Monday, August 10, 2020

Concurrent Sessions 1
10:30-11:45 a.m.

1-PS-A Cyber Risk

10:30-10:55 a.m.
Title: Cyber Claim Analysis Through Generalized Pareto Regression Trees With Applications to Insurance
Presenter: Sébastien Farkas, Sorbonne University
Abstract: With the rise of the cyber insurance market, there is a need for better quantification of the economic impact of this risk and its rapid evolution. Due to the relatively poor quality and consistency of databases on cyber events, and because of the heterogeneity of cyber claims, evaluating the appropriate premium and/or the required amount of reserves is a difficult task. In this paper, we propose a method based on regression trees to analyze cyber claims to identify criteria for claim classification and evaluation. We particularly focus on severe/extreme claims, by combining a Generalized Pareto modeling—legitimate from Extreme Value Theory—and a regression tree approach. Combined with an evaluation of the frequency, our procedure allows computations of central scenarios and extreme loss quantiles for a cyber portfolio. Finally, the method is illustrated on a public database.

10:55-11:20 a.m.
Title: Extreme Cyber Losses: An Alternative Approach to Estimating Probable Maximum Loss for Data Breach Risk
Presenter: Kwangmin Jung, Pohang University of Science and Technology/Drake University
Abstract: This paper proposes a measure of the probable maximum loss for data breach risk, which stands for the worst data breach loss likely to occur, with an alternative approach to estimating the potential loss size of an extreme event. We determine stationary loss maxima series, the presence of short-range temporal dependency, the Fréchet type of generalized extreme value distribution (GEV) as the best fit, and the presence of monthly bivariate extreme dependency. We find that the predicted data breach loss likely to occur in the next five years is almost seven times larger than the loss size estimated by the recent literature with a Pareto model. In particular, the comparison between the estimates from the data for the more recent period (after 2014) and those for the older period (before 2014) shows a significant increase with a break in loss severity, possibly supported by an anecdotal evidence on the link with the Moore's law. We provide cyber reinsurance design upon probable maximum loss estimates, where the mixture of excess-of-loss and quota share is utilized. Our findings are important for risk managers, actuaries and policymakers concerned about the enormous cost of a next extreme cyber event as a New Normal.
11:20-11:45 a.m.
Title: Unraveling Dependence among Cyber Risks

Presenter: Maochao Xu, Illinois State University

Abstract: The dependence among cyber risks has been an essential, but challenging, component in risk management. This study characterizes cyber dependence from both qualitative and quantitative perspectives. |In the former, the cyber risks always possess positive association dependence based on the proposed risk propagation model. In the latter, the arbitrary network is provided an explicit formula for computing the fundamental dependence measure of covariance. In particular, we study the impacts of factors, especially including external and internal compromise probabilities, propagation depth, and network topologies, on dependence among cyber risks. We conclude by presenting some examples and applications.

1-PS-B Post-Retirement Benefits

10:30-10:55 a.m.

Title: AHP Application to Post-Retirement Planning and Decision-Revisited

Presenter: Marie-Claire Koissi, University of Wisconsin- EC

Abstract: The recent publication "2019 Risk and Process of Retirement Survey" sponsored by the SOA (SOA, 2020), highlights many of the financial and emotional concerns of the to post-retirees and the retirees in the United States. Several concepts associated with post-retirement financial strategies are fuzzy in nature (Shapiro, 2011). Therefore, techniques involving fuzzy logic should be used to deal with post-retirement objectives. The Analytic Hierarchy Process (AHP) is a methodology based on pair-wise comparisons that relies on judgment to derive priority scales. An area of possible application of the AHP is retirement, where the AHP can be used for efficient asset allocation in order to meet retirees' goals.This paper studies an asset allocation methodology that involves the AHP which makes it possible to consider all the retiree's objectives together with their chosen priority ranking.

10:55-11:20 a.m.

Title: Tail Index-Linked Annuity: A Longevity Risk Sharing Retirement Plan

Presenter: Mark Schultze, Ulm University

Abstract: This paper proposes an innovative retirement product with a focus on longevity risk sharing, a contract we refer to as tail index-linked annuity (TILA). Specifically, the proposed TILA pays out variable annual payments, which will be equal to a regular nominal amount when a reference survival index is lower than a predetermined threshold (i.e., normal evolution of longevity risk), and a reduced, index-dependent payment when the threshold is passed (i.e., highly unfavorable evolution of longevity risk). The proposed TILA aims at not only improving the benefits of the policyholders, which has been the focus in recent literature on innovative retirement products, but also reducing the longevity risk exposure of the insurer, particularly for advanced retirement ages. Using real-world mortality data and stochastic multi-population mortality model, we find that the proposed TILA leads to higher expected lifetime utility than regular annuities for policyholders with different degrees of risk aversions. Meanwhile, numerical analysis shows that the proposed TILA could greatly mitigate the solvency risk of the insurer, leading to substantially lower loss probability and expected (tail-) loss

than regular annuities in the presence of longevity shock, and therefore could reduce the insurer's required solvency capital under latest solvency regulations.

11:20-11:45 a.m.
Title: Optimal Retirement Products Under Subjective Mortality Beliefs
Presenter: Peter Hieber, University of Ulm/Université Catholique de Louvain
Abstract: Many empirical studies confirm that policyholder's subjective mortality beliefs deviate from the information given by publicly available mortality tables. In this study, we look at the effect of subjective mortality beliefs on the perceived attractiveness of retirement products, focusing on two extreme products, conventional annuities (where the insurance company takes the longevity risk) and tontines (where a pool of policyholders shares the longevity risk). If risk loadings and charges are neglected, a standard expected utility framework without subjective mortality beliefs, leads to conclude that annuities are always preferred to tontines (Yaari (1965), Milevesky and Salisbury (2015)). In the same setting, we show that this result is easily reversed if an individual perceives her peer's life expectancies to be lower than the ones used by the insurance company. We prove that, assuming such subjective beliefs, there exists a critical tontine pool size from which on the tontine is always preferred over the annuity. This suggests that tontines might be perceived as much more attractive than suggested by standard expected utility theory without subjective mortality beliefs.

1-PS-C Actuarial Mathematics

10:30-10:55 a.m.
Title: Probability of Up-Crossing Before Ruin for a Levy Process Having Two-Sided Jumps
Presenter: Mohammad Jamsher Ali, University of Tartu
Abstract: In this work, we study the probability of up crossing before down crossing by a Lévy process, insurance reserve, having both sided jumps. We assume that both, the upward jumps (incoming money of the company), and the downward jumps (outgoing money of the company) have phase-type distribution. By using the Laplace transform, we construct exact formula for the probability of up crossing before the down crossing (ruin), provided that the ruin time is finite. An empirical example using the obtained formula is performed.

10:55-11:20 a.m.
Title: Analysis of Bounds for the Tail of Bivariate Compound Distributions
Presenter: Ang Li, University of Western Ontario
Abstract: In this paper, we consider the upper and lower bounds of the tail of bivariate compound distributions. Our results extend those in the literature (eg. Willmot and Lin (1994) and Willmot et al. (2001)) for univariate compound distributions. First, we derive the exponential upper bounds when the claim size distribution is light-tailed with nite moment generating function. Second, we present generalized upper and lower bounds when the claim size distribution is heavy- tailed without a nite moment generating function. Numerical examples are provided to illustrate the tightness of these bounds.

11:20-11:45 a.m.

Title: Do Jumps Matter in the Long Run? A Tale of Two Horizons

Presenter: Jean-François Bégin, Simon Fraser University

Abstract: Economic scenario generators (ESGs) for equities are important components of the valuation and risk management process of life insurance and pension plans. As the resulting liabilities are very long-lived, it is a desired feature of an ESG to replicate equity returns over such horizons. However, the short-term performance of the assets backing these liabilities may also trigger significant losses and in turn affect the financial stability of the insurer or plan. Therefore, the ESG must replicate both short- and long-term stock price dynamics consistently.

Concurrent Sessions 2

12:45-02:00 p.m.

2-PS-A Actuarial Techniques for COVID-19

12:45-01:10 p.m.

Title: Risk Management: Evaluating the Role of a National Risk Avoidance Policy in Limiting the Spread of Corona Virus (Perspective from Saudi Arabia)

Presenter: Hany Saleh, Mansoura University

Abstract: This research aims to present a "National Risk Management Policy" NRMP as a proposed scheme to help the country curb the spread of Covid-19. This scheme helps determine the classification for each country according to the severity and the evolutionary stage of the virus in that country. Also, analyze the risks of spreading the Corona virus in the Kingdom of Saudi Arabia by evaluating the role of a National Risk Avoidance Policy (NRAP) and a (NRMP) in limiting the spread and reduce the risk of the virus. Moreover, it assesses the Saudi state’ s performance regarding Covid-19 by analyzing the indicators of the virus and its evolution. Where the study found that the logistic growth model is the most appropriate to study confirmed cases. A prediction performed using this model found that the pandemic is supposed to fade "theoretically" during September 2020. According to proposed scheme and based on an analysis of Covid-19’ s indicators in Saudi Arabia until the date of July 23, 2020 a classification OC can be established for Saudi Arabia, which means that the evolutionary stage of the virus in Saudi Arabia is C and its severity is decreasing.

01:10-01:35 p.m.

Title: Insurance-by-Credit

Presenter: Hirbod Assa, University of Liverpool

Abstract: This paper takes an unusual path to its objective. First, concerning the recent COVID-19 outbreak and its financial impacts, the paper investigates if (re)insurances, state-backed or otherwise, can help mitigate the economic risk. As the answer to this question might not be so affirmative, in the second part of the paper

we explore what would be a more effective solution by looking into the insurance principles. From the second part, we realize the normal insurance practice cannot be a solution due to its foundation on running the business on surplus rather than deficit. Therefore, in the third part we suggest a new type of insurance, called insurance-by-credit, which runs the business on deficit.

2-PS-B Optimization

12:45-01:10 p.m.
Title: Deflators and Optimal Portfolios Under Random Horizon
Presenter: Sina Yansori, CIBC
Abstract: This paper investigates the impact of a random horizon on the optimal investment/portfolio. This random horizon is a general random time that might represent generally an occurrence time of an event (default time) that might impact the market somehow. In this setting, we address the numeraire portfolio and the utility maximization problem. Due to the duality between the investment strategies and the deflators, our ultimate goal translates on explicitly describing the impact of the random horizon on the optimal deflator. For the log utility, it's completely described. We also address the impact of the random time on the numeraire portfolio.

01:10-01:35 p.m.
Title: Mean-Variance Investment and Risk Control Strategies: A New Time-Consistent Formulation
Presenter: Bin Zou, University of Connecticut
Abstract: We consider an optimal investment and risk control problem for an insurer under the mean- variance (MV) criterion. By introducing a deterministic auxiliary process, we formulate a new time-consistent problem related to the original MV problem, and obtain the optimal strategy and the value function to the new problem in closed forms. We compare our formulation and optimal strategy to those under the precommitment and game-theoretic framework. Numerical studies show that, when the financial market is negatively correlated with the risk process, optimal investment may involve short selling the risky asset and, if that happens, a less risk averse insurer short sells more risky asset.

01:35-02:00 p.m.
Title: A Mixed Bond and Equity Fund Model for the Valuation of Segregated Fund Policies
Presenter: Frédéric Godin, Concordia University
Abstract: Segregated fund and variable annuity policies are typically issued on mutual funds invested in both fixed income and equity asset classes. However, due to the lack of specialized models to represent the dynamics of fixed income fund returns, the literature has primarily focused on studying long-term investment guarantees on single- asset equity funds. This article develops a mixed bond and equity fund model in which the fund return is linked to movements of the yield curve. Theoretical motivation for our proposed specification is provided through an analogy with a portfolio of rolling horizon bonds. Moreover, basis risk between the

portfolio return and its risk drivers is naturally incorporated into our framework. Numerical results show that the fit of our model to segregated fund data is adequate. Finally, the valuation of segregated fund policies is illustrated and it is found that the interest rate environment can have a substantial impact on guarantee costs.

2-PS-C Statistical Issues

12:45-01:10 p.m.
Title: Introduction to Splines and Their Implementation in Excel
Presenter: Manohararedddy Ramireddy, Maryville University
Abstract: Prior to building models, data scientist / modelers often times have to perform some sort of variable transformation. In this session, we discuss what splines are and how they could be used in place of (or as) variable transformations; we address advantages as well limitations of splines. Finally, we show an example of how to apply splines in creating an assumption table.

01:10-01:35 p.m.
Title: Regression Shrinkage and Selection for Actuarial Models
Presenter: Gee Lee, Michigan State University
Abstract: In this talk, the speaker will illustrate a general approach to implement fast shrinkage and selection routines (allowing variable selection) for regression models arising in actuarial science, with multiple shape parameters. The approach iteratively approximates the negative log-likelihood surface using a Taylor series expansion in the outer loop, while ensuring convergence of each step using the majorization minimization principle (which will be explained during the talk) in the inner loop. The speaker will explain how the approach can be applied to the GB2 distribution, which is a model with three shape parameters, commonly used for heavy-tailed severity modeling in actuarial science nowadays. The details of the implementation of a GB2 regression routine with shrinkage and selection capabilities using the approach, as well as the results from an application of the routine to real data, will be discussed during the talk. A comparison of the routine with existing tools such as glmnet will be provided as well.

01:35-02:00 p.m.
Title: Estimating Longormal Insurance Payment Severity Models
Presenter: Chudamani Poudyal, Tennessee Technological University
Abstract: The primary objective of this research work is to develop two estimation procedures { maximum likelihood estimator (MLE) and methods of trimmed moments (MTM) { for the mean and variance of log-normal insurance payment severity data sets affected by different loss control mechanism, e.g., truncation (due to deductibles), censoring (due to policy limits), and scaling (due to coinsurance proportions), in insurance and financial industries. Maximum likelihood estimating equations for both payment-per-payment and payment-per-loss data sets are derived which can be readily solved by any existing iterative numerical methods. The asymptotic distributions of those estimators are found via Fisher information matrices. Further,

with a goal of balancing efficiency and robustness and to remove point masses at certain data points, we develop MTM procedures for log-normal claim severity models for the above mentioned transformed data scenarios. The asymptotic distributional properties and the comparison with the corresponding MLEs of those MTM-estimators are established. Numerical examples, for hurricane damages in the United States from 1925 to 1995, are provided which illustrate the practical performance of the established results in this paper.

Concurrent Sessions 3
02:15-03:30 p.m.

3-PS-A Machine Learning

02:15-02:40 p.m.
Title: Joint Dynamic Pricing of Multiple Non-Life Perils Using Neural Networks and Telematics
Presenter: Roel Henckaerts, Katholieke Universiteit Leuven
Abstract: The digital age is pushing strong for two innovations in the non-life insurance industry: online simulations/purchases and the use of telematics. A prospective insurance buyer wants to put together a package covering multiple risks or perils based on his/her needs. Direct and transparent information concerning the price of the policy is very important to close the deal. We propose a model architecture to jointly price multiple perils in two steps. First, a predictive model for each of the perils separately captures the inherent risks. Second, a neural network architecture combines these tariffs while allowing for dependencies between the different perils. We demonstrate our strategy for third-party liability and own material damage coverages in motor insurance. Telematics devices are used increasingly to measure behavior, for example via pay-as-you-drive (PAYD) and pay-how-you-drive (PHYD) policies. We allow for dynamic updates on the base quote via driving behavior features. Examples are the distance driven on different road types and times of day or events like speeding, acceleration and cornering. We demonstrate our analysis on a real-life motor portfolio where young policyholders are given the choice to sign up for a telematics product or stick with the classic policy.

02:40-03:05 p.m.
Title: Quantile Regression Mixtures for Robust Estimates of Insurance Misrepresentation
Presenter: Jianxi Su, Purdue University
Abstract: This paper pertains to a class of kernel-based quantile regression models for studying insurance misrepresentation. Compared with the existing parametric methods, the proposed models showcase not only enhanced model flexibility through the distribution-free and non-linear regression structure, and thus alleviate the risk of model misspecification, but also being robust to outliers. Embedding state-of- the-art machine learning techniques, we present a novel statistics procedure to implement the proposed misrepresentation models, which has a great potential for massive insurance data applications.

03:05-03:30 p.m.

Title: Machine Learning: What Is It, What Are Its Components, and What Are Its Implications for the Insurance Industry?

Presenter: Arnold Shapiro, Penn State University

Abstract: The focus of this presentation is on machine learning (ML). While the actual presentation will elaborate on the definition of ML, for an intuitive definition we turn to its originator, Arthur Samuel, who in 1959 envisioned ML as a field of study that gives computers the ability to learn without being explicitly programmed. Of course, the scope of ML has evolved over the years, and this presentation will reflect that. The topics and subtopics of ML that will be addressed include: supervised learning, and its subtopics of regression and classification; unsupervised learning, and its subtopics of clustering and dimensionality reduction; and reinforced learning. The goal of the presentation is to provide the audience with an overview of the current state of the art of ML and to discuss the role of ML from an insurance perspective. The presentation will end with a prognosis with respect to these topics.

3-PS-B Variable Annuities

02:15-02:40 p.m.

Title: Pseudo-Model-Free Hedging for Variable Annuities Via Deep Reinforcement Learning

Presenter: Haoen Cui, Georgia Institute of Technology

Abstract: Effective dynamic hedging for variable annuities has been substantially studied in the literature, particularly since its market expansion. However, dynamic hedging via Greeks is computationally expensive, even when nested Monte Carlo simulations have been used. In this talk, we extend a pseudo-model-free approach to hedging variable annuities, via the state-of-the-art deep reinforcement learning, a thrilling field joining the theories of machine learning and optimal control. Instead of assuming a priori financial market and mortality models, an insurance company learns optimal hedging strategies for variable annuities by interacting with the actuarial and financial markets. We examine the effectiveness of the hedging strategies by the trained insurance company in the simplest financial market models, namely, binomial-tree and Black-Scholes, and when the policyholder exhibits a constant force of mortality.

02:40-03:05 p.m.

Title: Green Nested Simulation of Variable Annuities

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 efficient nested simulation procedure for tail risk estimation by recycling existing simulation output. The procedure can be applied to nested simulation of a wide range of VA products, including path-dependent

GMWBs. Our numerical results show that the green nested simulation procedure can be an order of magnitude more accurate that a standard nested simulation procedure.

03:05-03:30 p.m.
Title: Efficient Valuation of Variable Annuity Portfolios With Dynamic Programming
Presenter: Thorsten Moenig, Temple University
Abstract: The valuation of variable annuity (VA) portfolios provides major challenges for life insurers. Recent studies propose approximation methods at the portfolio level based on selecting a few representative guarantees. In contrast, I present a "bottom-up" valuation approach based on recursive dynamic programming (RDP), detail its implementation under various financial market models and show that the approximation performs well for all common guarantee types. Since the RDP approach determines the guarantee value at inception recursively, its potential future values are obtained simultaneously as functions of the relevant attributes ("state variables") on a discrete grid at no additional cost. All major computations occur at the pricing stage, and the later portfolio valuation is reduced to a single interpolation per in-force policy. Its minimal online computation time, accuracy, tractability and portability make the RDP approach ideally suited for valuing large VA portfolios. Moreover, RDP can naturally incorporate optimal policyholder behavior into the insurer's valuation.

3-PS-C Optimization

02:15-02:40 p.m.
Title: Bilateral Risk Sharing with Heterogeneous Beliefs and Exposure Constraints
Presenter: Mario Ghossoub, University of Waterloo
Abstract: This paper studies bilateral risk sharing under no aggregate uncertainty, where one agent has Expected-Utility preferences and the other agent has Rank-Dependent Utility preferences with a general probability distortion function. We impose exogenous constraints on the risk exposure for both agents, and we allow for any type or level of belief heterogeneity. We show that Pareto-optimal risk-sharing contracts can be obtained via a constrained utility maximization under a participation constraint of the other agent. This allows us to give an explicit characterization of optimal risk-sharing contracts. In particular, we show that an optimal risk-sharing contract contains allocations that are monotone functions of the likelihood ratio, where the latter is obtained from Lebesgue's Decomposition Theorem.

02:40-03:05 p.m.
Title: Optimal Investment and Consumption With Forward Preferences and Uncertain Parameters
Presenter: Wing Fung Chong, University of Illinois at Urbana-Champaign
Abstract: This talk solves the optimal investment and consumption strategies for a risk-averse and ambiguity-averse agent in an incomplete financial market with model uncertainty. The model uncertainty stems from drift and volatility processes for risky stocks in the financial market. The agent seeks her best and robust

strategies via optimizing her robust forward investment and consumption preferences. Her robust forward preferences and the associated optimal strategies are represented by solutions of infinite horizon backward stochastic differential equations, coupled with ordinary differential equations.

03:05-03:30 p.m.
Title: Portfolio Optimisation Within a Wasserstein Ball
Presenter: Silvana Pesenti, University of Toronto
Abstract: We consider the problem of active portfolio management where a loss-averse and/or risk-seeking investor aims to outperform a benchmark strategy's risk profile while staying ``close'' to the benchmark. Specifically, an investor considers alternative strategies whose (a) cost does not exceed that of the benchmark's, (b) whose terminal wealth and that of the benchmark's is comonotonic, and (c) whose terminal wealth lies within a Wasserstein ball around the benchmark's. The investor's personal risk profile is modelled by minimising a distortion risk measure. We prove that the optimal dynamic strategy exists and is unique, and provide a characterisation of the optimal strategy through the notion of isotonic projections. Moreover, we illustrate how investors with different risk preferences invest using the Tail Value-at-Risk and inverse S-shaped risk measures as examples.

Concurrent Sessions 4

03:45-05:00 p.m.

4-PS-A Health Economics

03:45-04:10 p.m.
Title: Trends in Pre-Diabetes: A Longitudinal Study of a South African Cohort
Presenter: Sam Zhang, University of California, Santa Barbara
Abstract: Diabetes can cause many different types of health issues. Therefore, preventing prediabetes patients transitioning to diabetes could improve patient health and lower the cost for both the patient and the insurance company. Using a database of South African lifestyle and clinical data the goal of our project is to determine the possible factors that are associated with the transition from prediabetes to diabetes from a few different perspectives including lifestyle and behavior.

04:10-04:35 p.m.
Title: Polypharmacy, Medication Possession and Deprescribing of Potentially Non-Beneficial Drugs In Hospice Patients
Presenter: Ian Duncan, University of California, Santa Barbara
Abstract: Patients at end of life frequently have comorbidities that when combined with their primary diagnosis qualify the patient for hospice. Consequently, patients are at risk for polypharmacy due to the number of medications prescribed to treat both the underlying conditions and the related symptoms. Polypharmacy is associated with negative consequences, including increased risk for adverse drug events, drug–drug and

drug–disease interactions, reduced functional status and falls, multiple geriatric syndromes, medication nonadherence, and increased mortality. Polypharmacy also increases the complexity of medication management for caregivers and contributes to the cost of prescription drugs for hospices and patients. Deprescribing or removing nonbeneficial or ineffective medications can reduce polypharmacy in hospice. We study medication possession ratios and rates of deprescribing of commonly prescribed but potentially nonbeneficial classes of medication using a large hospice pharmacy database. Prevalence of some classes of potentially inappropriate medications is high. We report possession ratios for 10 frequently prescribed classes, and, because death and prescription termination are competing events, we calculate prescription termination rates using Cumulative Incidence Functions. Median duration of antifungal and antiviral medications is brief (5 and 7 days, respectively), while statins and diabetes medications have slow discontinuance rates (median termination durations of 93 and 197 days). Almost all patients with a proton pump inhibitor prescription have the drug for their entire hospice stay. Data from this study identify those drug classes that are commonly deprescribed slowly, suggesting drug classes and diagnoses that hospices may wish to focus on more closely, as they act to limit polypharmacy and reduce prescription costs.

4-PS-B Loss Reserving

03:45-04:10 p.m.

Title: Tort Reform and Physician Moral Hazard

Presenter: Juan Zhang, NAIC

Abstract: States have been enacting tort reforms to reduce the liability of physicians conducting malpractice. However, tort reform may create a moral hazard because physicians may take less care due to reduced liability. This paper investigates whether physician moral hazard presents after tort reform. I study this problem through the lens of medical malpractice insurers who, as the primary payer of medical malpractice claims, have the data and ability to predict the behavioral changes of physicians as well as patients. I look at insurers' post-reform revisions on loss reserves, which were the overall changes in future expected malpractice losses and can be affected by three factors – physician moral hazard, patients filing fewer claims, and caps on loss payments. Physician moral hazard causes an increase in the expected malpractice losses, whereas the other two factors both lead to reduced loss payments. The loss reserve revision is estimated through the full information reserve revision, which is the reported incurred losses minus an actuarial prediction based on a regression method and previous year's reserve data. The main identification strategy is a difference-in-difference model. I find that after controlling for state and firm characteristics, insurers adjust loss reserves upward after the enactment of the reform to punitive damages and the reform to joint and several liability rules, indicating the prevalence of physician moral hazard. Punitive damages may unpredictably lead to a catastrophic jury verdict against physicians, and the joint and several liability rules can make physicians liable for losses of others who are jointly liable but bankrupt. The empirical results imply that tort reform that significantly lowers physicians' financial liabilities can reduce the deterrence effect of law and cause a moral hazard issue.

04:10-04:35 p.m.

Title: Macro and Micro Loss Reserves With Inflation, Discount, Trends and Dependence

Presenter: Anas Abdallah, McMaster University

Abstract: This paper addresses new issues in the loss reserving literature, that mainly reside in incorporating trend effects, inflation and discount factors for macro- and micro- level loss reserving models. This is very important for pricing and reserving considerations, as well as for decision making regarding capital issues, and more importantly for some guarantees for which the settlement of a claim takes more time, as in medical malpractice, which is the insurance coverage we focus on in our research. We propose to use an aggregate trend renewal model as a data generating process from which we study the differences between the micro-level and macro-level reserving methods. Some important theoretical results to both reserving schools of thoughts will be derived throughout this work. An empirical illustration is also performed on a real database and under practical considerations, where our model is calibrated for micro-and macro-level loss reserving methods. A simulation study of these methods is also be presented.

Poster Session

05:30-06:30 p.m.

Title: Sensitivity Analysis With Chi-Square Divergences

Presenter: Vaishno Devi Makam, University of London

Abstract: An approach to sensitivity analysis for quantitative risk models is introduced with an aim to identify the most influential inputs of a model. The Chi-square divergence is minimised to obtain a change of measure by stressing the expectation of a desired random variable which is further used to produce a stress on the distribution of any chosen random variable. We give an explicit solution to the minimization problem, which yields a Radon-Nikodym derivative that is a piecewise linear function of the random variable whose expectation is being stressed. In our approach, we first stress the expectation of the output and monitor the distribution of the inputs; in the second, we stress the expectation of all inputs, and evaluate the change in the output. Specific sensitivity measures are also introduced to evaluate the sensitivities of the input factors such that a high sensitivity value would be tantamount to a substantial change in the distribution of an input factor. Further, a simulation study is used to quantify the sampling error in the calculation of the sensitivity measures, showing that the Chi-square divergence performs better than Kullback-Leibler divergence in that respect.

Title: Joint Generalized Quantile and Conditional Tail Expectation Regression for Insurance Risk Analysis

Presenter: Albert Pitarque, University of Barcelona

Abstract: Based on recent developments in joint regression models for quantile and expected shortfall (or conditional tail expectation), this paper seeks to develop models to analyse the risk in the right tail of the distribution of non-negative dependent random variables. At the same time, we have shown that using standard linear regression versions there were predictions that did not fall within a plausible range of the

response variable and predictions for which the conditional tail expectation were greater than for their respective quantile. We propose an algorithm to estimate conditional tail expectation regressions, introducing generalized risk regression models with link functions that are similar to those in generalized linear models and, to preserve the natural ordering of risk measures conditional on a set of covariates, adding extra non-negative terms to the quantile regression. A case using telematics data in motor insurance illustrates the practical implementation of predictive risk models and their potential usefulness in actuarial analysis. We have shown that conditional tail expectation predictive modelling is helpful to locate risky drivers in a telematics data set. These methods are easy to implement and can guide risk analysis when there is exogenous information to be considered on the right side of the distribution of a positive response variable. Our case study shows that risk regression can be applied to the identification of bad drivers and may guide portfolio selection in motor insurance companies once a level of risk appetite has been chosen.

Title: Modelling Bivariate Count Data With Copula-Based Finite Mixture Models
Presenter: Lluis Bermúdez, University of Barcelona
Abstract: Modelling bivariate (or multivariate) count data has received interest in the recent years. The aim is to modelling the number of different but correlated counts taking into account covariate information. Bivariate Poisson regression models based on the shock model approach are widely used because of its simple form and interpretation. However, these models does not allow for overdispersion or negative correlation and thus some other models have been proposed in the literature to avoid these limitations. The present paper proposes a copula- based bivariate finite mixture model. The new model offers some advantages since it keeps all the pros of a finite mixture, allowing for unobserved heterogeneity and clustering effects, while the copula-based derivation can produce a more flexible structure, including negative correlations. In this paper, the new approach is defined, estimation through an EM algorithm is given, and then different models are applied to an Spanish insurance claim counts database. With a 2-finite mixture bivariate Poisson regression model, assuming the existence of two type of clients described separately by each component, the modelling of the dataset can be improved. The group separation is characterized by low mean for the first component (good drivers) and high mean with higher variance for the second one (bad drivers). The different copula-based approaches allow for a wide range of marginal distributions and dependence structures.

Title: AutoSULT: An R Package for Generating Life Contingencies Problems
Presenter: Chris Groendyke, Robert Morris University
Abstract: A key component of many introductory-level life contingencies classes involves using basic relationships to compute various quantities from some standard mortality table. Because these relationships are fundamental to life contingencies, it is important that students have a firm understanding of them, which is typically gained through doing a large number of problems, ideally with detailed solutions for students to check their work. While recent LaTeX packages such as actuarialsymbol (Beauchemin and Goulet, 2019) have made the typesetting of actuarial notation somewhat less cumbersome, producing a high volume of material that utilizes this notation is still tedious. The R package AutoSULT addresses this problem by providing a series of

functions that render PDF files with randomly generated problems (and accompanying solutions) of types selected by the user. The target audience for this software is instructors of university courses covering life contingencies concepts. Instructors could generate (perhaps individualized) homework assignments, quizzes, or problem sets for use in recitation or tutorial sessions, without having to invest the time to learn all of the corresponding LaTeX code for life contingencies symbols, or to manually typeset each solution.

Title: Stochastic Mortality Modelling for Dependent Coupled Lives
Presenter: Kira Henshaw, University of Liverpool
Abstract: Broken-heart syndrome is the most common form of short-term dependence, inducing a temporary increase in an individual's force of mortality upon the occurrence of extreme events, such as the loss of a spouse. Socioeconomic influences on bereavement processes allow for suggestion of variability in the significance of short-term dependence between couples in countries of differing levels of economic development. Motivated by analysis of a Ghanaian data set, we propose a stochastic mortality model of the joint mortality of paired lives and the causal relation between their death times, in a less economically developed country than those considered in existing studies. The paired mortality intensities are assumed to be non-mean-reverting Cox- Ingersoll-Ross processes, reflecting the reduced concentration of the initial loss impact apparent in the data set. The effect of the death on the mortality intensity of the surviving spouse is given by a mean-reverting Ornstein- Uhlenbeck process which captures the subsiding nature of the mortality increase characteristic of broken-heart syndrome. Inclusion of a population wide volatility parameter in the Ornstein-Uhlenbeck bereavement process gives rise to a significant non-diversifiable risk, heightening the importance of the dependence assumption in this case. Applying the model proposed to an insurance pricing problem, we obtain the appropriate premium under consideration of dependence between coupled lives through application of the indifference pricing principle.

Title: Actuarial Formula Predictor
Presenter: Lahiru Somaratne, University of Nebraska - Lincoln
Abstract: Artificial Intelligence(AI) is proving to be an increasing formative part of human experience of the 21s t century. Whilst the industrial Actuarial applications of AI are beginning to take traction, there is vast untapped potential for AI in the field of actuarial education. The aim of this project is to build a program, which when given a certain actuarial question, the formula used in the question, and a wrong response, is able determine possible erroneous applications of the given formula used by the responder. A prototype of the program has already been developed. This program currently reads a user input and the associated formula, and identifies all variables and constants in the given formula. These variables are then permuted into an array of possible wrong values. These values are then put back into the original formula to calculate and assess the proximity of the resulting output to the original user input. All permuted equations resulting from this selection are output to the user as possible equations that could have resulted in their wrong response. The next identified upgrade is imbuing this program with the capability to build profiles of users to further accurately prognosticate erroneous formulae.

Title: Minimizing Shootings in Multi-State and Differential Equation Models of Gun Violence
Presenter: Yulong Wu, University of Michigan
Abstract: Firearm deaths and injuries are a significant problem in the United States. There are many avenues of approach for addressing the problem of gun violence: public health, injury prevention, medicine, mental health, community-based programs, legislation, and more. Gun availability and prevalence are among the most common, obvious, and possibly divisive avenues. At one end of the spectrum, some argue that widespread gun ownership and defensive gun use (DGU) are key to reducing gun violence. At the other end of the spectrum, proponents of gun control (GC) argue that measures such as background checks, court-ordered removal of firearms from individuals who are a risk to themselves or others, and safe storage practices will be more effective in reducing firearm-related injuries and fatalities. Alternatively, others argue that mental health (MH) interventions might most effectively reduce shootings. This question lends itself to mathematical modeling. We propose Markov chain multi-state and differential equation models in which individuals transition among states. Parameters that correspond to DGU, GC, and MH impact the transition probabilities or flow rates. We compute the equilibrium population distributions, examine the strategies that are most effective in reducing shootings, and determine tipping point conditions for the existence of stable low-crime equilibria.

Title: Modeling Malicious Hacking Data Breach Risks
Presenter: Hong Sun, Lanzhou University
Abstract: Malicious hacking data breaches cause millions of dollars in financial losses each year, and more companies are seeking cyber insurance coverage. The lack of suitable statistical approaches for scoring breach risks is an obstacle in the insurance industry. We propose a novel frequency-severity model to analyze hacking breach risks at the individual company level, which would be valuable for underwriting purposes. We find that breach frequency can be modeled by a hurdle-Poisson model, which is different from the negative binomial model used in the literature. The breach severity shows a heavy tail that can be captured by a nonparametric-GPD model. We further discover a positive nonlinear dependence between frequency and severity, which our model also accommodates. Both the in-sample and out-of-sample studies show that the proposed frequency-severity model that accommodates nonlinear dependence has satisfactory performance, and is superior to the other models, including the independence frequency-severity and Tweedie models.

Title: Optimal Reinsurance and Investment Problem With Default Risk and Correlation for an Insurer Under the CEV Model
Presenter: Yiqi Yan, Tianjin University
Abstract: This paper studies the optimal investment and reinsurance problem for an insurer with constant absolute risk aversion (CARA) utility. The claim process is assumed to be a Brownian motion with drift and the insurer is allowed to purchase proportional reinsurance and invest in a risk- free bond, a stock and a

defaultable bond. Moreover, the price process of the stock follows the constant elasticity of variance (CEV) model and the correlation between the risk process and the stock's price is considered. For the objective of expected utility maximization, we derive the optimal reinsurance-investment strategy explicitly for the pre-default case and the post-default case via stochastic control approach. Finally, numerical examples and sensitivity analyses are provided to illustrate the effects of model parameters on the optimal strategy.

Title: Robust Optimal Investment and Benefit Payment Adjustment Strategy for Target Benefit Pension Plans Under Default Risk
Presenter: Hui Zhao, Tianjin University
Abstract: In this paper, we consider the optimal investment and benefit payment problem for a target benefit pension (TBP) with default risk and model uncertainty. The pension fund is invested in a risk-free asset, a stock and a defaultable bond. The objective is to maximize the wealth and benefit excess from the target value or minimize the wealth and benefit gap from the target value with CARA utility. Applying stochastic control approach, we establish the Hamilton- Jacobi-Bellman equations for both the post-default case and the pre-default case, respectively. Robust optimal investment strategies and benefit payment adjustment strategies are derived explicitly for the two cases. We also consider the no-ambiguity model for degenerate case and compare the results under two cases. Numerical analyses are provided to illustrate the effects of parameters on the optimal strategies and demonstrate properties of the strategies.

Tuesday, August 11, 2020
Concurrent Sessions 5
8:00-9:15 a.m.

5-PS-A Mortality and Longevity

08:00-08:25 a.m.

Title: Mortality Forecasting Using Factor Models: Time-Varying or Time-Invariant Factor Loadings?
Presenter: Jianjie Shi, Monash University
Abstract: Many existing mortality models follow the framework of classical fac- tor model, such as Lee-Carter model and its variants. Factor loadings, which capture the relationship between age variables and latent factors, are assumed to be time-invariant. This assumption is usually too restrictive in reality as mortality datasets typically span a long period of time. Driving forces such as medical improvements, environmental changes and technological progress may influence the relationship of different variables significantly. In this paper, we first develop a factor model with time- varying factor loadings (time-varying factor model) as an extension of classical factor model for mortality modelling and forecasting. From the empirical analysis, we find that the new model can capture empirical feature of time-varying factor loadings and significantly improve mortality forecasting in the short-term. However, the classical factor model usually generates more accurate forecasting results in the long-term. We then propose a novel approach based on change-point analysis to

estimate the optimal "boundary" between short-term and long-term forecasting, which is favoured by the time-varying factor model and classical factor model, respectively. Additionally, we conduct simulation studies to show performances of the time-varying factor model under different scenarios and investigate the reasons why it is good at short-term forecasting.

08:25-08:50 a.m.

Title: Tempered Pareto-Type Modelling Using Weibull Distributions

Presenter: José Carlos Araujo-Acuna, University of Lausanne

Abstract: In various applications of heavy-tail modelling, the assumed Pareto behavior is tempered ultimately in the range of the largest data. In insurance applications, claim payments are influenced by claim management and claims may for instance be subject to a higher level of inspection at highest damage levels leading to weaker tails than apparent from modal claims. Generalizing earlier results of Meerschaert et al. (2012) and Raschke (2019), in this paper we consider tempering of a Pareto-type distribution with a general Weibull distribution in a peaks-over-threshold approach. This requires to modulate the tempering parameters as a function of the chosen threshold. We use a pseudo maximum likelihood approach to estimate the model parameters, and consider the estimation of extreme quantiles. We derive basic asymptotic results for the estimators, give illustrations with simulation experiments and apply the developed techniques to re and liability insurance data, providing insight into the relevance of the tempering component in heavy-tail modelling.

08:50-09:15 p.m

Title: Modelling Life Tables With Advanced Ages: An Extreme Value Theory Approach

Presenter: Fei Huang, University of New South Wales

Abstract: We propose a new model – we call it a smoothed threshold life table (STLT) model – to generate life tables incorporating information on advanced ages. Our method allows a smooth mortality transition from non-extreme to extreme ages, and provides objectively determined highest attained ages with which to close the life table. We proceed by modifying the threshold life table (TLT) model developed by Li, Hardy & Tan (2008). Our novel contribution is to constrain the hazard function of the two-part lifetime distribution to be continuous at the changeover point between the Gompertz and EVT models. This simple but far-reaching modification not only guarantees a smooth transition from non-extreme to extreme ages, but also provides a better and more robust fit than the TLT model when applied to a high quality Netherlands dataset. We show that the STLT model also compares favourably with other existing methods, including the Gompertz-Makeham model, logistic models, Heligman-Pollard model and Coale-Kisker method, and that a further generalisation, a time-dependent dynamic smooth threshold life table (DSTLT) model, generally has superior in-sample fitting as well as better out-of- sample forecasting performance, compared, for example, with the Cairns, Blake & Dowd (2006) model.

5-PS-B Long-Term Care

08:00-08:25 a.m.

Title: Disability and Survival Among People aged 50+: The English Longitudinal Study of Ageing
Presenter: Marjan Qazvini, Heriot-Watt University
Abstract: This study aims to investigate the association between disability and non- communicable diseases (NCDs) with survival among people aged 50 and older. We use data from 5 waves of the English Longitudinal Study of Ageing (ELSA). ELSA is based on the information provided by the participants and in this study we focus on information regarding difficulties in mobility, performing activities of daily living (ADL), performing instrumental activities of daily living (IADL) and the experience of NCDs. We apply discrete time-to-event (survival) analysis, which is an approximation to the continuous-time survival analysis. This method can be applied in situations where the exact time of, say, death is unknown and the status of individuals is only known within a time interval. We use logistic, Gompertz (clog-log) and Gumbel models and find that the logistic model performs as good as the Gompertz model. Our results confirm gender differences in health and survival and show that difficulty in mobility, ADLs, IADLs and NCDs such as cancer, Alzheimer and dementia significantly affect survival in old population with the results being more evident among men.

08:25-08:50 a.m.
Title: Demand for Reverse Mortgages: The Role of Mental Accounting and Choice Bracketing
Presenter: Tin Long Ho, University of New South Wales
Abstract: Households hold a large part of their wealth in the form of housing. Reverse mortgages allow households to access this wealth without having to sell and move. Economic theory suggests that these products should be popular, but reverse mortgage markets are small internationally. We explore the role of behavioural factors in explaining this 'reverse mortgage puzzle'. We analyse how mental accounting and choice bracketing affect the demand for reverse mortgages using a stated preference choice task. We conduct an experimental online survey administered to a sample of 948 Australian homeowners aged 60 to 80. The participants are randomly assigned to different treatment groups to examine the effect of behavioural factors on the demand for reverse mortgages. Our result shows that 43% of homeowners are interested in using reverse mortgages to plan for their retirement. We make the following contributions: (1) We are the first to test the impact of behavioural effects on the demand for reverse mortgages; and (2) we develop a presentation format for reverse mortgages that facilitates individuals' understanding of reverse mortgages and allows them to make better retirement financing decisions. Our results will allow policymakers and businesses to assess the potential demand for reverse mortgage and will inform the development of reverse mortgage markets internationally.

08:50-09:15 p.m
Title: Combining Reverse Mortgage and Long-Term Care Insurance
Presenter: Yang Shen, University of New South Wales
Abstract: This paper investigates an innovative product that combines reverse mortgage and long-term care (LTC) insurance. The policyholder will receive a lump-sum payment at inception of the contract and regular incomes if health condition worsens, that is, entering LTC states. The valuation of the no negative equity

guarantee (NNEG), which is embedded in the reverse mortgage contract to protect the policyholder from loan amount exceeding the price of their house, is discussed through the use of stochastic models for house price and interest rate which may be considered as two major factors having essential impact on reverse mortgage products. Specifically, the Arbitrage Free Nelson-Siegel model is used to describe the evolution of the interest rates through time, which incorporates three latent state variables including the level, slope and curvature of the yield curve. Together with the related house price, a five-state modelling framework is formulated, and we apply Kalman filter techniques and maximum likelihood estimation method to estimate the parameters of the model. The expression of NNEG is obtained via application forward measure techniques and Fourier cosine method. Finally, different schemes for mortgage insurance premium are designed and the implications of their solutions are discussed.

5-PS-C Demography

08:00-08:25 a.m.

Title: Using Bayesian Spatiotemporal Modeling to Understand Mortality Rates in the United States

Presenter: Zoe Gibbs, Brigham Young University

Abstract: The lifestyles and backgrounds of individuals across the United States differ widely. Some of these differences are easily measurable (ethnicity, age, income, etc.) while others are not (stress levels, empathy, diet, exercise, etc.). Though every person is unique, individuals living closer together likely have more similar lifestyles than individuals living hundreds of miles apart. In our project, we explore the spatial relationships between locations and build models to better predict both mortality rates and mortality improvement. We borrow strength from those locations which are close to each other but build flexible models which allow for the mortality rates to be very different between locations which are far apart. Specifically, we use Bayesian conditional autoregressive (CAR) models to understand the spatial and temporal variation of mortality by county in the United States.

08:25-08:50 a.m.

Title: Age Heaping in Population Data of Emerging Countries

Presenter: Andres Barajas Paz, Heriot-Watt University

Abstract: Mortality analyses have commonly focused on countries represented in the Human Mortality Database that have good quality mortality data. We address the challenge that in many countries population and deaths data can be somewhat unreliable. In many countries, for example, there is significant misreporting of age in both census and deaths data: referred to as `age heaping'. The purpose of our research is to develop Bayesian computational methods for fitting a new model for misreporting of age for countries where their population data is affected by age heaping. We design a method to improve the quality of the data by taking into account two dimensional data. Hence, we consider population and deaths data by age and by calendar years. We use this model to obtain all the parameters by using Bayesian approach. We apply this model to Canada and Mexico. To do so, we estimate a matrix of probabilities for both, true exposures and true deaths.

We show empirical results for Mexican mortality to illustrate our approach. We obtain improved exposures and death rates by reducing age heaping across all calendars years.

08:50-09:15 p.m

Title: Subnational mortality modeling: Bayesian hierarchical models with common factors

Presenter: Katja Hanewald, University of New South Wales

Abstract: China has experienced large improvements in mortality rates, but there remain substantial variations at the provincial level. This paper develops new models to project mortality at both the national and provincial levels in China. We propose two models in a Bayesian hierarchical framework based on principal components and a random walk process, and compile a new comprehensive database containing mortality data for 31 provinces over the period 1982–2010. The baseline two-level model with a national–province hierarchy allows for information pooling across provinces, common national factors and consistency conditions. The extended three-level model with a national–region–province hierarchy pools information in the region and also allows for common factors within the region. Both models provide good estimates and reasonable forecasts for China and its provinces. The baseline two-level model provides good fit and reasonable forecasts with equal width intervals for the provinces. The three-level model has a better fit with a lower deviance information criterion and provides forecast intervals reflecting regional uncertainty. The sensitivity analyses show that the forecasts are robust when changing the trend assumptions and regional groups.

Session 6
10:45 a.m.-12:00 p.m.

Concurrent Sessions 7
01:00-02:15 p.m.

7-PS-A Actuarial Modeling

01:00-01:25 p.m.

Title: On the Cost of Misspecifying Risk Categories in Pricing

Presenter: Dina Finger, University of Lausanne

Abstract: In non-life insurance, pricing is often done relative to individual criteria of policyholders. With the massive use of big data, the choice of classification algorithms to categorize policyholders into risk classes has become a crucial part of the insurer's pricing activities. Yet, classification errors may arise. In this paper we examine the impact of such misspecifications. We distinguish between two risk types and solve the insurer's optimization problem of specifying appropriate premiums for given probabilities of misspecification. We then quantify the cost of misspecifying an individual's risk type under certain conditions, and study different levels of risk tradeoffs using efficient mean-variance frontiers.

01:25-01:50 p.m.

Title: Deep Hedging of Long-Term Derivatives: A Numerical Study
Presenter: Alexandre Carbonneau, Concordia University
Abstract: This study presents a deep reinforcement learning approach for global hedging of long-term financial derivatives. A similar setup as in [1] is considered with the risk management of lookback options embedded in guarantees of variable annuities with ratchet features. The deep hedging algorithm of [2] is applied to optimize global hedging policies parametrized by neural networks with both quadratic and non-quadratic penalties. An extensive numerical study is presented to benchmark the hedging effectiveness of global policies to the local risk minimization scheme of [1] with multiple hedging instruments (e.g. underlying and standard options) and with the presence of jump risk for equity. Monte Carlo experiments demonstrate the vast superiority of non-quadratic global hedging as it results simultaneously in downside risk metrics two to three times smaller than the best benchmark and in significant hedging gains. Numerical results also indicate that non-quadratic global policies are significantly more geared towards being long equity risk which entails earning the equity risk premium.
[1]Coleman, T., Kim, Y., Li, Y., and Patron, M. (2007), Robustly hedging variable annuities with guarantees under jump and volatility risks. Journal of Risk and Insurance , vol. 74(2), pp. 347-376.
[2]Buehler, H., Gonon, L., Teichmann, J. and Wood, B. (2019), Deep hedging. Quantitative Finance, vol. 19(8), pp. 1271-1291.

01:50-02:15 p.m.
Title: LRMoE: An R Package for Flexible Actuarial Loss Modelling Using Mixture of Experts Regression Model
Presenter: Chau Lung Ngan Spark Tseung, University of Toronto
Abstract: We introduce a new R package called LRMoE, a statistical software tailor-made for actuarial applications which allows actuarial researchers and practitioners to model and analyze insurance loss frequencies and severities using the Logit-weighted Reduced Mixture-of-Experts (LRMoE) model. LRMoE offers several new distinctive features which are motivated by various actuarial applications and mostly cannot be achieved using existing packages for mixture models. Key features include a wider coverage on frequency and severity distributions and their zero inflation, the flexibility to vary classes of distributions across components, parameter estimation under data censoring and truncation, and a collection of insurance rate making and reserving functions. The package also provides several model evaluation and visualization functions to help users easily analyze the performance of the fitted model and interpret the model in insurance contexts.

7-PS-B Mortality and Longevity

01:00-01:25 p.m.
Title: Local Modeling of U.S. Mortality Rates: A Multiscale Geographically Weighted Regression Approach
Presenter: Kyran Cupido, St. Francis Xavier University
Abstract: This work provides an investigation of the presence of spatial variability in the determinants of mortality rates. Specifically, by using the age-adjusted mortality rates of the counties of the contiguous United

States, this research applies a multiscale geographically weighted regression (MGWE) approach to examine the spatial variations in the relationships between mortality rates and a diverse group of associated determinants. The results of this study demonstrate that the MGWR approach produces an interpretable and accurate account of the global, regional and local effects acting on the mortality rates of the United States. Thus, this work lays the groundwork for the consideration of spatial varying effects on mortality rates which operate at different spatial scales.

01:25-01:50 p.m.

Title: Unravelling the Contribution of Financial and Longevity Risks to Changes Over Time in Life Annuities

Presenter: Jesus-Adrian Alvarez, University of Southern Denmark

Abstract: Actuaries and risk managers are interested in developing strategies to ensure that changes in interest rates do not affect the value of a portfolio (commonly known as immunization). Similarly, there is a long-standing tradition among demographers to measure how changes over time in mortality affect summary measures such as life expectancy. In this paper, we bring together these two perspectives. We develop a new decomposition method for determining the contribution of changes in mortality and interest rates to the change in the present value of life annuities. We propose neat and intuitive formulations that allow actuaries and risk man- agers to easily asses stochastic changes in financial and longevity risks embedded in their life annuities' portfolios. To illustrate our method, we look at the long-term development of life annuity prices using financial and mortality data from the United Kingdom since 1841. We found that there is clear interplay between longevity and financial risk, where the former one was masked by high financial risk. This changed as of 1980, where life annuities became more sensitive to changes in mortality.

01:50-02:15 p.m.

Title: Forecasting Mortality With International Linkages: A Global Vector-Autoregression Approach

Presenter: Hong Li, University of Manitoba

Abstract: This paper proposes a multi-population mortality model in which the joint mortality dynamics of all populations are formulated in a large vector autoregression model with a set of contemporaneous global mortality factors. The proposed model is based on the Global Vector Autoregression (GVAR) algorithm, which has been widely applied to study large VAR systems. The essential feature of our proposed GVAR model is that the large VAR regression of age-specific mortality rates could be decomposed into population-wise local systems, with each system consisting of an autoregressive part on the population itself, and a cross- sectional part with respect to a small set of global mortality factors which contain systematic information of all populations. This decomposition could substantially reduce the extra estimation cost of including additional populations, and makes it possible to study the joint mortality dynamics of a large group of populations. Using single-age mortality data of 15 low-mortality countries as considered in Li and Lee (2005), we find that the global factors have substantial impacts on mortality improvements of individual populations, especially for the old ages. Furthermore, empirical analysis shows that the proposed GVAR model outperforms the widely used multi-population mortality models under various choice of data.

7-PS-C Actuarial Risk Theory

01:00-01:25 p.m.

Title: Ruin Probabilities for Generalisations of Cox-Renewal Risk Processes Via Time Change

Presenter: Ronnie Loeffen, University of Manchester

Abstract: We consider Lévy processes time-changed by the inverse of an independent subordinator. These non-Markovian processes are known as subdiffusive processes and contain in particular the subclass of renewal processes that are also Cox processes. Using the time change and a measure change, we show how one can characterise the distribution of the first passage time of subdiffusive processes over both constant and some non-constant boundaries. This in particular allows one to determine the ruin probability for several generalisations of Cox-renewal risk processes.

01:25-01:50 p.m.

Title: Ruin and Dividend Measures in the Renewal Dual Risk Model

Presenter: Renata Alcoforado, Universidade de Lisboa

Abstract: In this manuscript we consider the dual risk model with financial application, where the random gains (or claims, using the insurance risk model) occur under a renewal process. Most known works under the dual model target their study on optimal strategies and calculation of expected discounted future dividends. Although addressing the calculation of these expectations with a non standard perspective, our study focus on other and related problems, such as the computation of the probability of getting a dividend, the distribution of that single amount, the distribution of the number of gains to reach a given upper target (like a dividend barrier), number of gains to get ruined. We finalize these problems by presenting final closed formulae. Besides, we work a Gerber-Shiu type of penalty function under randomized observations (see Albrecher et al. 2013) but under a renewal gain process by presenting final differential equations. Some of the above problems were addressed by Afonso et al. (2013) but for the classical compound Poisson model. Some of their methods are generalized to some renewal models and other new problems are addressed. We also use methods introduced by Rodr ıguez-Mart ınez et al. (2015). We finish our manuscript by showingfigures fromnumerical examples.

01:50-02:15 p.m.

Title: A Ruin Model With a Resampled Environment

Presenter: Corina Constantinescu, University of Liverpool

Abstract: We consider a Cramér–Lundberg risk setting, where the components of the underlying model change over time. We allow the more general setting of the cumulative claim process being modeled as a spectrally positive Lévy process. We provide an intuitively appealing mechanism to create such parameter uncertainty: at Poisson epochs, we resample the model components from a finite number of d settings. It results in a setup that is particularly suited to describe situations in which the risk reserve dynamics are affected by external processes. We extend the classical Cramér–Lundberg approximation (asymptotically

characterizing the all-time ruin probability in a light-tailed setting) to this more general setup. In addition, for the situation that the driving Lévy processes are sums of Brownian motions and compound Poisson processes, we find an explicit uniform bound on the ruin probability.

Concurrent Sessions 8
02:30-03:45 p.m.

8-PS-A Financial Mathematics

02:30-02:55 p.m.

Title: Convolution Bounds on Quantile Aggregation
Presenter: Yang Liu, Tsinghua University
Abstract: The problem of quantile aggregation with dependence uncertainty has a long history in probability theory and has received an increasing attention recently due to its wide applications in problems in finance, risk management, and operations research. From a new perspective of Range-Value-at-Risk (RVaR) aggregation, we establish convolution bounds for the problem and show that these new analytical bounds are sharp in all cases with analytical formulas in the literature. Further, we propose an explicit candidate and suboptimal for the extremal dependence structure, which are verified to be useful in visualizing and realizing the extremal quantile aggregation. Moreover, we find that the convolution bound is equal to the optimal value of the dual problem through a one-to-one correspondence between the minimizers of both problems. Finally, we compare the convolution bound with the existing results by numerical examples, showing that it is not only an analytically better but also numerically quick estimator for the worst-case quantile aggregation. As applications to operations research, the convolution bound provides an analytical method for the assembly line crew scheduling problem.

02:55-03:20 p.m.

Title: A Comprehensive Framework for Flexible Group Benefit Plans
Presenter: Cherie Ng, Simon Fraser University
Abstract: Currently, most flexible group benefit plans are designed and priced based on simplified, deterministic assumptions about the plan members' option selections. These assumptions can be inadequate for pricing sound premium rates, causing instability in option enrolment, premium rates and funding status over time, which threatens the sustainability of the plan. Therefore, we propose a comprehensive framework with a novel pricing formula that incorporates both a model for claims and a model for plan members' enrolment decisions. With this framework, we study the evolution of flex plans over time. Our project provides insight into the sustainability of flex plans and serves as a tool to evaluate plan designs and to calculate sound premium rates.

03:20-03:45 p.m.

Title: Some Recent Theories for the Expected Shortfall (TVaR)

Presenter: Ruodu Wang, University of Waterloo

Abstract: The Expected Shortfall (ES/TVaR) is arguably the most important risk measure in finance and insurance. Despite its celebrated history of over 20 years, there are still new fundamental research findings on this risk measure. Depending on available time, I plan to discuss an axiomatic foundation, diversification effects, co-elicitability, and a characterization through Bayes risk. The talk is based on a series of recent working papers. Related working papers are available at http://sas.uwaterloo.ca/~wang/pages/WPS1.html

8-PS-B Predictive Modeling

02:30-02:55 p.m.

Title: Benchmarking Predictive Models for Insurance Pricing: A Story of Black Boxes and Surrogate Models

Presenter: Marie-Pier Côté, Universite Laval

Abstract: Highly regulated industries, like insurance, ask for transparent decision-making algorithms. At the same time, the competitive market drives insurer towards the use of highly sophisticated black box predictive models for pricing. We therefore present maidrr: a procedure to develop a Model-Agnostic Interpretable Data-driven suRRogate model. Insights are extracted from a black box model via partial dependence (PD) effects. A dynamic programming variant of the K-means algorithm allows to cluster feature values based on the PD effects, resulting in an optimal and reproducible segmentation of the feature space with automatic feature selection. A transparent GLM is fit using the features in a categorical format and relevant interactions. We demonstrate results from our R package maidrr with a case study on general insurance claim frequency modeling for six publicly available datasets. We show that maidrr closely approximates a gradient boosting model taken as the black box and generally outperforms other surrogates. We also compare the performance and explainability of maidrr, gradient boosting and neural nets on two real large-scale pricing tasks: a Quebec motorcycle insurance portfolio and a Belgian telematics car insurance dataset.

03:20-03:45 p.m.

Title: A Posteriori Ratemaking Using the Bivariate Negative Binomial-Inverse Gaussian Regression Model

Presenter: George Tzougas, London School of Economics

Abstract: This paper is concerned with the bivariate extension of the Negative Binomial-Inverse Gaussian regression model which was considered by Tzougas et al. (2018) in the context of insurance ratemaking. The bivariate Negative Binomial-Inverse Gaussian regression model is ideally suited for capturing overdispersion and positive dependencies in two-dimensional count data settings which as all recent studies suggest are the norm when the ratemaking consists of pricing of two different types of claim counts arising from the same policy. A novel Expectation-Maximization type algorithm is developed for maximum likelihood estimation of the parameters of the bivariate Negative Binomial-Inverse Gaussian model for which the definition of a joint probability mass function in closed form is not feasible when its marginal means are modelled in terms of covariates. In order to illustrate the versatility of the proposed estimation procedure a numerical illustration is performed on motor insurance data on the number of claims from third party liability property damage and third party liability bodily injury. Finally, the a posteriori, or Bonus-Malus, premium rates resulting from the bivariate

Negative Binomial-Inverse Gaussian regression model are compared to those determined by the bivariate Negative Binomial and Poisson-Inverse Gaussian regression models.

03:20-03:45 p.m.

Title: Predicting the Highest Health Care Utilizers Using Clustering Methods

Presenter: Margie Rosenberg, University of Wisconsin-Madison

Abstract: It has been documented that 1% of US individuals account for 20% of health care expenditures, while 5% of US individuals account for 50% of health care expenditures (Long et al. 2017). Prior methods to predict these highest utilizers mainly used logistic regression models. The disadvantage of these methods is that they are targeting a list of variables and do not treat the individual as a mixture of their characteristics. In addition, those who are the highest utilizers in one year are most often not the highest utilizers in another year. Our approach is to use a method that reflect the latent dependencies among the variables. The variables used in forming clusters reflect social determinants of health of individuals with a nationally representative data set for the working-age US population. We use a clustering method called Partitioning Around Medoids (PAM), somewhat similar to k-means, to classify individuals into clusters. Our findings show that these clusters can provide health care organizations a sampling approach to perform a first-stage audit using a small segment of the population that can help identify the highest of the utilizers.

8-PS-C Variable Annuities

02:30-02:55 p.m.

Title: High-Water Mark Fee Structure in Variable Annuities

Presenter: Yumin Wang, University of Waterloo

Abstract: The fee structure of variable annuities is important for both insurers and policyholders. A well-designed fee structure may help reduce the insurer's risk exposure and simultaneously increase the policyholder's welfare. In light of this, we propose a variable annuity with a novel high-water mark fee structure and examine its implications for both the insurer and the policyholder. From the insurer's perspective, we determine the fair insurance fees within the risk-neutral pricing framework and discuss the insurer's risk management implications. From the policyholder's perspective, we consider three types of policyholders with a mean-variance preference. We evaluate these policyholders' welfare in the context of the variable annuity with the high-water mark fee structure. A comparative analysis of policyholders' welfare under a constant and a state-dependent fee structures is also included. We find that the high- water mark fee structure can generally increase the policyholder's welfare in comparison to the other two fee structures.

03:20-03:45 p.m.

Title: Accommodation or Obfuscation? Product Innovation in the Variable Annuities Market

Presenter: Xiaochen Jing, University of Wisconsin-Madison

Abstract: Variable Annuity products, which make up a substantial part of retirement products sold by insurers, have become increasingly complex over the past decades. In this paper, we investigate the drivers for these

product innovations. We distinguish "virtuous" innovations that complete the market and "obfuscating" innovations that increase complexity without benefitting consumers. We demonstrate that both forms are potentially relevant in the Variable Annuities market, both theoretically and empirically. In particular, we document a recurring pattern where innovative products that expand the scope of attainable consumption paths in retirement are followed by many more complex variants in the same product class.

03:20-03:45 p.m.
Title: Basis Risk in Variable Annuities
Presenter: Wenchu Li, Temple University
Abstract: Variable annuities are popular personal investment products with long-term financial guarantees. Hedging these guarantees is crucial for variable annuity providers, but is complicated by basis risk, i.e. the discrepancy in returns between the underlying mutual funds and suitable hedging instruments. Enhancing fund mapping methods with machine learning techniques, we document empirically that even under favorable conditions at least 23% of the volatility of fund returns cannot be eliminated through hedging, far exceeding traditional hedging errors. However, some of this basis risk can potentially be diversified. Our findings persist across model specifications, hedging instruments, asset classes, and most Lipper Objective Codes.

Concurrent Sessions 9
04:00-05:15 p.m.

9-PS-A Actuarial Techniques for COVID-19

04:00-04:25 p.m.
Title: Pandemic Risk Management: Resources Contingency Planning and Allocation
Presenter: Runhuan Feng, University of Illinois at Urbana-Champaign
Abstract: Repeated history of pandemics such as SARS, swine flu, Ebola, Zika and COVID-19 have shown that contingency planning for pandemics is a necessary component of risk management for all organizations in modern society. Today's technology allows us to use epidemiological models to predict the spread of infectious diseases in the similar way that meteorological models are used to forecast weather. Taking advantage of epidemic models, we project the dynamics of demand and supply for medical resources at different phases of a pandemic. Such predictions provide quantitative bases for decision makers of healthcare system to understand the potential imbalance of supply and demand, and to address disparities of access to critical medical supply across different subsidiaries and in the course of the pandemic. This paper extends the concepts of reserving and capital management in the classic insurance literature and aims to provide a quantitative framework for quantifying and assessing pandemic risk, and developing optimal strategies for resources stockpiling, emergency acquisition, and spatio-temporal resource allocations.

04:25-04:50 p.m.
Title: Gaussian Process Modeling for Covid-19 Excess Deaths

Presenter: Michael Ludkovski, University of California, Santa Barbara

Abstract: We investigate the Covid-19 excess deaths using an actuarial machine learning approach to mortality modeling. Our analysis is based on the Short Term Mortality Fluctuation (STMF) database that was released in May 2020 by the Human Mortality Database and contains weekly mortality data for 22+ countries and 10+ years. In our approach, we treat the observed mortality experience as a 2-dim spatial grid indexed by (Week, Year) and hold out 2020 data to determine the difference between predicted and realized mortality. Our methodology employs Gaussian Process regression with a bespoke mean function and squared-exponential covariance and provides non-parametric credible intervals around predictions, enabling to assess the statistical significance of observed deviations. Our open-source model is written in R and is deployed publicly at https://nhanhuynh46.github.io/MOGPTutorials/SOGP_Covid19.html which will be used to illustrate and discuss the findings.

9-PS-B Cyber Risk

04:00-04:25 p.m.

Title: Statistical Modeling of Data Breaches and Its Application in Cyber Insurance

Presenter: Meng Sun, Simon Fraser University

Abstract: Data breach incidents result in severe financial loss and reputational damage, which raises the importance of using insurance to manage cyber-related risks and protect industries exposed to such risks. Different from traditional loss distribution approach that treats claims frequency and severity separately and compound their fitted distributions by convolution, we study statistical models for records of data breaches due to cyber security incidents since 2005 collected by Privacy Rights Clearinghouse. Specifically, an ordinal response variable is introduced representing different ordered severity levels based on the number of records exposed due to data breaches. The corresponding spatial location and types of breach and organization are taken into consideration as continuous and nominal categorical explanatory variables. Ordered probit regression modeling techniques and Bayesian approach are adopted to investigate the relationship between these variables. Predictions and applications of the proposed model in cyber insurance are discussed.

04:25-04:50 p.m.

Title: (Self-)Insurance of Social Networks: Dynamic Structural Percolation Model of Loss Distribution on Erdős-Rényi graphs

Presenter: Petar Jevtic, Arizona State University

Abstract: The social networks such as Facebook, Twitter, Instagram etc. are stellar examples of entrepreneurship and value creation of the 21st century's digital economy, However, in the coming decade, due to the emerging confluence of cultural, societal, political, and judicial forces, their risk landscape may be at the cusp of large scale structural changes which can place unprecedented burdens on their wealth protection. (Self-)Insurance from emerging sources of networked liabilities, such as social-media libel, harassment or cyberbullying, deep fakes, cyber-attacks, errors and omissions as well as operational failures, etc., can play a significant role in that effort. In this paper, as a main contribution to the existing body of actuarial literature, we

pro-pose a structural framework for aggregate loss distribution for networked type risks that may emerge in the context of social networks. Up to our knowledge, no previous work exists in this context. Here, we pioneer the solution which contextualizes the problem in the probabilistic graph-theoretical framework by using percolation models. As a generative example, we assume that the social network topology is represented by a Erdős-Rényi random graph where users are merely nodes. To make the framework more applicable, in the situation of contagion, when an adverse materialization of risk spreads thorough of the network, we allow for heterogeneous loss topology. The instructive numerical examples are given.

9-PS-C General Insurance

04:00-04:25 p.m.

Title: Peer-to-Peer Multi-Risk Insurance and Mutual Aid

Presenter: Samal Abdikerimova, University of Illinois at Urbana-Champaign

Abstract: Peer-to-peer (P2P) insurance is a decentralized network in which participants pool their resources together to compensate those who suffer losses. It is a revival of a centuries-old practice in many ancient societies. With the aid of internet technology, P2P insurance is a transparent, high-tech and low-cost alternative to traditional insurance and is viewed by many as a disruptor to the traditional insurance industry in the same way Uber is to the taxi industry. Despite the fast-changing landscape in this field, there has been no previous academic literature on the theoretical underpinning of P2P insurance. This paper presents the first effort to build the framework for the design and engineering of mutual aid and P2P insurance. Most of existing business models are developed to insure against a particular risk. However, even with the same type of risk, not all peers have the same loss. While differential pricing has well developed for traditional insurance, the fair allocation of cost for P2P insurance is not yet well understood. This paper presents a variety of P2P insurance/mutual aid models that facilitate the exchange of multiple risks and enable peers with different needs to financially support each other in a transparent and fair way.

04:25-04:50 p.m.

Title: Demand for Non-Life Insurance under Habit Formation

Presenter: Wenyuan Li, University of Waterloo

Abstract: This paper studies the optimal non-life insurance for an individual exhibiting internal habit formation in a life-cycle model. We show that the optimal indemnity is deductible under the expected premium principle. Under the additional assumption of exponential utility functions, we obtain the optimal strategies explicitly and find that habit formation reduces insurance coverage. Our model offers a potential explanation for global underinsurance phenomenon. Some numerical examples and sensitivity analysis are presented to highlight our theoretical results.

04:50-05:15 p.m.

Title: Developments in Multi-Factor and Multi-Cohort Continuous Time Mortality Modelling

Presenter: Michael Sherris, University of New South Wales

Abstract: This presentation draws on the research carried out at the ARC Centre of Excellence in Population Ageing Research (CEPAR) on mortality modelling over the last decade. The emphasis is on methods of most interest to practitioners in life insurance and pensions. The presentation will introduce continuous-time mortality models highlighting the analytical tractability of the models arising from closed form for cohort survival curves for the affine class of models, consistency between the mortality dynamics and the functional form of the survival curve, and the stability of parameter estimates. The models include multi-factor models reflecting level, slope and curvature changes in the mortality curve, as well as multi-cohort models that can capture differing trends, volatility and correlations by age. A comparison of fits and prediction using historical US mortality data is provided along with an application estimating a multi-cohort model and quantifying the price of mortality risk using Blackrock CORI indices.

Wednesday, August 12, 2020
Concurrent Sessions 10
7:30-8:45 a.m.

10-PS-A Actuarial Risk Theory

07:30-07:55 a.m.

Title: Dividend Barrier Strategies in a Renewal Risk Model With Phase-Type Distributed Interclaim Times
Presenter: Linlin Tian, Nankai University
Abstract: In this paper, we consider the dividend problem of the renewal risk model with phase-type distributed interclaim times and exponentially distributed claim sizes. Assume that the phases of the interclaim times can be observed. After we get some necessary conditions for the optimal phase-wise barriers, we study the optimal phase-wise barrier under the 2–order and the n–order ($n \geq 3$) phase-type distributed interclaim times separately. In the case of 2-order phase-type distributed interclaim times, we show that the phase with the higher optimal barrier is the phase with the higher intensity to the next claim. We also show that under the 2–order phase-type interclaim times, the optimal phase-wise barrier strategy is optimal among all dividend strategies. In the case of n-order ($n \geq 3$) phase-type distributed interclaim times, an iteration algorithm is presented and some numerical examples are given. Based on the numerical experiments, we bring up a conjecture that the phase with the highest barrier has the highest intensity to the next claim. We show this conjecture holds under some reasonable assumption.

07:55-08:20 a.m.

Title: Testing for Random Effects in Compound Risk Models via Bregman Divergence
Presenter: Himchan Jeong, Simon Fraser University
Abstract: Due to the inherent longitudinality of property and casualty insurance claim datasets, there have been some trials of incorporating unobserved heterogeneity of each policyholder from the repeated observations. To achieve this goal, random effects models have been proposed but theoretical discussions of

the methods to test the presence of random effects in GLM framework are still scarce. In this article, we apply model diagnostics derived from the Bregman divergence for testing robustness of a chosen prior by the modeler to possible misspecification of prior distribution both on the naive model, which assumes that random effects follow a point mass distribution as its prior distribution, and the proposed model, which assumes a continuous prior density of random effects. This approach provides insurance companies a concrete framework for testing the presence of non-constant random effects in both claim frequency and severity and furthermore appropriate hierarchical model which can explain both observed and unobserved heterogeneity of the policyholders for insurance ratemaking. Both models are calibrated using a claim dataset from the Wisconsin Local Government Property Insurance Fund which includes both observed claim counts and amounts from a portfolio of policyholders.

08:20-08:45 a.m.

Title: Collective Risk Model: Choices Between Historical Frequency and Aggregate Severity.

Presenter: Jae Youn Ahn, Ewha Womans University

Abstract: Typical risk classification procedure in insurance is consists of a priori risk classification determined by observable risk characteristics, and a posteriori risk classification where the premium is adjusted to reflect the policyholder's claim history. While using the full claim history data is optimal in a posteriori risk classification procedure, some insurance sectors, however, only use partial information of the claim history for determining the appropriate premium to charge. Classical examples include that auto insurances premium are determined by the claim frequency data and workers' compensation insurances are based on the aggregate severity. The motivation for such practice is to have a simplified and efficient posteriori risk classification procedure which is customized to the involved insurance policy. This paper compares the relative efficiency of the two simplified posteriori risk classifications, i.e. based on frequency versus severity, and provides the mathematical framework to assist practitioners in choosing the most appropriate practice.

10-PS-B Actuarial Modeling

07:30-07:55 a.m.

Title: A Generalized Linear Model for Bush Fire Insurance in Australia

Presenter: Kevin Fergusson, University of Melbourne

Abstract: Bushfires are common throughout Australia, often passing in two to five minutes, but smouldering for days. Historically, bushfires have caused loss of life and significant damage to property. We propose a generalised linear model for modelling the occurrence of bushfires, accounting for population, housing, climate and vegetation. Based on this, we compute insurance premiums for typical homes and comment on the feasibility of insurance.

07:55-08:20 a.m.

Title: Generalized Risk-Based Premiums for Insurance Guaranty Schemes

Presenter: Gaeun Lee, Sungkyunkwan University

Abstract: This paper derives generalized closed-form solutions for the risk-based premiums charged by the insurance guaranty fund. We exploit the actuarial methods of the Esscher transform and factorization formula to derive the pricing formula for premiums in ex ante insurance guaranty schemes that include early closure and capital forbearance during a grace period. To make the formulas in a generalized form, we take advantage of multi-step barrier option in a dynamic structure to reflect the sudden movement of liability and monitoring frequency of regulatory institution. Also, Doob's optional sampling theorem is used to derive early closure component. The results of this numerical analysis demonstrate how regulatory levels and capital structure affect premiums.

08:20-08:45 a.m.
Title: What Determines Life Insurance Lapsation in Kerala, India?
Presenter: Biju Mathew, Malabar Christian College
Abstract: Life insurance assumes greater significance in India due to the absence of a formal social security system, where it is restricted to a meagre 8 per cent of the formal sector workers in 2018. Although low life insurance participation and high lapse rates threaten the life insurance industry in India, few studies exist on the challenges faced by the industry. This paper analyses the determinants of life insurance lapsation in India, through a state-specific study of Kerala, the most socially developed state of India. The study utilises primary data collected from a sample of 634 life insurance policy holders, across Kerala during 2017-18, to estimate a lapse model employing the probit regression. Age, education, occupation, and income are policy holder characteristics that have a significant influence on lapsation. The supply side factors that predict lapsation are company ownership and post-sales service from the company and the distributing agent. The product features that explain lapsation are the number of policies, the product type and the contract age. The study recommends a need-based distribution of life insurance products and a flexible reinstatement of lapsed policies.

10-PS-C Quantitative Risk Management

07:30-07:55 a.m.
Title: Monte Carlo Valuation of Future Annuity Contracts
Presenter: Fabio Viviano, University of Udine
Abstract: The systematic improvements of health conditions in most industrialized countries led the insurance sector to carefully evaluate and manage the so-called longevity risk. In particular, the implementation of de-risking strategies for pension providers, e.g. buy-ins and buy-outs, involves the valuation of annuity contracts at future time horizons. In this paper, we propose a methodology for valuing such contracts based on the Least-Squares Monte Carlo (LSMC) approach. This method, originally applied for valuing American-type options, was then used in many other contexts, e.g. estimating solvency capital requirements for insurance companies. Its popularity relies essentially on its flexibility, as it is implementable regardless of model complexity. Specifically, we evaluate the distribution of future annuity values. We adopt, as first step, a simplified computational framework where just one risk factor is taken into account, i.e. longevity risk. We give

a detailed description of the valuation algorithm and provide several numerical illustrations. Furthermore, to test the efficiency of the proposed methodology, we compare our results with those obtained by applying a straightforward and time-consuming approach based on nested simulations. This comparison seems to suggest that the LSMC method provides accurate estimates of all the relevant quantities.

07:55-08:20 a.m.

Title: Optimal Reinsurance to Minimize the Probability of Drawdown Under the Mean-Variance Premium Principle

Presenter: Xia Han, Nanjing Normal University

Abstract: In this paper, we determine the optimal reinsurance strategy to minimize the probability of drawdown, namely, the probability that the insurer's surplus process reaches some fixed fraction of its maximum value to date. We assume that the reinsurance premium is computed according to the mean-variance premium principle, a combination of the expected-value and variance premium principles. We derive closed-form expressions of the optimal reinsurance strategy and the corresponding minimum probability of drawdown. Then, under the variance premium principle, we show that the safe level can never be reached before drawdown under the optimally controlled surplus process. Finally, we present some numerical examples to show the impact of model parameters on the optimal results.

08:20-08:45 a.m.

Title: On Copula-based Collective Risk Models:from Elliptical Copulas to Vine Copulas

Presenter: Rosy Oh, Ewha Womans University

Abstract: Several collective risk models have recently been proposed by relaxing the widely used but controversial assumption of independence between claim frequency and severity. Approaches include the bivariate copula model, random effect model, and two-part frequency-severity model. This study focuses on the copula approach to develop collective risk models that allow a flexible dependence structure for frequency and severity. We first revisit the bivariate copula method for frequency and average severity. After examining the inherent difficulties of the bivariate copula model, we alternatively propose modeling the dependence of frequency and individual severities using multivariate Gaussian and t-copula functions. We also explain how to generalize those copulas into vine copula. The proposed copula models have computational advantages and provide intuitive interpretations for the dependence structure. Our analytical findings are illustrated by analyzing automobile insurance data.

Concurrent Sessions 11

10:15-11:30 a.m.

11-PS-A Financial Mathematics

10:15-10:40 a.m.

Title: Haezendonck-Goovaerts Capital Allocation Rules

Presenter: Gabriele Canna, Università di Milano-Bicocca

Abstract: The paper deals with the problem of capital allocation w.r.t. a peculiar class of risk measures, namely the Haezendonck-Goovaerts (HG) ones [2, 4]. We introduce and study capital allocation rules (CARs) for Orlicz risk premia [5], generalizing the work of [6], using first an approach based on Orlicz quantiles [3] and second a more general one based on the, here introduced, concept of linking function. Further on, we use the same construction of [2] to extend the CARs previously introduced, in order to work with HG risk measures. We therefore study the properties of different CARs for HG risk measures, both in the quantile based setting and in the linking one. Finally, we provide robust versions of the introduced CARs, both considering the case of ambiguity over the probabilistic model and the one of multiple Young functions, following the scheme of [1]

[1]Bellini, F., Laeven, R. J., Rosazza Gianin, E. (2018). Robust return risk measures. Mathematics and Financial Economics, 12(1), 5-32.

[2]Bellini, F., Rosazza Gianin, E. (2008). On Haezendonck risk measures. Journal of Banking and Finance, 32(6), 986-994.

[3]Bellini, F., Rosazza Gianin, E. (2012). Haezendonck-Goovaerts risk mea-sures and Orlicz quantiles. Insurance: Mathematics and Economics, 51(1), 107-114.

[4]Goovaerts, M.J., Kaas, R., Dhaene, J., Tang, Q. (2004). Some new classes of consistent risk measures. Insurance: Mathematics and Economics, 34(3), 505-516.

[5]Haezendonck, J., Goovaerts, M. (1982). A new premium calculation principle based on Orlicz norms. Insurance: Mathematics and Economics, 1(1), 41-53.

[6]Xun, L., Zhou, Y., Zhou, Y. (2019). A generalization of Expected Shortfall based capital allocation. Statistics and Probability Letters, 146, 193-199.

10:40-11:05 a.m.

Title: Predicting the Time for the Highest Gain for the Money Makers

Presenter: Mian Adnan, Bowling Green State University

Abstract: Financial turmoil is a fear or a lucrative feature for a latent or a set of latent reasons to the investors or money makers respectively. Besides, financial organizations want to predict the financial turmoil or volatility for implementing its short run or long run derivatives and/or prerequisites as early as possible. Volatility in S & P 500 index Stock Prices signifies the financial turmoil. A step by step approach of quickly identifying the model for the most important latent variable has been inaugurated for demonstrating the capricious behavior of the time series pattern of S&P 500 index strike price-changes over time using the optimum number of predictor(s). The resultant time series model checks the series of sequences of the moving variances (and/or shapes) of the residuals to identify which set of few time points contribute the highest variation in the prices. The money makers want to predict these time points.

11:05-11:30 a.m.

Title: Insurance With Heterogeneous Preferences

Presenter: Tim J. Boonen, University of Amsterdam

Abstract: This paper studies an optimal insurance problem with finitely many potential policyholders. A monopolistic, risk-neutral insurer offers an insurance contract, and exponential utility maximizing individuals accept the offer or not. We show that it is optimal for the insurer to offer only a full insurance contract, and the price optimization problem is reduced to a finite dimension. Moreover, if individuals can individually select a proportionality factor, then we find that coinsurance is generally optimal. Since the risk-aversion parameters of individuals is generally unobserved, we present a simulation framework. We show its convergence, and provide numerical examples.

11-PS-B Predictive Modeling

10:15-10:40 a.m.

Title: Inference on Latent Factor Models for Informative Censoring

Presenter: Francesco Ungolo, Technische Universiteit Eindhoven

Abstract: We discuss the use of latent factor models to introduce point identifying assumptions on the joint distribution of the time to event and the time to censoring. We address the inferential task and analyse its application in the context of semi-parametric proportional hazard models in a fully Bayesian setting. The posterior distribution has been estimated using Stan and a simulation studies has been carried out. In addition we discuss about a few actuarial application of this modeling framework.

10:40-11:05 a.m.

Title: Discrimination-Aware Decisions in Finance and Insurance

Presenter: Carlos Araiza, University of Waterloo

Abstract: We discuss the implications of considering protected attributes when individuals are paired with measures of risk. Two examples are analyzed, a credit scoring example using simulated data is given from the perspective of the regulator and an insurance pricing scenario is analyzed in view of the underlying causal model.

11:05-11:30 a.m.

Title: Synthesizing Property & Casualty Ratemaking 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 for methodological development in actuarial science, or other fields where personal data are important. We show how to design three different types of generative adversarial networks (GANs) that can build a synthetic insurance dataset from a confidential original dataset. The goal is to obtain synthetic data that no longer contains sensitive information, but 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 use GAN architectures adapted for multi-categorical data: a Wassertein GAN with gradient penalty (MC-WGAN- GP), a conditional tabular GAN (CTGAN) and a Mixed Numerical and Categorical Differentially Private GAN (MNCDP-GAN). For transparency, the approaches are illustrated using a public dataset, the

French motor third party liability data available in the R package CAS datasets. We compare the three different GANs on various aspects; ability to reproduce the original data, the multivariate relationships, and predictive models. We find that the MC-WGAN-GP synthesizes the best data, the CTGAN is the easiest to use, and the MNCDP guarantees differential privacy.

11-PS-C Life Insurance

10:15-10:40 a.m.

Title: Is There Structural Exploitation in Life Settlement Market?

Presenter: Yujia Zhang, Renmin University of China

Abstract: Life settlement is the sale of an existing life policy to a third party for a one-time cash payment. The life settlement market has developed rapidly since 1980s and transacts billions of dollars each year. The existence of such a market is argued to benefit both policyholders and life insurers. When a policyholder experiences a liquidity crisis, the policyholder has the extra option to settle in this market, other than to hold or to surrender. In the case that the policyholder chooses to hold or settle, the life insurer also receives the benefit of deferring its financial obligation. In this paper, the claimed benefits resulting from life settlement market are investigated via leader-follower models. The purpose of the study is to understand changes in the objective values of policyholder and life insurer, due to the mechanism of life settlement, and to provide a theoretical foundation for detection and analysis of structural exploitation in the market, if any.

10:40-11:05 a.m.

Title: Hedge Interest Rate Risk: Evidence from U.S. Life Insurance Industry

Presenter: Qianlong Liu, Georgia State University

Abstract: In order to immunize themselves against the interest rate fluctuation life insurers match the duration of the asset and the liability carefully. To match the duration, life insurers can structure asset portfolios and trade interest rate derivatives as well. This paper studies how the term structure factors and cross-sectional attributes of life insurers, in particular, financial constraints and organizational forms, play a role in duration matching behaviors. Disentangling two impacts of the interest rate risk, it conjectures and shows that life insurers react to the interest rate change through two channels in a systematic pattern. Specifically, using the panel data from the U.S. life insurance industry, it indicates that the combined dollar duration in the asset and derivative portfolios is negatively associated with the level and the slope of the term structure and positively associated with the curvature. Cross-sectionally, this paper finds a U-shaped hedging pattern associated with financial constraints: insurers with both the best and the worst financial strength ratings hedge more against the interest rate risk. In terms of organizational forms, it verifies that mutual life insurers are more conservative towards taking in the interest rate risk than stock insurers because of a higher cost of external financing.

11:05-11:30 a.m.

Title: Asset-Liability Management of Life Insurers in the Negative Interest Rate Environment

Presenter: Xun Zhang, Central University of Finance and Economics

Abstract: This study investigates the asset-liability management (ALM) of life insurers in the markets with negative interest rates. Using a sample of Japanese life insurers between 1999 and 2018, we provide initial evidence that the negative interest rate environment produces a serious consequence on insurers than that in the positive interest rate environment. Given that duration matching is a tool commonly used by insurers for managing assets and liabilities, we highlight that the assumption of parallel shift of yield underlying the widely used Modified duration is invalid when interest rates become negative. To address the duration mismatch between assets and liabilities under negative interest rates, we propose a duration matching strategy based on the Vasicek stochastic model, and then derive the optimal investment and business strategies for a life insurer. Our results show that the duration matching strategy based on the Vasicek model outperforms the Modified duration strategy in the negative interest rate environment.

Concurrent Sessions 12
01:00-02:15 p.m.

12-PS-A Machine Learning

01:00-01:25 p.m.

Title: Data Augmentation for Improving Telematics based Risk Evaluation

Presenter: Sak Lee, University of Iowa

Abstract: Data augmentation, a technique from machine learning, enables researchers to increase the diversity of data, albeit synthetic, for training models without requiring further collection of data. We explore its use to alleviate the bottleneck of limited publicly available telematics data faced by researchers interested in the field of telematics based auto insurance. Models that classify drivers based on their risk profile inferred from telematics data are predominantly unsupervised with riskiness inferred from the profile of drivers in each cluster. This is largely so because telematics data accompanied by historical claim records is not publicly available. In the talk, we explore the training of a model to assign a risk score to the drivers. Specifically, telematics data is collected from a small cohort of drivers, and this data is supplemented with self-disclosed historical claim records, a self evaluation survey, and a peer assessment of riskiness. Subsequently, the data is augmented to represent the telematics data of a larger cohort of synthetic drivers with varying risk profiles based on identification of driving-events such as turns and braking in the collected telematics data. In the talk we will report the results from our implementation as well as discuss avenues for further enhancements.

01:25-01:50 p.m.

Title: A Machine Learning Approach to Incorporating Industry Mortality Table Features Into a Company's Insured Mortality Analysis

Presenter: Marc Vincelli, SCOR

Abstract: This paper introduces a novel framework for leveraging the "architecture" of an industry mortality table within a company's predictive analytics-based insured mortality analysis. The author shows that by reverse-engineering the industry mortality table into a series of higher- dimensional features and then using

those features as inputs to a nonlinear predictive model (in this case a neural net), a company can better model relationships between mortality cells across the full spectrum of ages and durations when faced with sparse experience data. One potential application of this approach is in the initial calibration of an industry mortality table, via its learned features, to a company's own experience.

01:50-02:15 p.m.
Title: Emerging Data Analytics Techniques With Actuarial Applications
Presenter: Marie-Claire Koissi, University of Wisconsin- EC
Abstract: Data analytics strongly rely on data and available techniques and analytics tools. Recent years have seen an increase in data volume worldwide. Advanced computational methods and machine learning tools have been developed to extract meaningful information from the data. The research surveyed emerging data analytics techniques and discussed their evolution and growing usage in the actuarial profession. The paper also discusses emerging data analytics techniques with potential actuarial applications.
The research work for this talk was in a large part supported by a grant from the Society of Actuaries, which is greatly acknowledged.

12-PS-B Mortality and Longevity

01:00-01:25 p.m.
Title: Adjusting for IBNR in Life Settlements Mortality Using Cure Rate Models
Presenter: Hong Beng Lim, University of Iowa
Abstract: The trading price of life policies in the life settlements market hinges upon Life Expectancy (LE) assessments provided by specialized firms known as medical underwriters. Being a third party to the sale of life policies in the market, in compiling data on underwritten insureds, these underwriters are forced to use unreliable public data for the purpose of mortality-tracking. Adjusting for the significant proportion of IBNR deaths present in such public data is important towards fairly evaluating the quality of an underwriter's assessments. Importantly, life settlement funds regularly license data from underwriters to correct for emerging biases in the LE assessments as the sizes of their held portfolios are often insufficient to credibly estimate such biases. However, existing methods for determining IBNR rates in mortality studies are either ad-hoc or require a study span not currently feasible for the life settlements industry. We propose the use of cure rate models from survival analysis towards coherently estimating mortality rates in the presence of IBNR deaths. We demonstrate that, suitably adapted, these models can yield estimates of the underlying mortality rates superior in accuracy to those given by existing methods.

01:25-01:50 p.m.
Title: Stacked Regression Ensemble Learning for Mortality Forecasting
Presenter: Salvatory Kessy, University of New South Wales
Abstract: Model combination aggregates the forecasts produced from different models, and it often generates more accurate forecasts than a forecast from the best single model. The prime limitation of existing model

combination techniques in mortality modelling is that the model selection is not treated in conjunction with the model combination. Furthermore, an ongoing challenge is the development of a broadly applicable horizon dependent forecasting mortality model. This paper addresses the need for a generalizable approach to mortality forecasting through the formulation of a stacked regression ensemble method that concurrently solves the problem of model selection and estimation of the model combinations to improve model predictions. The stacked regression ensemble offers a coherent way to integrate the base mortality models using a meta-learner that chooses the optimal weights by minimizing the cross-validation criterion. The developed ensemble method reduces the need for an intensive model choice on a case-by-case basis. The ensemble is demonstrated using data from the human mortality database for ages between 50 and 89. The initial results show that the ensemble outperforms the individual and the existing model combination procedures implemented in this study. This paper demonstrates that the stacked regression ensemble is an encouraging methodology for mortality rates forecasting.

01:50-02:15 p.m.

Title: The Exact Number of Members that Remove Idiosyncratic Mortality Risk In Pooled Annuity Funds

Presenter: Thomas Bernhardt, University of Michigan

Abstract: Since the financial crisis, the insurance sector seeks to reduce its risk exposure in retirement funds. Pooled annuity funds are promising candidates for future retirement products without any risk for the insurer but a possible unstable income for retirees. Partially, the instability comes from the difference between the empirical distribution of death times and the theoretical mortality distribution. Using Kolmogorov-Smirnov ideas from Statistics, we compute the exact number of members in the pool that remove that idiosyncratic risk regardless of the underlying mortality distribution.

12-PS-C Professional Actuarial Education

01:00-01:25 p.m.

Title: Academic Integrity in the Time of COVID-19

Presenter: Diana Skrzydlo, University of Waterloo

Abstract: One major concern about the rapid move to online teaching is the increased potential for academic integrity violations. Instructors and institutions have proposed solutions such as remote proctoring software or posting fake answers on cheating websites. However, these can be expensive, unfair, easy for students to circumvent, and overly focused on punishing the symptom.

My talk focuses instead on addressing the causes of cheating, while encouraging student learning and growth. By structuring the course and assessments to reduce the temptation to cheat, many time-consuming and unpleasant conversations can be avoided. When violations do occur, just as the SOA's ABCD focuses on Counselling first before Discipline, your goal should be educational and not punitive.

I will share specific examples from my teaching career and how I dealt with each issue, and attendees will come away with practical suggestions to use in their own courses.

01:25-01:50 p.m.

Title: Enhancing the Utility of Complex Tables in Actuarial Teaching

Presenter: Russell Hendel, Towson University

Abstract: The presentation begins with two lessons of identical content, that differ in the graphic organizers used to present; the contrast shows the importance of using graphic organizers (tables) in instruction and learning. Instructors and students are familiar with use of the table as a graphic organizer that compactly summarizes complex data; the main innovation of this presentation is applying the prime implicant Boolean form (PIBF), from Electrical Engineering (EE); PIBF is routinely used by EE to reduce complex truth tables to a bare minimum of core relationships. PIBF can be mechanically generated, using algebraic reduction, Karnaugh maps, and software. We apply PIBF to two complex tables in actuarial science: i) We show how PIBF illuminates the table of the 9 money growth functions in the FM preliminary track; PIBF can prevent typical student mistakes such as use of relative vs. absolute time in discounting. ii) PIBF can simplify the table of half a dozen interest rate models from the QFIQF fellowship track by identifying key drivers of closed form solutions, avoidance of negative rates, reversion to the mean, and good term structure. We believe PIBF is easy to use and can significantly enhance the teaching/learning experience.

01:50-02:15 p.m.

Title: Society of Actuaries Education Update

Presenter: Stuart Klugman, Society of Actuaries

Abstract: The COVID-19 pandemic has led to a lot of changes in SOA education and assessment. This presentation will provide an update on what has transpired and what is planned for the remainder of 2020. Other SOA education information of note will also be presented.

Concurrent Sessions 13

02:30-03:45 p.m.