relaxes the assumption of Gaussianity. The details for implementation are presented. Bayesian nonparametric regression is applied to a dataset of claims by episode treatment group (ETG) with a specific focus on prediction of new observations. It is shown that the predictive accuracy improves when compared both to standard linear model assumptions and the more flexible Generalized Beta regression. Of the 347 different ETGs, the nonparametric regression outperformed both the standard linear and generalized beta regression on all but 11. By studying Conjunctivitis and Lung Transplants specifically, it is shown that this approach can handle complex characteristics of the regression error distribution such as skewness, thick tails, outliers, and bimodality.

4E: Chair: Vytaras Brazauskas
Location: Room 162
Title: Generating Synthetic Insurance Datasets using Generative Adversarial Networks
Presenter: Brian Hartman, Brigham Young University
Abstract: Due to confidentiality issues, it can be difficult to access or share interesting datasets used for methodological development in actuarial science. We show how a generative adversarial network (GAN) can be designed for building a synthetic insurance dataset from a confidential original dataset. Although the synthetic data no longer contains sensitive information, it still has the same structure as the original dataset and retains the relationships between the variables. In order to adequately model the specific characteristics of insurance data, we adapt the architecture of the GAN for multi-categorical data. The approach is illustrated in a Property/Casualty ratemaking application using the French Motor Third Party Liability dataset available in the R package CASdatasets.

Title: Dynamic structural percolation model of loss distribution for cyber risk or contagious failure of smart contracts on random tree-stars graphs
Presenter: Petar Jevtic, Arizona State University
Abstract: Smart Contract risk can be seen as a financial risk of loss due to cyber-attacks or contagious failure of smart contracts. In this paper, as a primary contribution to the existing body of actuarial literature, we propose a structural model of aggregate loss distribution for smart contract risk under the assumption of a tree-stars graph topology representing smart contract network and its users. Up to our knowledge, there exist no theoretical models of an aggregate loss distribution for smart contracts in this setting. To achieve our goal, we contextualize the problem in the probabilistic graph-theoretical framework using percolation models. We assume that the smart contract network topology is represented by a tree random graph of finite or infinite size, where each node is a center of a star graph whose leaves represent users of a given smart contract. We allow for heterogeneous cost topology superimposed on this smart contract and user topology and provide instructive numerical examples.
Title: Natural Language Processing in Insurance Industry  
Presenter: MengChu Tsai, Maryville University of St. Louis  
Abstract: Insurance companies collect enormous amounts of text every day. The text data have significant potentials for economic value. Natural Language Process (NLP) techniques can be used to discover insights in the large unstructured text data so insurers can benefit from the information available in documents. Word Embeddings techniques, used to help machine understand our natural languages, are pervasive on a wide spectrum of NLP applications. These word representations can improve downstream tasks such as Sentiment Analysis, Topic Modeling and Text Generator. This project is to show how pre-trained Word Embedding models improve the effectiveness and performance of NLP applications in insurance industry.

Friday, August 16, 2019  
Session 5A: Plenary Session 2  
Time: 8:45 am - 10:00 am  
Location: Auditorium - Room 152

8:45 AM - 8:50 AM  
Announcements  
Carl Cowen, Planning Committee

8:50 AM - 9:00 AM  
Invitation to 55th ARC at University of Nebraska, Sue Vagts

9:00 AM – 9:05 AM  
Simon Conference for Young Researchers in Risk Management and Insurance  
Thorsten Moenig

9:05 AM - 10:00 AM Keynote Presentation  
Title: Long Term Portfolio Protection  
Presenter: Jan Vecer, Professor, Charles University

Abstract: This talk discusses novel approaches how to protect potential portfolio losses on long term horizons in the scale of several decades, which is a typical investment horizon of pension fund investments. The prices of existing financial products, such as put or call options, are increasing as a function of maturity, and their prices quickly take a significant percentage of the underlying assets. In this respect, such financial products become prohibitively expensive on horizons longer than a couple of years at most. In addition, these contracts tend to insure only static rather than actively traded portfolios which are more appropriate for pension funds. Our talk presents two novel ideas on long term portfolio protection. The first one is a protection of actively traded portfolio where the client is free to move her wealth within different asset classes, but the portfolio would be protected against any trading losses. This is a generalization of a previously studied contract known as a passport option, but in our setup, the price of this contract is small enough to be attractive on 20-30 year investment horizons and thus the respective hedging strategy can be potentially embedded in pension fund products. The second presented idea shows how a small change of a put/call payoff would make the option attractive in long term horizons. The standard options are basically contracts on simple returns, but an almost identical contract on log returns has many desirable properties discussed in detail in the talk.
Parallel Sessions 6A-6E  
**Time:** 10:30 am - 12:00 pm  
**Location:** Auditorium - Room 152

### 6A: Invited Session 4: Industry – Academic Cooperation

- Runhuan Feng, PhD, FSA, CERA – Professor at University of Illinois in Champaign
- Sara Teppema, FSA, MAAA – DVP and Actuary at Health Care Service Corporation
- Andrew Cairns, PhD, FIA - Heriot-Watt University and Actuarial Research Centre of the Institute and Faculty of Actuaries
- Edward Furman, PhD – Professor at York University
- Thomas Totten, PhD, FSA – Nyhart and University of Notre Dame

### 6B: Chair: Chris Groendyke
**Location:** Room 157

**Title:** The Pearson System of Frequency Curves: An Analysis of the Distribution of the Returns on Stocks  
**Presenter:** Natalia A. Humphreys, University of Texas at Dallas  
**Abstract:** The behavior of the distribution of the stock returns is of fundamental importance in financial economics. It is well established that lognormal distribution is the basis for analyzing stock and option prices. It rests on the assumption that the underlying asset returns are normally distributed. This presentation investigates returns of a major auto stock in the context of the Pearson system of frequency curves. Using the time series data of daily returns, we find that the entire series, as well as the subintervals of consecutive trading days tested, can be described by the leptokurtic Pearson Type IV distribution. When an infinite time horizon is assumed, our results suggest that the distribution tends toward the Pearson Type VII distribution, the symmetric case of the Pearson Type IV distribution. We discuss the implications of our findings for financial modeling.

**Title:** Negative Marginal Option Values: The Interaction of Frictions and Option Exercise in Variable Annuities  
**Presenter:** Thorsten Moenig, Temple University  
**Abstract:** Market frictions can affect option exercise, which in turn affects the value of a marginal option to the writer—and may even yield negative marginal option values. We demonstrate the relevance of this mechanism in the context of variable annuities with popular withdrawal guarantees, both theoretically and empirically. More precisely, we show that in the presence of income and capital gains taxation for the policyholder, adding on a common death benefit option—allowing to continue the withdrawal guarantee in case of death—changes the policyholder’s optimal withdrawal behavior. As a consequence, the total value of the contract from the perspective of the insurer may decrease, i.e. the marginal option value is negative. This may explain the common practice of including death benefit options without additional charges in these products.
Title: Modeling and Reserving for GMMB using Representative (Pivot) Scenarios in R for Variable Annuity
Presenter: Yvonne C. Chueh, Central Washington University
Abstract: A variable annuity (or termed segregated fund in Canada), which is essentially a mutual fund with insurance guarantee, is a valuable estate planning tool to protect from creditors or probate. This financial product has gained increasing use reflected on the sale and backing assets. In the US market, variable annuities has accumulated 2 trillion US dollars of asset value with recent sale increase facing volatile stock market as well as downside protection seekers. In practice, calculations for dynamic hedging models for variable annuities (for the purpose of reserving for the fund guarantees) are computationally intensive and literally become time prohibitive since there are nested stochastic scenario calculations that often take several days of computing time running a cluster of super computers. In this presentation, we present a representative scenario approach (i.e. adaptation of Chueh’s (2002) algorithm and Clara’s clustering algorithm) to reduce computing time from 100% to 33% for a simple dynamic risk hedging models for a guaranteed minimum maturity benefit (GMMB). A comparison on GMMB reserves is made between the adaptation of Chueh’s (2002) algorithm and Clara’s clustering algorithm.

6C: Chair: Gary Dean
Location: Room 159
Title: Premium optimization with policyholder loyalty
Presenter: Himchan Jeong, University of Connecticut
Abstract: For automobile insurance, the possible relationship between policyholder lapse and the characteristics of policyholder has been studied in Jeong et al. (2018). According to their work using association rule learning, it was shown that if a policyholder has higher size of claim than average tends to switch so as to enjoy possible discount on the premium of subsequent year. However, since it is hard to use association rule learning for prediction purpose, there is need of constructing a classification model which can predict the policyholder lapse provided the policyholder characteristics are given. For the construction of classification model, we may consider both GLM-based models such as logit model or probit model, and nonparametric methods such as tree-based models or neural network.

Title: On Algorithms for Testing Membership of Tail-Dependence Matrices
Presenter: Siyang Tao, University of Iowa
Abstract: The tail dependence coefficient is a bivariate measure of dependence in the tail, and the Tail Dependence Matrix (TDM) is a bi-dimensional array of these coefficients corresponding to a random vector. The TDM serves as a measure of multivariate tail dependence. The set of all TDMs corresponding to d-dimensional random vectors is a convex polytope with a complex description, and that has a known representation only for d≤6. Testing the membership of any matrix in the set of TDMs has gained a lot of attention recently. It is known that this problem is equivalent to solving a linear programming problem, albeit with its size having an exponential dependence on d. This results in restricting straightforward implementations to matrices of dimensions up to about 20 on current computing platforms. A recent approach sequentially introduces vertices, and hence avoids facing the full brunt of the curse of dimensionality head on; and interestingly doubles the upper limit on the dimension. The choice of the incoming vertex requires solving a Binary Quadratic Problem (BQP) which by itself is a NP-hard problem. While a naive continuous relaxation results in another NP hard problem, in this talk we will discuss a particular continuous relaxation that results in a polynomial time problem. And importantly, one that significantly extends the limit on the dimension.
Title: On optimal hybrid dividend strategies for diffusion processes
Presenter: Hayden Lau, University of New South Wales
Abstract: Dividend maximization is one classical stability criterion in actuarial risk theory, whose objective is to assess the riskiness of a risky business. Motivated by the fact that dividends are paid periodically in real life, periodic dividend strategies were introduced (Albrecher, Cheung, and Thonhauser, 2011). In this paper, we discuss the case when dividends can also be paid outside the periodic times but have to be penalised by an affine function (transaction costs). We proved that a hybrid \((ap, ac, b)\) strategy is optimal, when the business is profitable. On the other hand, a liquidation \((b_1, b_2)\) strategy is optimal when the business is non-profitable.

6D: Chair: Louis Adam
Location: Room 160
Title: DSA Algorithms for Mortality Forecasting
Presenter: Yechao Meng, University of Waterloo
Abstract: It has been well recognized that borrowing information from populations with similar structural mortality patterns and trajectories is helpful to the mortality forecasting of a target population. One crucial step to gain an enhanced forecasting accuracy lies in the selection of a proper group of populations. To the best of our knowledge, however, no structured method exists to select the group flexibly and effectively. In our paper, we consider the mortality forecasting for a general target population from the Human Mortality Database (HMD). We develop an effective procedure to select a group of populations from the HMD to enhance the mortality prediction of the target population. Instead of grouping populations according to geographical or socioeconomic information, we obtain the group from the mortality data themselves via some machine learning methods. We design a DSA (deletion-substitution-addition) algorithm to choose the “best” grouping, which has both reliable explanatory power for current mortality patterns and superior performance in terms of forecasting accuracy for each target country.

Title: A Semiparametric Method for Assessing the Quality of Life Expectancy Evaluations
Presenter: Hong Beng Lim, University of Iowa
Abstract: In the life settlements industry, Life Expectancy (LE) providers are firms which conduct health underwriting towards determining the future mortality rates for an insured. Multiple stakeholders are interested in assessing the quality of their evaluations. There has been some recent interest in better alternatives to the traditional metric, the so-called A/E ratio: the ratio of actual to expected number of deaths. One such proposal is the Implied Difference in Life Expectancies (IDLE) metric of Bauer et al. (2018), which requires a baseline mortality table to infer the degree of discrepancy in the LE evaluations from the truth. An underlying assumption of this method is that the true death rates are a constant multiple of the rates in the baseline table. Even in the case when the LE provider’s evaluations equal the true future life expectation, material biases can arise when this assumption does not hold. Towards developing a more robust metric, we propose the use of a Cox proportional hazards model which utilizes information contained in the LE evaluations as covariates. In this talk, we show that this model can capture the underlying mortality reasonably well, provided the life expectancy evaluations are sufficiently informative. Also, we present evidence that the deviation of the LE provider’s evaluations from the LE estimates derived using this model is a reasonable metric.
Title: A Flexible Phase-Type Aging Model  
Presenter: Boquan Cheng, Western University  
Abstract: A phase-type aging model (PTAM) is a type of hidden Markov model, which describes the progressive and irreversible aging process. Our proposed PTAM has a constant transition rate for the aging process, and a functional form for the relationship between aging and death with a shape parameter to capture the biologically deteriorating effect due to aging. For different values of the shape parameter, this functional form achieves different patterns of the dying rate, e.g. linearly increasing/decreasing, or exponentially increasing/decreasing. We calibrate the PTAM by minimizing the Kullback-Leibler divergence between the PTAM and assess how well the PTAM approximates these lifetime distributions. We have observed an interesting phenomenon that the calibrated PTAM requires more states in the case of decreasing hazard rate.

6E: Chair: Wei Wei  
Location: Room 162  
Title: Gompertz Law Revisited: Forecasting Mortality in a Multi-factor Framework  
Presenter: Hong Li, University of Manitoba  
Abstract: This paper provides a flexible multi-factor framework to address some ongoing challenging issues in mortality modeling, particularly focusing on the mortality curvature and old age mortality plateau. In particular, we extend the Gompertz law (Gompertz 1825) to include factors capturing the curvature of mortality increase over age, as well as the decelerating mortality increase for the very old ages. The proposed framework permits a convenient estimation and prediction algorithm. An extensive empirical analysis is conducted using the propose framework and different existing Gompertz-based mortality models with a merged mortality database containing a large number of developed countries. The factor model is estimated to mortality data in different developed countries, and an optimal parameterization is then determined based on multiple criteria, such as cross-validation and qualitative assessment of long-term mortality forecast. We find that allowing a more flexible age pattern of mortality decline may lead to better fitness of historical data, and sometimes substantially different mortality forecasts in the long-term.

Title: A Historical Mortality Study Using 18th Century Naval Records or Using Actuarial Models to Prove Dr. Johnson Wrong  
Presenter: Peter Douglas  
Abstract: Eighteenth Century English Scholar Dr. Samuel Johnson said that  
No man will be a sailor who has contrivance enough to get himself into jail; for being in a ship is being in a jail, with the chance of being drowned of being drowned.  
Mostly out of personal interest I have been looking at tracking mortality among the crews for 18th century long-term voyages of discovery (such as those of James Cook) to disprove this statement. Along the way, I am finding interesting data issues and observations. Individual seriatim data is available due to historical naval records and continuing public interest in these voyages. In addition the ships involved were largely self- contained environments with little contact with outside influences for long periods of time. Simple survival models are presented based on the data available and compared to historical mortality studies.
Title: Scenario Weights for Importance Measurement - An R package for sensitivity analysis
Presenter: Silvana Pesenti, University of Toronto
Abstract: When modelling portfolios of risks, it is of central importance to analyse the propagation of changes in model assumptions. As is typical in applications, we view a model as a random vector of input factors that is mapped, via an aggregation function, to a random output. Performing sensitivity testing includes stressing the inputs and observing the impact on the output, as well as stressing the output and monitoring the impact on different inputs (reverse sensitivity testing). We propose an approach to sensitivity analysis, based on [1], that circumvents the need for additional simulation runs and thus does not require time-consuming re-evaluations of the aggregation function. The approach is implemented via the R-package SWIM. Specifically, we define a stress on a random variable as a probabilistic modification, resulting from an increase or decrease in e.g. moments or risk measures such as VaR and ES. The distribution of the stressed random variable is chosen such that, subject to the constraints, the Kullback-Leibler divergence is minimised. In a Monte Carlo setting, the R-package calculates the importance weights of the resulting change of probability measure. Thus, using the weighting of simulated scenarios, the entire probabilistic characterisation of the stressed model is provided. Calculation of the stressed model including usual common sensitivity metrics and plotting facilities are implemented in the R-package.

Parallel Sessions 7A-7E
Time: 1:30 am - 3:00 pm
Location: Auditorium - Room 152

7A: Invited Session 5: Catastrophe Modeling and Insurance
Steve Kolk, ACAS – Kolkulations
Michael Angelina, ACAS – Saint Joseph's University
Graham Hall, FIA – Pricewaterhouse Coopers
Qihe Tang, PhD – University of New South Wales

7B: Chair: Natalia Humphreys
Location: Room 157
Title: Optimal Insurance with Belief Heterogeneity and Incentive Compatibility
Presenter: Shengchao Zhuang, University of Nebraska – Lincoln
Abstract: The behavior of the distribution of the stock returns is of fundamental importance in financial economics. It is well established that lognormal distribution is the basis for analyzing stock and option prices. It rests on the assumption that the underlying asset returns are normally distributed. This presentation investigates returns of a major auto stock in the context of the Pearson system of frequency curves. Using the time series data of daily returns, we find that the entire series, as well as the subintervals of consecutive trading days tested, can be described by the leptokurtic Pearson Type IV distribution. When an infinite time horizon is assumed, our results suggest that the distribution tends toward the Pearson Type VII distribution, the symmetric case of the Pearson Type IV distribution. We discuss the implications of our findings for financial modeling.
**Title:** Optimal reinsurance with model uncertainty  
**Presenter:** Haiyan Liu, Michigan State University  
**Abstract:** In this paper, we first provide an alternative and simple proof of a well-known optimal reinsurance problem in Cheung et al. (2014) under general conditions. Then we study four optimal reinsurance problems under model uncertainty with the uncertainty set being the class of exponential distributions, the class of Pareto distributions, the class of Weibull distributions, and the class of lognormal distributions, respectively. Explicit optimal solutions for minimax problems are obtained. In addition, we present a numerical approach to calculating the optimal solutions and compare the result with the analytical solutions. We show that the theoretical predictions are supported by the numerical methods.

**Title:** Affordable and Adequate Annuities with Stable Payouts: Fantasy or Reality?  
**Presenter:** Daniel Linders, University of Illinois at Urbana-Champaign  
**Abstract:** Over the last few decades, the number of pension plans offering guaranteed lifelong payout streams has declined significantly due to the high costs these plans impose on insurers. On the other hand, the number of pension plans offering variable payout streams has grown rapidly. This paper develops a new unit-linked (i.e., investment-linked) annuity product that is both affordable and adequate, as well as consistent with people’s preferences. We introduce a class of unit-linked annuities that extends existing annuities by allowing portfolio shocks to be gradually absorbed into the annuity payouts. Consequently, our new class enables insurers to offer an affordable and adequate annuity with a stable payout stream. We show that buffering of portfolio shocks is optimal when the individual derives his utility by comparing current consumption with an internal habit level. We show how to price and adequately hedge the annuity payouts in a general financial environment. Our stock return model is a natural generalization of the much celebrated Black and Scholes model. In particular, our model accounts for various stylized facts of stock returns such as asymmetry and heavy-tailedness. We determine the underlying investment strategy by extending the principle of delta hedging – which is familiar from the Black and Scholes model – to our generic stock return model. Furthermore, the generality of our framework makes it possible to explore the impact of a parameter misspecification on the annuity price and the hedging performance.

**Title:** Diversification of bounded risks  
**Presenter:** Hengxin Cui, University of Waterloo  
**Abstract:** It is a known fact that diversification is not necessary a preferred risk mitigation strategy for extremely heavy-tailed (infinite first moment), independent and unbounded risks. This finding has important implications in the management of extreme risks, especially in catastrophe insurance market. However, in many real world applications, the extremely heavy-tailed risks are not just independent and unbounded; they can be dependent and often truncated. In this paper, we provide a comprehensive study on how the truncation affects the diversification for extremely heavy-tailed risks with different dependence structures. For both real-valued and non-negative risks, we derive the bounds of the truncation such that the diversification is suboptimal or optimal. We find that the diversification effect is much easier to become suboptimal for non-negative risks than that for real-valued risks. For non-negative risks, when the truncation level is sufficiently high, the diversification effect is not affected by the dependence structure or the heavy-tailedness of the marginals. We argue that our analysis can be used to explain low levels of reinsurance among insurance providers in catastrophe insurance market. Simulation studies are also provided to highlight the key findings of our results.
Title: Holistic Allocation Principle  
Presenter: Longhao Jin, University of Illinois at Urbana-Champaign  
Abstract: Risk aggregation and capital allocation are of paramount importance in the business world, as they play critical roles in product pricing, risk assessment, risk management, project financing, performance management, financial reporting, regulatory supervision, and so on. The conventional approach, which is rooted in nearly all existing business practices involving risk assessment, is to sequentially perform the two components. More precisely, there is a “natural” sequence of actions: (i) identifying all risks involved; (ii) aggregating individual risks to determine required capital at a group level; and (iii) allocating the total capital back to the granular levels. In this talk, we challenge this conventional thinking underlying the current business practices and propose an alternative approach, which takes into account both aggregation and allocation simultaneously at both individual and aggregate levels. This talk is based on a joint work with Wing Fung Chong and Runhuan Feng.

Title: Model Efficiency and Uncertainty in Quantile Estimation of Loss Severity Distributions  
Presenter: Sahadeb Upretee, University of Wisconsin – Milwaukee  
Abstract: Quantiles of probability distributions play a key role in evaluating the riskiness of the distribution tail, which affects contract pricing and reserving. In this talk, we develop he empirical, maximum likelihood, and percentile-matching estimators of quantiles. Asymptotic distributions of these estimators are derived when data are modified by deductible and policy limit. Then, relative efficiency curves (REC) for the parametric estimators are constructed and their role in assessing model uncertainty is examined. We conjecture that RECs can be developed into an effective diagnostic tool when standard approaches are inadequate.

7D: Chair: Breanne Richins  
Location: Room 160  
Title: Retirement planning with systematic disability and mortality risk  
Presenter: Mengyi Xu, University of New South Wales  
Abstract: This paper studies retirement planning for a retiree in the presence of systematic disability and mortality risk. We use the U.S. Health and Retirement Study (HRS) data to calibrate a multi-state model which incorporates a deterministic time trend and a stochastic factor in the transition rates between different health states as proxies for systematic trend and uncertainty, respectively. We study how systematic trend and uncertainty affect retiree’s demand for long-term care (LTC) insurance and life annuity. We also assess the welfare loss if the retiree ignores systematic trend and / or uncertainty or has no access to a complete menu of retirement products including LTC insurance and life annuity. The welfare cost from following the suboptimal strategy is measured as the percentage of extra initial wealth required to bring the investor to the utility level that is obtained by following the optimal strategy with the original initial wealth. The welfare cost of ignoring trend and uncertainty is most significant for low-wealth people (up to 48% of their wealth at retirement), while that of market incompleteness is relatively high for medium-wealth people (up to 11% of their wealth at retirement). In contrast, the welfare costs for high-wealth people are negligible, rarely above 2% of their wealth at retirement.
Title: Intergenerational Equity: Metrics for Conditional Indexation in Pension Plans  
Presenter: Louis Adam, Laval University  
Abstract: Intergenerational equity has been a relevant qualitative concept in plan design, management and governance of public and private pension plans. There are, however, challenges even in defining what constitutes equity or an adequate level of intergenerational transfer for all involved parties. An additional challenge for the actuary is to design and use adequate metrics, thus providing a quantitative dimension to the conversation which often relies only on qualitative assessments. As an example of the application of intergenerational equity issue, we consider the specific framework of granting conditional indexation in an occupational contributory defined benefit pension plan. With the recent changes to legislative constraints applicable to such plans in the province of Quebec (Canada), specific requirements on establishing a provision for adverse deviation have been enacted in separate pieces of legislation depending upon the nature of the plan sponsor. The legislation leaves some leeway in how this provision can be used for either smoothing future contributions from active participants and plan sponsor, or providing some form of indexation to plan beneficiaries, contingent on the plan funded ratio. Intergenerational equity issues arise in the conflicting objective of three interested parties: minimize and stabilize future contributions, allocate cost between the plan sponsor and active members, and maximize the benefits received by plan beneficiaries by modulating conditional indexation. The presentation will describe the framework, define some metrics of cost and indexation, and show the simulation results of a representative conditional indexation policy applicable to a mature plan. Metrics should capture the value to the plan retirees of the indexation policy over the course of the simulation horizon, while cost or funding metrics should measure the impact on active members and plan sponsor, within the objective set out in the plan financing policy. Alternate results using different indexation policies, alternate sets of economic scenarios, or modifying key parameters will provide insight on the interplay between the ability for the plan to provide conditional indexation and the impact on cost metrics.

Title: Valuation of Risk-Based Premium of DB Pension Plan with Terminations  
Presenter: Zhixin Yang, Ball State University  
Abstract: This paper concentrates on the premium valuation of pension insurance provided by the Pension Benefit Guaranty Corporation (PBGC). The PBGC provides a defined benefit pension sponsor with coverage in case that the pension fund fails to make pension payments as promised or that the plan sponsor does not stay in business any more. In practice, both the pension fund and the sponsor assets play a critical role in fulfilling the commitment of pension payments, and thereby it is not reasonable to isolate the risk of distress termination of the sponsor assets from that of the premature termination of the pension fund. Different from previous works in which the premature termination of the pension fund and the distress termination of the sponsor assets are analyzed separately, our model examines the situation in which retirees suffer the risk of two types of terminations at the same time. We evaluate the risk-based fair premium under the framework that the pension fund and the sponsor assets are correlated and subject to the risk of the involuntary termination (i.e., premature termination) and the distress termination, respectively. In this framework, we manage to obtain closed-form pricing formulas. Our model is more practical because of the realistic design of termination schemes. Numerical simulations are also carried out to demonstrate our findings. Our numerical experiments validate that a variable rate premium is more appropriate for the PBGC to implement.
**Title:** Insurance Premium Principles for Dependent Risks  
**Presenter:** Wei Wei, University of Wisconsin – Milwaukee  
**Abstract:** In traditional insurance practice, premiums are determined based on the underlying assumption that individual risks are independent. With the evolvement of insurance industry, this assumption tends to fail in many circumstances, such as cyber insurance or catastrophe insurance, where individual risks are likely to be interdependent. In those cases, if continuing to use traditional premium principles, insurance providers would suffer huge losses when extreme events occur. New insurance premium principles are needed to address the challenges raised by interdependence. In this presentation, we shall propose several insurance premium principles to price dependent risks. The notion of coherence will be extended to a multivariate framework and will be used to evaluate the reasonability of the proposed premium principles. Practical implications of the proposed premium principles will also be investigated.

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**Title:** Gaussian Process Models for Actuarial Risk Analytics  
**Presenter:** Michael Ludkovski, University of California, Santa Barbara  
**Abstract:** Gaussian Process (GP) Regression is a powerful nonparametric machine learning technique for empirical model building. GPs are especially relevant in the context of risk analytics by offering full uncertainty quantification and a hierarchical, data-driven representation of nonlinear models. In this presentation we will provide an overview and guided tour of GPs for actuarial contexts, including (i) spatio-temporal longevity modeling [1-2]; (ii) stochastic loss development models [3]; (iii) parametric pricing of structured products [4]. The presentation will be accompanied by a RMarkdown document that illustrates GP-based analytics on real-life mortality and loss triangle datasets. This is joint work with Howard Zail and partially supported by CKER.

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**Title:** Cohort-wise mortality prediction under survival energy hypothesis  
**Presenter:** Yasutaka Shimizu, Waseda University  
**Abstract:** Mortality prediction is an important problem for risk management in insurance, and many models have been proposed so far, but we now propose a quite new approach by using a technique of ruin theory. We assume there exists the survival energy in human beings: a human is born with a certain quantities of survival energy, and the energy changes stochastically in time. The human dies if the energy decreases and hits the level zero, that is, the time of death is the first hitting time of the survival energy processes. In this paper, we suppose the survival energy follows a diffusion process and define the mortality as the first hitting time distribution of the process. We estimate the unknown parameters in the stochastic differential equations (SDE) via the least squares estimation by fitting the model to the empirical hitting time distribution function using the historical data from Human Mortality Database”. We shall demonstrate that this structural approach gives a surprisingly good prediction for future’s mortality, and it has many advantages for computations in practice.
平行会议 8A-8E
时间：下午3:30 - 5:00
地点：礼堂 - 房间152

8A: 主席：Margie Rosenberg
地点：房间157
标题：Modeling HPI price index using HJM approach
演讲者：Vajira Manathunga and Kushantha Fernando, Austin Peay State University
摘要：Housing Price Index (HPI) 是抵押贷款建模空间中的一个重要参数。HPI 是美国各州单个住房价格变化的衡量指标。根据联邦住房金融局（FHFA），HPI 是一个及时、准确的房屋价格趋势指标。HPI 提供了美国特定地区住宅价格升值或贬值的估计。因此，对 HPI 进行预测是抵押债券估值的一个关键组件。在 [1] 中，Alexander Levin 和 Andrew Davidson 提出了 Heath-Jarrow-Morton (HJM) 模型用于 HPI 预测。原始 HJM 模型专注于债券作为底层资产，但最近的研究已经扩展该模型至其他金融证券，如远期波动率预测和期权估值。在本次演讲中，我们将介绍 HJM 模型的实现，使用历史数据预测 HPI 指数，并测量预测的准确性。

标题：Risk Sharing with Multiple Indemnity Environments
演讲者：Wing Fung Chong, University of Illinois at Urbana-Champaign
摘要：最优风险分担安排在文献中进行了广泛研究，涉及一般化目标函数、整合更多业务约束，以及研究不同最优性概念。然而，这些研究成果尚未在行业实施。这可以归因于这些工作假定最优风险分担安排独立于外生风险环境。然而，例如，在再保险安排中，不同保障额和限制在不同风险情景下应用于不同的风险场景。因此，在本次演讲中，我们将重新审视具有多个赔偿环境的帕累托风险分担安排问题。本次演讲基于 Vali Asimit, Tim Boonen, 和 Yichun Chi 合作的联合工作。

标题：Blockchain applications in insurance
演讲者：Arnold Shapiro, Penn State University
摘要：在 ARC 2018，我做了一个关于区块链的演讲，讨论了它们是什么，如何工作，以及它们对保险行业的意义。主要目标是传达区块链是一种去中心化的事务和数据管理技术，它是一个分布式、不可变的数字记录系统，由许多独立的实体共享，并且只有在它们的共识下才能更新。本次演讲将扩展这些讨论，探索区块链在保险业务中的代表性应用。将讨论的应用领域包括参数保险、汽车索赔服务、欺诈监控和检测、群体健康政策开发和索赔，以及财产承保 XOL 合同。演讲将从公共和私有区块链的基本概览开始。然后，将讨论区块链在保险中的应用。演讲将结束时对这些话题的前景进行预测。
8B: **Chair:** Tom Edwalds  
**Location:** Room 159  
**Title:** Age Matters  
**Presenter:** Phelim Boyle, Wilfrid Laurier University  
**Abstract:** This paper examines the performance of equally weighted 1/N stock portfolios over time. During the last four decades these portfolios outperformed the market. The construction of these portfolios implies that their constituent stocks are in general older than those in the market as a whole. We show that the differential performance can be explained by the relation between stock returns and stock age. We document a significant relation between age and returns. Since 1977 stock returns have been an increasing function of age apart from the oldest ages. For this period the age effect completely dominates the size effect.

**Title:** When Does The 1/N Rule Work?  
**Presenter:** Chengguo Weng, University of Waterloo  
**Abstract:** The 1/N rule provides a simple way to obtain a diversified portfolio. Studies have shown it often outperforms more sophisticated approaches. We show that the 1/N rule only outperforms an optimal portfolio in two out of seven major equity markets: the USA and Japan. We develop a market-specific measure that indicates when the 1/N rule will dominate. Our measure is based on the distance between the 1/N portfolio and the maximum Sharpe ratio portfolio. We label it the 1/N favorability index. The 1/N rule also does well when the market as a whole performs well and we analyze the joint contribution of this factor and the favorability index. This is a joint work with Danqiao Guo, Phelim Boyle, and Tony Wirjanto.

**Title:** Hidden Markov Model for Portfolio Management with Mortgage-Backed Securities Exchange-Traded Fund  
**Presenter:** Moon Nguyen, Youngtown State University  
**Abstract:** The hidden Markov model (HMM) is a regime-shift model that assumes observation data were driven by hidden regimes (or states). The model has been used in many fields, such as speech recognition, handwriting recognition, biomathematics and financial economics. In this talk, we will begin with a primer on the hidden Markov model, covering main concepts, the models algorithms and examples to demonstrate the concepts. Next, we introduce some applications of the model in actuarial and financial areas. We then present applications of HMM on MBS ETFs. Finally, we establish a new use of HMM for a portfolio management with MBS ETFs: predicting prices and trading some MBS ETFs. This work was funded by SOA.
Title: A Dependent Frequency-Severity Approach to Modeling Longitudinal Insurance Claims
Presenter: Peng Shi, University of Wisconsin – Madison

Abstract: In nonlife insurance, frequency and severity are two essential building blocks in the actuarial modeling of insurance claims. In this paper, we propose a dependent modeling framework to jointly examine the two components in a longitudinal context where the quantity of interest is the predictive distribution. The proposed model accommodates the temporal correlation in both the frequency and the severity, as well as the association between the frequency and severity using a novel copula regression. The resulting predictive claims distribution allows to incorporate claim history on both the frequency and severity into ratemaking and other prediction applications. In this application, we examine the insurance claim frequencies and severities for specific peril types from a government property insurance portfolio, namely lightning and vehicle claims, which tend to be frequent in terms of their count. We discover that the frequencies and severities of these frequent peril types tend to have a high serial correlation over time. Using dependence modeling in a longitudinal setting, we demonstrate how the prediction of these frequent claims can be improved.

Title: Convolutions and Transforms Analysis in Casualty Loss Reserving
Presenter: James Ely, Convolved, Inc.

Abstract: The session will present a distributional interpretation of the Bornhuetter-Ferguson method as a convolution equation. Moment generating functions convert convolution to multiplication, so the session will also present a natural interpretation of the MGF in a loss reserving context. The result is that the MGF transforms loss payment patterns to link ratios expressed in terms of inflation. The session should be of interest to academics because it helps to justify the treatment of actuarial science as a discipline in its own right. The topic literally establishes a duality relationship between time domain and the value of money.

Title: Capital Allocation Techniques: Review and Comparison
Presenter: Qiheng Guo, University of California, Santa Barbara

Abstract: Capital allocation is an essential task for risk pricing and performance measurement of insurance business lines. This paper provides a survey of existing capital allocation methods, including common approaches based on the gradients of risk measures and “economic” allocation arising from counterparty risk aversion. We implement all methods in two example settings: binomial losses and using loss realizations from a catastrophe reinsurer. We assess stability based on sensitivity analysis with regards to losses. Our results show that capital allocations appear to be intrinsically (geometrically) related, although the stability varies considerably. We find stark differences between common and “economic” capital allocations.
Title: Assessing the Public and Private Impact of Retirement Income Products (CIPRs) Allowing for Health Heterogeneity
Presenter: Yulong Li, University of New South Wales
Abstract: With the ageing population and increasing life expectancy worldwide, there have been pressures for government budgets internationally. In Australia, this pressure is expected to decrease with retirees purchasing longevity income products through MyRetirement system (CIPRs). As is indicated in government paper [1], this kind of Comprehensive Income Products for Retirement (CIPRs) could better meet both the income and risk management needs for retirees and the whole retirement system. By now, there have been some papers analysing the impact of CIPRs (eg. see [2]), However, the previous studies on CIPRs do not take into consideration the retirees’ health heterogeneity which should be a significant part of retirement planning, and this may lower the efficiency of CIPRs. In this paper, we are going to extend the impact analysis from two aspects: Firstly, rather than using mortality model that only considers systematic mortality risk, we are going to use a previously developed multiple state health mortality model in which we can get mortality considering both systematic mortality and health heterogeneity. Based on this model, with initial health status deteriorating, retirees will have shorter life expectancy and are more likely to transfer into worse health status, which will affect the product price and the total retirement health costs. Secondly, we are going to add a health component (Deferred Health Annuity) into CIPRs’ portfolio framework aiming at providing a top up income stream for retirees when their health costs will increase significantly. We think this extension will help to increase the efficiency and attractiveness of the MyRetirement system which only includes traditional life annuities. After re-designing the CIPRs including health components, by projecting the retirement cash flows for each scenario dependent sub-group that has different starting characters (wealth and health levels) and comparing the projections of each group provided to the corresponding case with traditional Account-based Income Stream Product, we find two key results: i) compared to traditional ABIS, in all scenarios, the total payment from government Age Pension will decrease which means the ease of government burden in the means test system. ii) after taking health costs effect into consideration, the net total income for retirees will be at least not lower than the income generated from traditional product. This effect will be more significant if the initial wealth level is higher. Based on the health dependent utility function, if we assume retirees are more likely to get higher income when health costs are significant, individuals retirement life utility will at least not decrease. An additional contribution will be based on the comparison between the impact of new CIPRs and that of the CIPRs which do not include deferred health annuity. And this will help us to justify the necessary of including health component directly and provide insights in the design of MyRetirement system.
Title: Comparison of Equity Models and Computational Methods for Variable Annuity Guarantees
Presenter: Xiao Xu, University of New South Wales
Abstract: This paper compares the efficiency of a variety of Fourier-based numerical methods in generating fair guarantee fees for guaranteed minimum maturity (GMAB) and guaranteed minimum death benefit (GMDB) riders embedded in variable annuity contracts when the underlying fund dynamics evolve under various modelling assumptions. From the perspective of equity models, we consider the Lévy processes, stochastic volatility processes and time-changed Lévy processes. The pricing efficiency is examined by implementing the fast Fourier transform (FFT), the convolution method (CONV), the Fourier space time-stepping method (FST), the Fourier-cosine method (COS) and the Shannon wavelets inverse Fourier technique (SWIFT). The results suggest that advanced models generally provide a better fitting to market observed option prices and may result in higher fees for VA+GMBs. Practitioners are advised to use multiple equity models simultaneously to reduce extrapolation risk. The COS and SWIFT methods are efficient in pricing while the optimal varies with time-to-expiry and equity model assumptions.

8E: Chair: Jeff Zheng
Location: Room 162
Title: Joint model for individual-level reserving
Presenter: A Nii-Armah Okine, University of Wisconsin-Madison
Abstract: Loss reserves are the most substantial liability on a non-life insurer’s balance sheet (Grace and Leverty, 2012). As a result, the accuracy in the estimation of loss reserves is essential for insurers to meet regulatory requirements, remain solvent, and competitive. In non-life insurance, loss reserves are usually based on aggregate models which use aggregate claims data summarized in a run-off triangle. The ease of implementation and interpretation of macro-level models is one its strengths, but they come with a huge risk of inaccurate predictions. Over the last decade, it is well documented in the literature that loss reserve estimates based on individual-level data are generally more accurate than those computed from aggregate data. The individual-level models can provide better reserve estimates because of their ability to capture the claim development process and covariate information about the policy, the policy-holder, and the claim to estimate outstanding liabilities. Due to the high-degree heterogeneities displayed in claims reserving data, the performance of micro-level models is improved with the appropriate use of covariate. In this paper, a new micro-level model that focuses on the association between claim payment history and settlement is specified. In the claim payment process, the claim payment history can be predictive of a settlement. Ignoring the association between the settlement process and the payment history could lead to inaccurate reserve prediction. This paper proposes the joint modeling of longitudinal claim payments and settlement processes using random effects for reserve estimation. With the joint model (JM) framework, the association between the two processes can be captured. Also, unobserved claim heterogeneities are described using random effects which improves claim-specific dynamic predictions. In addition, the JM allows for extensive use of covariates for both the longitudinal and settlement processes to improve predictions. Results from a simulation study and an empirical analysis of data from Wisconsin Local Government Property Insurance Fund (LGPIF) shows the JM framework is a viable approach for RBNS prediction.
**Title**: Impact of individual explanatory variables in loss reserves  
**Presenter**: Juan-Sebastian Yanez, Université du Québec à Montréal  
**Abstract**: Non-life insurance companies are required to control their solvency in order to protect their policyholders, especially those who sustained a loss. Therefore, a provision, or loss reserve, must be made for claims whose total amount has not been fully paid. Given the importance of this task, several models have been proposed to estimate loss reserves, which are usually divided into two categories: collective and individual. Although the former has been widely studied by researchers and is commonly used by practitioners, the latter has only recently caught the eye of researchers and is rarely put into practice despite its many advantages. In this presentation, we shed light on one of the main benefits of using individual models: keeping intact the attributes of each claim. We suggest a three-component parametric individual model, that uses explanatory variables at each step. The first predicts the time between the occurrence, declaration, and settlement of each claim using a Weibull distribution. As for the second and third components, we use GLM models for the severity and frequency of payments of each claim. Time is used as an exposure variable in the count model. Moreover, we discuss estimation procedures, make predictions and compare the results with other individual and collective models, using a data set from a major Canadian insurance company.

**Title**: Recurrent Neural Network for Individual Loss Reserving in Non-Life Insurance  
**Presenter**: Ihsan Chaoubi, Laval University  
**Abstract**: Traditional loss reserving methods rely on aggregate claims data structured in claims development triangles. These macro-level methods induce a loss of detailed information about the individual claims. Recently, researchers have proposed micro-level loss reserving approaches which use individual claims to predict the outstanding loss amount. In this talk, we introduce a new individual reserving framework that incorporates granular information using a deep learning approach named Recurrent Neural Network. The estimation procedure is illustrated using a simulated non-life insurance database of individual claims histories generated with the stochastic simulation generator of Gabrielli and Wthrich (2018). The performance of our individual approach is evaluated by comparing the predictive outstanding loss estimates with their true values and with multiple aggregate methods.
Saturday, August 17, 2019
Session 9A: Plenary Session 3
Time: 8:45 am - 10:00 am
Location: Auditorium - Room 152

8:45 AM - 9:00 AM
Announcements
Chris Wilson – Planning Committee

9:00 AM – 10:00 AM
Keynote Presentation

Title: Should Life Insurers Use an Applicant’s Genetic Information?: Policy Lessons from the UK, Australia, and Canada
Presenter: Anya Prince, Associate Professor of Law and a Member of the University of Iowa Genetics Cluster

Abstract: Insurer use of genetic information has long been debated in the US and around the world. Although federal law prohibits health insurers from underwriting on the basis of genetic information, it does not address use by other lines such as, life, long-term care, and disability insurers. The debate in this area continues, highlighting tensions between social fairness concerns and the economic concerns of the insurance industry. The US, however, is not alone in its struggle to balance between business and social considerations. Other countries are considering or have adopted policies regulating life insurer use of genetic information. This presentation will report on qualitative results from semi-structured interviews with stakeholders in the United Kingdom, Australia, and Canada, including policy experts, government officials, genetic professionals, advocacy group members, and insurance representatives. Interviews highlight how different policy options have affected the fervor of the debate and fear of genetic discrimination. Additionally, debate about the usefulness of genetic test results to insurers impacts the policy options selected. Analysis of the effectiveness of international policy allows us to draw potential lessons for US policy-makers. Stepping back and getting some critical distance from this entrenched debate through examination of the experiences abroad may provide insight into more nuanced policy options.

Parallel Sessions 10A-10E
Time: 10:30 am - 12:00 pm
Location: Auditorium - Room 152

10A: Chair: Carl Cowen
Location: Auditorium – Room 152
Title: Impact of Shocks on Insurance through a Financial Network
Presenter: Zhiwei Tong, University of New South Wales

Abstract: Financial institutions are interdependent through cross-holdings, which results from the need for diversification but in the meantime creates a channel for the propagation of systemic risk. As a lesson learned from the collapse and near-failure of insurance giant American International Group (AIG) in 2008, it is important to quantitatively understand the systemic risk in insurance. In this work, we consider a network consisting of a number of financial firms, which have opportunities to invest in multiple risky assets. Assume that these risky assets are vulnerable to an exogenous shock, and that external to this network is an insurer who sells a general insurance product to help the firms hedge their losses. Each firm in the network determines how much to purchase of this insurance product to optimize its portfolio according to the mean-variance principle. As a result, the exogenous shock will impact the insurer through the network. To quantify this impact, we examine the insurer's risk reserve. Our main finding is that if the shock size is within a certain range, as the network integration is increased, the impact of the shock is first alleviated and then exacerbated.
Efficient Dynamic Hedging for Large Variable Annuity Portfolios with Multiple Underlying Assets

Shuai (Alex) Yang, University of Toronto

The contributions of a variable annuity (VA) are normally invested in multiple underlying assets (e.g., mutual funds). Hence, the liability of the embedded guarantees in a VA is subject to financial market risks. Unlike the mortality risk, the market risks are not diversifiable. As a result, insurance companies that manage large VA portfolios are exposed to significant market risks and hedging the total VA liability over time is essential in risk managing these portfolios. In order to dynamically hedge the total VA liability, the insurance companies would need to construct a hedging portfolio consisting of the underlying assets. The positions of the underlying assets may be determined by their Greeks and Dollar Deltas in particular. In practice, these Greeks are often calculated using the 'bump and revalue' approach, which involves rerunning the nested simulation algorithm that is used to calculate the liability with different sets of outer-loops. Due to the size of a large VA portfolio (e.g. 100K+), the complexity of the guarantee payoffs and the stochastic-on-stochastic nature of the nested simulation algorithm, the calculation of Greeks through a full nested simulation is extremely time-consuming. In the case where multiple underlying assets are involved, it is almost impossible to calculate the Greeks within a reasonable time frame for hedging purposes. In this paper, we extend the surrogate model assisted nest simulation algorithm proposed in Lin & Yang (2019) to efficiently calculate the total VA liability and partial dollar Deltas for large VA portfolios with multiple underlying assets. With the proposed algorithm, the nested simulation is run with only small sets of selected representative policies and representative outer-loops. As a result, the computing time is cut substantially, allowing the implementation of a dynamic hedging program over time. The computational advantages of the proposed algorithm are illustrated by conducting profit and loss (P&L) analyses for a large synthetic VA portfolio. Moreover, the robustness of the performance of the proposed algorithm is tested with multiple simulation runs. Numerical results show that the proposed algorithm is able to accurately approximate different quantities of interest and the performance is robust with respect to different sets of parameter inputs.

Modeling of Persistent Extrema in Financial Markets and Its Implication for Equity-Linked Insurance

Runhuan Feng, University of Illinois at Urbana-Champaign

A new class of stochastic processes with sticky extrema is proposed to model common phenomena of winning and losing streaks in financial markets including equity, commodity, foreign exchange, etc. Most stochastic process models for financial market data in the current literature focus on stylized facts such as fat-tailedness relative to normality, volatility clustering, mean reversion. However, none of existing financial models captures a frequently observable feature of persistent extremes - financial indices often report record highs or lows in concentrated periods of time. The lack of persistent extremes in a stochastic model for asset valuation can have grave impact on the valuation and risk management of financial instruments. The new model in this paper enables us to measure and assess the impact of persistent extremes on insurance products whose values can be severely misestimated. In particular, the model in this paper reveals a paradox that investors who bet on the growth of financial market may be worse off with the presence of winning streaks in the market.
Title: A Class of Mixture of Experts Models for General Insurance
Presenter: Tsz Chai Fung, University of Toronto
Abstract: In the Property and Casualty (P&C) ratemaking process, it is critical to understand the effect of policyholders’ risk profile to the claim distributions and the dependence among various business lines, motivating us to propose a class of logit-weighted reduced mixture of experts (LRMoE) regression models for multivariate claim frequencies or severities distributions. LRMoE is interpretable, as it has two components: Gating functions, which classify policyholders into various latent sub-classes; and Expert functions, which govern the claim distributions. Developing the denseness theory in regression setting, the LRMoE can be fully flexible to capture any distribution, dependence and regression structures. Also, deriving the marginalization, moment and identifiability properties, the LRMoE is mathematically and statistically tractable. Further, we develop the Expectation-Conditional-Maximization (ECM) algorithm for efficient model calibrations. Choosing Erlang Count distributions as the expect functions, the LRMoE shows excellent fittings to simulated datasets and a real automobile insurance dataset containing correlated claim frequencies. We are also able to interpret the fitted model in an insurance perspective and to visualize the relationship between policyholders’ information and their risk level. Finally, we demonstrate how the fitted model may be useful for insurance ratemaking.

Title: Model misspecification, Bayesian estimator, credibility estimator, and Gibbs posterior
Presenter: Liang Hong, Robert Morris University
Abstract: We investigate the large-sample performance of the Bayesian estimator and the credibility estimator under a possibly misspecified model. When the model is well-specified, both estimators are asymptotically accurate. But, if the model is genuinely misspecified, the Bayesian estimator might be off the mark even asymptotically while the credibility estimator still guarantees asymptotic accuracy. We argue that this asymptotic robustness of the credibility estimator stems from the fact that it is a special case of the mean of a Gibbs posterior. Moreover, we provide a sample size criterion for practitioners to use the credibility estimator.

Title: Comparative Study of Predictive Analytics Algorithms and Tools on Property & Casualty Insurance Solvency Prediction
Presenter: Lu Xiong, Middle Tennessee State University
Abstract: The Insurance Regulatory Information System (IRIS) is a widely used US solvency monitoring framework, but it does not consider important factors such as company size, operating product lines, and states. Previous researches have pointed out the IRIS needs improvement. The recent advancements in machine learning and cloud computing provide new algorithms and tools for solving this problem. In this study, we combined the NAIC IRIS results data from more than 2,700 property and casualty insurance companies from 2005 to 2017, and the states in which each of the companies are operating, the list of product lines, the scale of underwriting premiums, and other company information. We use caret package in R, scikit-learn in Python, H2O, Spark, Azure as the tools to predict the value of IRIS ratios for any given property and casualty company. Various predictive analytics algorithms and tools are compared with their prediction accuracy and computing performance. We found that compared with only using the current IRIS ratios, combining the company's states, product lines, underwriting size, historical IRIS ratios, and other information can improve the predictive power of IRIS. The corresponding optimal algorithms and tools are given. This study can improve the early warning ability and accuracy of IRIS.
Hybrid Tree-based Models for Insurance Claims

Presenter: Zhiyu Quan, University of Connecticut

Abstract: Modeling loss costs for short-term insurance contracts has conventionally been based on claim frequency and claim severity. While it is not uncommon to use a two-part framework with frequency and severity as components, there has been an interest in the use of Tweedie Generalized Linear Model (GLM) as a direct approach. For most insurance claims datasets, there is typically a large proportion of zero claims that leads to imbalances that cause inferior prediction accuracy of these traditional approaches. As an alternative approach, we propose to use tree-based models with a hybrid structure that involves a two-step algorithm. The first step is the construction of a classification tree to build the probability model for frequency. In the second step, we employ elastic net regression model at each terminal node from the classification tree to build the distribution model for severity. This hybrid structure captures the benefits of tuning hyperparameters at each step of the algorithm thereby allowing for an improved prediction accuracy. We examined the performance of this model vis-à-vis the Tweedie GLM using the LGPIF and simulated datasets. Our empirical results indicate that this hybrid tree-based model produces more accurate predictions without loss of intuitive interpretation.

Tree-based models for individual loss reserving

Presenter: Andra Crainic, Université du Québec à Montréal

Abstract: Non-life insurance companies need to constantly make sure that they are able to meet their financial engagements. In order to do so, actuaries have to regularly ensure that there is enough liquidity in the reserve. Based on the granularity of the underlying dataset, almost all existing models can be divided into two main categories: individual and collective. We decide to tackle the individual approach for its numerous advantages despite the fact that it is rarely used in practice. The reserve is considered, in this talk, to have a frequency-severity structure where the frequency is modeled using decision trees in line with several recent publications, e.g., Wüthrich (2018). The severity is modeled using a generalized linear model for individual loss reserving. We illustrate results with an empirical analysis using a detailed real portfolio from a major Canadian insurance company. We also contrast individual and collective paradigms and we quantify the risk associated to the reserve. Finally, we discuss some points related to the application in practice.

Territorial Ratemaking Using Moran Basis Functions

Presenter: Zach Horton, Brigham Young University

Abstract: Territorial risk classification is a critical component in non-life insurance pricing for accounting for unobserved spatial heterogeneity. We explore using Moran basis functions as a tool for building ratemaking models. Moran basis functions can be used as model covariates that incorporate the neighborhood structure implicit in areal data and are orthogonal to the other spatially-varying covariates. Accounting for spatial effects using covariates lends itself to standard pricing tools such as GLM or modern machine learning methods, a trait not shared by more complicated spatial covariance models. We show the value of this method on a set of auto insurance policies from Massachusetts and discuss its advantage over traditional approaches including the conditional autoregressive model and bivariate spatial splines.
Title: Multi-population longevity models: a spatial random field approach
Presenter: Nhan Huynh, University of California, Santa Barbara
Abstract: We investigate joint modeling of longevity trends using the spatial statistical framework of Gaussian Process regression. Our analysis is motivated by considering the Human Mortality Database that provides raw mortality tables for nearly 40 countries and clearly demonstrates the commonality in global longevity. Yet few stochastic models exist for handling more than 2 populations at a time. To bridge this gap, we develop a spatial covariance approach that treats mortality data through the lens of smoothing and forecasting noisy input-output relationships. In our framework, multiple populations are approached as distinct levels of a factor covariate, explicitly capturing the cross-population dependence. We demonstrate that our approach not only provides improved accuracy, but intrinsically generates coherent joint future longevity scenarios. It also offers an opportunity to borrow the most recently available data from other datasets, leading to more precise (and statistically more credible) forecasts regarding mortality improvement rates. All the numerical algorithms are implemented using R and Stan statistical languages and are publicly available. We illustrate using numerous figures on multiple European HMD datasets for both Males and Females.

Title: The County Fair Cyber Loss Distribution: Drawing Inferences from Insurance Prices
Presenter: Daniel Woods, Oxford University
Abstract: The actuarially fair insurance premium reflects the expected loss for each insured. Given the dearth of cyber security loss data, market premiums could shed light on the true magnitude of cyber losses despite noise from factors unrelated to losses. To that end, we extract cyber insurance pricing information from the regulatory filings of 26 insurers. We provide empirical observations on how premiums vary by coverage type, amount, policyholder type, and over time. A method using Particle Swarm Optimisation is introduced to iterate through candidate parameterised distributions with the goal of reducing error in predicting observed prices. We then aggregate the inferred loss models across 6,828 observed prices from all 26 insurers to derive the County Fair Cyber Loss Distribution. We demonstrate its value in decision support by applying it to a theoretical retail firm with annual revenue of $50M. The results suggest that the expected cyber liability loss is $428K, and that the firm faces a 2.3% chance of experiencing a cyber liability loss between $100K and $10M each year. The method could help organisations better manage cyber risk, regardless of whether they purchase insurance.

Title: Proportional allocations revisited
Presenter: Jianxi Su
Abstract: In this talk, we connect the allocation of risk capital to a general class of Dirichlet distributions defined on the n-dimensional simplex. The mixed-scaled Dirichlet distributions proposed herein contain the classical Dirichlet distribution as a special case, exhibit a multitude of desirable closure properties, and emerge naturally within the multivariate risk analysis context. As a by-product, our invention revisits the proportional allocation rule that is often used in applications (e.g., [1, 2]).
10E: **Chair: Zhixin Yang**  
**Location: Room 162**  
**Title:** An insurance approach to Biosecurity risks  
**Presenter:** Atibhav Chaudhry, University of Melbourne

**Abstract:** We are proposing that biosecurity can be established as an insurance mechanism. Presently, any losses relating to pests/disease incursion are absorbed by the government (i.e. the taxpayers). These losses relate to controlling the risk, loss of productivity and market access losses. However, a country’s biodiversity is at risk due to importers following negligent practices. An insurance mechanism can be formed out of this situation – where premiums are paid by the importers and an insurance “payoff” occurs in case of a pest/disease incursion. This payoff is used to pay for the losses ensuing due to the incursion. Importer premiums are suggested to be priced taking into account the risk that they present. The characteristics of the goods that best explain the risks presented should be used for risk classification (rating factors). For example, country imported from, level of existing precautions taken etc. This achieves a number of goals. Firstly, there is a natural incentive alignment between the importer and the government. Importers are encouraged to import goods that are safer due to the smaller premium. As a result, the overall risk presented to the country is reduced and a more optimal set of goods is imported into a country (taking into account the demand for the product and its biosecurity risk). Finally, there is also some cost recovery for the government by sharing the risk with the importers.

**Title:** Predicting extreme surges from sparse data using a copula-based hierarchical Bayesian spatial model  
**Presenter:** Nicholas Beck, McGill University  
**Abstract:** All around the world, overland floods are increasingly considered to be one of the most catastrophic natural disasters, both in terms of damages and the number of victims. According to [Winsemius et al.(2016)], between 1980 and 2013, economic losses due to floods exceeded $1 trillion (2013 USD) with more than 220,000 lives lost. In this presentation, a hierarchical Bayesian model is proposed to quantify the magnitude of extreme surges on the Atlantic Coast of Canada with limited data. At the data level, generalized extreme-value distributions (GEVs) are fitted to surges derived from water levels measured at 21 buoys along the coast. In such setups, it is often assumed that the GEVs will be conditionally independent given the parameters. However, as discussed by [Tawn et al.(2018)], see also see also [Towe et al.(2018)], the consideration of events at a site-by-site basis, independent of the surrounding area, is overly simplistic when impact across the entire domain is of interest. To this end, a Student's t-copula is introduced at the data level to connect the marginal distributions. Allowing for this additional feature is important, particularly in an insurance context, where the possibility of concurrent extreme events might affect the assessment of risk and, ultimately, premiums and the insurer's economic capital. At the process level, the location and log-scale parameters of the GEVs are linked together through Gaussian fields whose mean and variance are driven by atmospheric sea-level pressure and the distance between stations, respectively. Inclusion of this latent spatial process will allow for information sharing across the original stations, strengthening fit. With this we were able to easily fit GEVs at nearly 1400 unmonitored locations along the coast, expanding the possibilities for inference. Model fit is completed using a Gibbs sampling scheme with a Metropolis-Hastings accept/reject step. Several models are compared using Watanabe-Akaike information criterion. Finally, it is shown how the extreme surges derived from the model can be combined with the tidal process to predict potentially catastrophic water levels. With this information, further exploration can be done on the risks of flooding across this large domain, including the impact of floods on local communities.
Abstract: The Actuaries Climate Index (ACI) is the newly released index by actuarial professional associations to measure climate risk. Composite with elements including temperature, precipitation, wind power, and sea level, it reflects extreme climate changes in Canada and the United States. In this paper, we investigate the forecasting power of the ACI to stock returns in relevant sectors. We find that less ACI time trends predict higher returns in agriculture-related portfolios and that the portfolio return is amplified for a more extended holding period. We also test the efficiency of the stock market with respect to the ACI. In light of the relative strength trading strategy, we invest in stocks with less climate risk and sell stocks with more climate risk. The outperformance of the “buy winner and sell loser” strategy in agriculture-related industries implies the inefficiency of the stock market. We find that the food and beverages sector contributes most to the outperformance. Our results shed a useful insight into how the stock market can be used to mitigate the adverse effect of the climate risk on the profitability of a company.