2025 AAERS

Australasian Actuarial Education and Research Symposium

1 – 2 DECEMBER 2025

COLOMBO THEATRE, UNSW

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Enquiries: rasadmin@unsw.edu.au

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Welcome to AAERS 2025

Contents:

Day 1 Program

Time	Monday, 01 December 2025			Location
09:00	**Registration and Coffee**			***Colombo Foyer***
09:20 – 09:30	**Welcome and Opening Remarks** **Bernard Wong, Head of School**			***Colombo A***
09:30 – 10:30	**Keynote Address 1 – Severine Arnold, University of Lausanne** Chair: Katja Ignatieva, UNSW Sydney			***Colombo A***
10:30 – 11:00	**Morning Tea break**			***Colombo Foyer***
11:00 – 12:20	**Concurrent Session 1**			***Colombo A, B, C***
11:00 – 11:20	**Session 1A:** **Mortality Modelling I** **Chair: Han Lin Shang, Macquarie University** Forecasting Age Distribution of Deaths Across Countries: Life Expectancy and Annuity Valuation Han Lin Shang, Macquarie University	**Session 1B:** **CAT Bonds & Risk Transfer** **Chair: Maochao Xu, Illinois State University** Crypto CAT Bonds: A Framework for Transferring Catastrophic Blockchain Risk to Capital Markets Maochao Xu, Illinois State University	**Session 1C:** **Portfolio Optimisation & Risk Methods** **Chair: Liyuan Lin, Monash University** Diversification Quotient Based on Expectiles Liyuan Lin, Monash University	
11:20 – 11:40	Gradient Boosted multi-population mortality modelling with high frequency data	Design and Pricing of Catastrophe Bonds for Pandemic Risk Transfer	Robust Mean-Variance Portfolio Selection Problem with Logarithmic	

	Ziting Miao, University of Melbourne	Chang Zhai, University of Melbourne	Returns in a Non-Markovian Environment Ge Wang, Beijing University of Posts and Tele-communications	
11:40 – 12:00	Comparing Evaluation Metric for Individual- Level Mortality Forecasting via Models with Applications to Neural Network Frameworks Xiaochuan Lu, UNSW Sydney	Better Prices, Better Decisions: A New Approach to CAT Bond Premiums Yufan Lu, University of Melbourne	Dynamic Telematics-Based Risk Scoring via Factor-Augmented Integer-Valued Time Series with Machine Learning Offsets Xindi Fang, University of Melbourne	
12:00 – 12:20	Dynamic Mortality Forecasting via Mixed-Frequency State Space Models Runze Li, The University of Melbourne	Catastrophe Risk Sharing with Insurance Levy Under Distorted Probabilities Yiying Zhang, Southern University of Science and Technology, China	Continuous-time Reinforcement Learning for Robust Portfolio Optimisation Tetian Madfouni, UNSW Sydney	
12:20 – 13:30	**Lunch Break**			**Colombo Foyer**
13:30 – 14:50	**Concurrent Session 2**			***Colombo A, B, C***
13:30 – 13:50	**Session 2A:** **Mortality Modelling II**	**Session 2B:** **Climate Change & Risk I** **Chair: Rui Zhou,**	**Session 2C:** **Risk Theory & Distributions I**	

	Chair: Jean-Francois Begin, Simon Fraser University, Canada Modelling Seasonal Mortality: An age-period-cohort Approach Jean-Francois Begin, Simon Fraser University, Canada	**University of Melbourne** Climate-driven Coastal Inundation and Victorias Land Transfer Duty Risk Rui Zhou, University of Melbourne	**Chair: Katja Ignatieva, UNSW Sydney** Quantile Connectedness, Tail Spillovers, and Systemic Risk Across Energy and Financial Markets Katja Ignatieva, UNSW Sydney	
13:50 – 14:10	Forecasting Mortality: Leveraging Cause-of-Death Data Through Fully Connected Neural Network. Dion Krisnadi, University of Lausanne	Climate Risk Stress Testing for the Agricultural Sector Yaxiao Liu, UNSW Sydney	Fairness Testing for Insurance Pricing: A Statistical Inference Framework Fei Huang, UNSW Sydney	
14:10 - 14:30	What KAN Mortality Say: Smooth and Interpretable Mortality Modelling Using Kolmogorov – Arnold Networks Yuan Zhuang, UNSW Sydney	Analysing the Impact of Climate Change on Reinsurance Cycles: A Dynamic Financial Analysis (DFA) Approach Yanfeng Li, UNSW Sydney	Inhomogeneous Phase-type Modelling using Neural Network Mohammad Hossein Nezhadhaghighi, UNSW Sydney	
14:30 – 14:50	Towards Fairer Retirement Outcomes: Health-Related Mortality Modelling	Refining Vulnerability Assessment in Catastrophe (CAT) Models with Distributional	On the Sum of Lindley Random Variables: Implications of Risk Theory	

	Pramo Samarasinghe, AGA	Regression: Application to Flood Damage Forecasting Zherui Li, UNSW Sydney	Enrique Calderin, University of Melbourne	
14:50 - 15:30	**Afternoon Tea**			***Colombo Foyer***
15:30 – 16:30	**Keynote Address 2 – Susan Thorp, University of Sydney** Chair: Katja Hanewald, UNSW Sydney			***Colombo A***
16:30 – 17:50	**Concurrent Sessions 3**			***Colombo A, B , C***
16:30-16:50	**Session 3A:** **Longevity Risk & Retirement Income** **Chair: Lingfeng Lyu, CEPAR, UNSW** Financing Aged Care with Home Equity Allowing for Government Age Pension and Aged Care Support Lingfeng Lyu, CEPAR, UNSW Sydney	**Session 3B:** **Climate Change & Risk II** **Chair: Jae Kyung Woo UNSW, Sydney** Cointegration Analysis of Crop Yields and Extreme Weather Factors using Actuaries Climate Index with Application of Bonus-malus System Jae Kyung Woo, UNSW Sydney	**Session 3C:** **Insurance Pricing and Product Design** **Chair: Alan Xian, UNSW Sydney, Taylor Fry Consulting** Beyond our Means? – A Distributional Approach to Actuarial Reserving Alan Xian, UNSW Sydney, Taylor Fry Consulting	
16:50-17:10	What Should Investment Models Say about Superannuation Returns and Asset Price Inflation	Climate Risks and Their Influence on Environmental Beliefs and Actions Across Australia	An Interpretable Deep Learning Model for General Insurance Pricing	

	Anthony Asher, UNSW Sydney	Matteo Malavasi, UNSW Sydney	Tu Pho, UNSW Sydney	
17:10 – 17:30	Longevity Risk-Sharing Programs Around the World Gayani Thalagoda, UNSW Sydney	Bayesian Learning of Regional Economic Impacts of Climate Change Shawn Yang, UNSW Sydney	Reimagining Mental Health Insurance: Co-Designing Inclusive Product Solutions for Australia Alyona Berkovich, UNSW Sydney	
17:30 – 17:50	Protection, Flexibility, and Bequests Seniors' Retirement Income Preferences Evidence from a Discrete Choice Experiment Hengzhe Zhao, Macquarie University	Measuring Systemic Climate Risk in Insurance Eugenia Fang, UNSW Sydney	Composite Distributions and their Associated Risk Measures for Auto-mobile Insurance Claims Data Williams Kumi, University of Energy and Natural Resources, Ghana	
17:50 – 18:30	**NETWORKING SESSION**			***Colombo Foyer***

Day 2 Program

Time	Tuesday, 02 December 2025			Location
08:30	**Coffee**			***Colombo Foyer***
09:00 – 10:00	**Keynote Address 3 – Peng Shi, University of Wisconsin-Madison** Chair: Qihe Tang, UNSW Sydney			***Colombo A***
10:00 – 11:20	**Concurrent Session 4**			***Colombo A, B, C***
10:00 – 10:20	**Session 4A:** **Behavioural & Systemic Finance** **Chair: Eric Ulm, Victoria University of Wellington** Risk and Time Preferences: Implications from Consumption Optimization Eric Ulm, Victoria University of Wellington	**Session 4B:** **Pension Finance & CDC** **Chair: Ping Chen, University of Melbourne** Optimal Investment-benefit Allocation for a Collective Defined Contribution Plan with Guaranteed Replacement Ratio Ping Chen, University of Melbourne	**Session 4C:** **Risk Theory & Methods II** **Chair: Colin Priest, UNSW Sydney** Turning Bloom Upside Down: Actuarial Education in the Age of Automatable Modelling Colin Priest, UNSW Sydney	
10:20 – 10:40	Pricing Carbon Emissions Permits Under the Cap-and-Trade Policy Ryan Dai, UNSW Sydney	Can Improving Longevity Literacy Motivate Interest in Life Annuities? Jaimin Yan, UNSW Sydney	Capitol Allocation and Tail Central Moments for the Multivariate Normal Mean-variance Mixture Distribution Soon Wei Tan, University of Melbourne	
10:40 – 11:00	How do Individuals Learn about Investments in Self-	Improving Pension Welfare through a Reinvestment Option	Uncertainty-Aware Neural Networks for Actuaries	

	Insurance and Self-Protection Over Time? Sophie Ma, UNSW	Darcy Harcourt, Victoria University of Wellington	Tian (Eric) Dong, UNSW Sydney	
11:00 – 11:20	Value of Reorganisation Zhen Dong Chen, UNSW Sydney	No Abstract to be presented, *please move to Colombo A or C*	Stochastic Dominance for Linear Combination of Infinite-Mean Risks Yuyu Chen, University of Melbourne	
11:20-11:30	**Quick Coffee Break**			***Colombo Foyer***
11:30 – 12:20	**Concurrent Session 5**			***Colombo A, B, C***
11:30 – 11:50	**Session 5A:** **Longevity & Annuities** **Chair: Katja Hanewald, UNSW Sydney** Cohort Trends in Intrinsic Capacity in Europe Katja Hanewald, UNSW Sydney	**Session 5B:** **Reserving & Insurance Pricing** **Chair: Greg Taylor, UNSW Sydney** Chain Ladder is not Preserved Under Aggregation of Calendar Periods Greg Taylor, UNSW Sydney	**Session 5C: Telematics & Claims Modelling** **Chair: Eric C.K Cheung, UNSW Sydney** Modelling Discrete Common-shock Risks through Matric Distributions Eric C.K Cheung, UNSW Sydney	
11:50 – 12:10	Decumulation Strategy with Long-Term Care Insurance and Guaranteed Minimum Death Benefit Yuxin Zhou, UNSW Sydney	Chain ladder and Data Granularity Greg Taylor, UNSW Sydney	Correcting Credibility Premiums using Integrated CANN with Telematics Data Mohamed Hanafy Kotb Ibrhim, UNSW Sydney	

12:10 – 12:30	Optimal Hedging of Longevity Risks for Group Self-Annuity Portfolios Yawei Wang, UNSW Sydney	Operations, Risks, and Insurance for EV-Sharing Systems Sizhe Chen, Macquarie University	Optimal Relativities in a Nonus-Malus System under Frequency-severity Dependence and Different Objective Functions Kelvin Tang, UNSW Sydney	
12:30 – 13:30	**Lunch Break**			***Colombo Foyer***
13:30 – 14:30	**Keynote Address – Win-Li Toh, Taylor Fry and the Actuaries Institute of Australia** Chair: Michael Callan, The Actuaries Institute of Australia			***Colombo A***
14:30	**Farewell and Closing Remarks**			***Colombo A***

AAERS Keynote Speakers:

Susan Thorp:

Susan Thorp is Professor of Finance at the University of Sydney Business School. Her research focuses on consumer financial decision making, especially as related to pensions and retirement finance. Her research has been published in leading international academic journals including Management Science, the Review of Finance, and the Economic Journal. She has won nationally competitive research grants amounting to over four million dollars in public and industry funding. Susan is a member of the Steering Committee of the Mercer CFA Institute Global Pensions Index, the Australian Securities and Investments Commission Consultative Panel, and was a founding director of Super Consumers Australia, the first independent consumer advocacy organisation for Australian pension fund members.

Title: The Big Picture: The Impact of Feedback and Projections on Retirement Plan Saving and Investment

Abstract: Over a working life, retirement plan participants have many opportunities to adjust contributions and investments. Failing to attend to these opportunities can be costly. Using an online experimental survey, we measure effects of giving plan participants both backward-looking and forward-looking information on sequences of contribution and investment decisions. Results reveal that feedback on past choices and projections of future retirement wealth and income lead to small increases in long-term voluntary contributions. In terms of investment decisions, participants adjust exposure to risky assets after feedback on realized returns, however projections, that do not change perceptions of the returns distribution, do not influence investment allocations. Respondents from all age groups reduce exposure to investment risk as they approach retirement, independent of projections.

Séverine Arnold:

Séverine Arnold is Professor in Actuarial Science at the University of Lausanne, Switzerland. Besides a PhD in Actuarial Science, she has a Certificate in Population Study from the University of Geneva, Switzerland. Her research focuses on longevity risk/mortality modeling, with a particular interest in cause-specific mortality rates, and on social security financial systems and inclusive insurance.

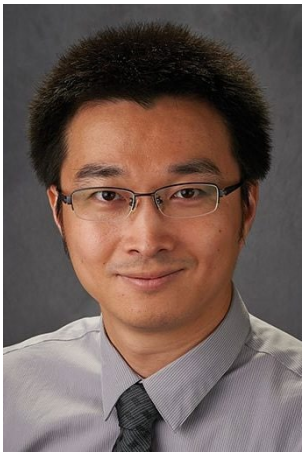
With the University of York and Liverpool, she is currently building a Consortium of Excellence for the 17 Goals (C-17), that will serve as the premier hub for Academia, Industry, NGOs and Governments from all over the world to promote and achieve the United Nations Sustainable Development Goals. Drawing its strength from Actuarial Science and related disciplines, the Consortium will become an international driver of transformative research, of research-infused innovative learning and training as well as of modern policy, aimed to facilitate the UN's 2030 Agenda for a better world.

In addition to teaching and research, she was involved in social security projects with the International Labour Organization, is the Chair of the International Actuarial Association (IAA) Life Section Research Committee, a member of the IAA Mortality Virtual Forum and a member of the Social Security Sub-Committee of the AAE (Actuarial Association of Europe). She also represents the Confederation in the Swiss Occupational Pension Supervisory Commission. More recently, she started to collaborate with the International Labour Organization on projects related to inclusive insurance.

Title: Subsidising Inclusive Insurance to Reduce Poverty

Abstract: In this article, we assess the benefits of coordination and partnerships between governments and private insurers, and provide further evidence for microinsurance products as powerful and cost-effective tools for achieving poverty reduction. To explore these ideas, we model the capital of a household from a ruin-theoretic perspective to measure the impact of microinsurance on poverty dynamics and the governmental cost of social protection. We analyse the model under four frameworks: uninsured, insured (without subsidies), insured with subsidised constant premiums and insured with subsidised flexible premiums. Although insurance alone (without subsidies) may not be sufficient to reduce the likelihood of falling into the area of poverty for specific groups of households, since premium payments constrain their capital growth, our analysis suggests that subsidised schemes can provide maximum social benefits while reducing governmental costs.

Peng Shi



Peng Shi is a Professor in the Risk and Insurance Department and the Data Science Institute at the University of Wisconsin-Madison, where he holds the Charles & Laura Albright Professorship in Business and Finance. Peng is an Associate of the Casualty Actuarial Society (ACAS) and a Fellow of the Society of Actuaries (FSA). He has worked in various capacities with companies in the property, casualty, and health (re)insurance sectors. His research has been published in leading journals in actuarial science, risk management and insurance, statistics and econometrics. He has received numerous research awards, including the Charles Hachemeister Prize, ARIA-CAS Award, Patrick Brockett & Arnold Shapiro Actuarial Award, Ronald Bornhuetter Loss Reserve Prize, CAS Ratemaking Prize, and IAA Best Paper Award, among others. Peng also serves on the editorial board of several major actuarial journals.

Title: Algorithmic Insurable Risk Portfolios: Sensitivity and Data Uncertainty

Abstract: Organizations face diverse insurable risks—from property damage and liability exposures to emerging threats such as cyberattacks. Viewing these exposures as a portfolio, similar to an asset portfolio, enables the use of data-driven optimization to guide decisions on risk retention and transfer. In this presentation, we first introduce an algorithmic framework for constructing optimal insurable risk portfolios and then examine the issue of data uncertainty—a major challenge in investment portfolio optimization—to investigate whether it similarly affects insurance portfolios. By integrating concepts from constrained optimization and stochastic sensitivity analysis, we quantify how small changes in risk parameter estimates can affect optimal insurance decisions. Both empirical evidence and theoretical analysis show that while data uncertainty can significantly impact investment portfolios, its influence on standard insurance coverages is much less severe. Together, these studies offer a practical decision-support tool for risk managers and provide theoretical insights into the stability of insurance portfolio optimization.

Win-Li Toh

Win-Li Toh is the current President of the Actuaries Institute, and a Principal at Taylor Fry Consulting. She has more than 25 years' experience as a general insurance actuary in Australia and internationally. As a pre-eminent expert on cyber risk, Win-Li authored two Actuaries Institute papers on cyber risk and the role of insurance. In recognition of her contribution to the industry, she was awarded Australian and New Zealand Institute of Insurance and Finance (ANZIIF) Insurance Leader of the Year 2023 and the Insurance Business Global Top 100 insurance professionals in 2024. Win-Li was previously Chair of the Actuaries Institute General Insurance Practice Committee and joined the Board in 2022.

Title: Cyber Risk and the Protection Gap: What Actuaries Bring

Abstract: As technology, connectivity, and AI use expand, cyber threats such as ransomware and business email compromise are growing in scale and sophistication. Beyond financial loss, these incidents damage trust and reputation. While cyber hygiene and risk mitigation are vital, insurance plays a key role in resilience. Yet, as risks evolve, the cyber protection gap-especially for SMEs-is widening. This keynote explores the causes of that gap and the unique value and insights that actuaries bring in enabling businesses and insurers make robust, evidence-based decisions that strengthen resilience and help close the gap.

AAERS Abstracts:

SESSION 1A

MORTALITY MODELLING I

Venue: Colombo A

Chair: Han Lin Shang

Title: CONFORMAL PREDICTION FOR FUNCTIONAL TIME SERIES: APPLICATION TO AGE-SPECIFIC MORTALITY RATES

Author: Han Lin Shang

Abstract:

We introduce a model-agnostic, distribution-free procedure for constructing prediction intervals for a functional time series, including age-specific mortality rates. In the family of conformal prediction, split conformal prediction divides the data into training, validation, and test sets. Within the validation set, we can select optimal tuning parameters by calibrating the empirical coverage probabilities to match their nominal values. With the selected optimal tuning parameters, we then construct the prediction intervals using the same forecasting models for the holdout data in the testing set. Without sample splitting, sequential conformal prediction sequentially updates the predicted quantiles via an autoregressive process. Using Australian age- and sex-specific log mortality rates, we evaluate and compare the interval forecast accuracy, as measured by empirical coverage probabilities and mean interval score, between the two variants of conformal prediction.

Title: GRADIENT BOOSTED MULTI-POPULATION MORTALITY MODELLING WITH HIGH-FREQUENCY DATA

Author: Zitting Miao

Abstract:

High-frequency mortality data remains an understudied yet critical research area. While its analysis can reveal short-term health impacts of climate extremes and enable more timely mortality forecasts, its complex temporal structure poses significant challenges to traditional mortality models. To leverage the power of high-frequency mortality data, this paper introduces a novel integration of gradient boosting techniques into traditional stochastic mortality models under a multi-

population setting. Our key innovation lies in using the Li and Lee model as the weak learner within the gradient boosting framework, replacing conventional decision trees. Empirical studies are conducted using weekly mortality data from 30 countries (Human Mortality Database, 2015–2019). The proposed methodology not only enhances model fit by accurately capturing underlying mortality trends and seasonal patterns, but also achieves superior forecast accuracy, compared to the benchmark models. We also investigate a key challenge in multi-population mortality modelling: how to select appropriate sub-populations with sufficiently similar mortality experiences. A comprehensive clustering exercise is conducted based on mortality improvement rates and seasonal strength. The results demonstrate the robustness of our proposed model, yielding stable forecast accuracy under different clustering configurations.

Title: COMPARING EVALUATION METRICS FOR INDIVIDUAL-LEVEL MORTALITY MODELS WITH APPLICATIONS TO NEURAL NETWORK FRAMEWORKS

Author: Xiaochuan Lu

Abstract:

There is a growing demand for individual-level mortality modelling as new survival analysis methods emerge, yet evaluating these models remains challenging because the widely used Brier score is improper, raising concerns about current practice. This paper systematically compares evaluation metrics for individual-level mortality models by proposing a set of axioms for desirable properties and designing simulations where the true model is known and censoring can be controlled. Metrics including the C-index, log-likelihood, D-calibration, and the Brier score are assessed alongside new metrics that satisfy properness, actuarial usefulness, and closeness to the true model, leading to a ranking and practical guidance for their use. With these insights, we apply the recently proposed "universe" framework to develop a neural networks model with map-to-parameter link in which everyone follows the same family of distributions with covariate-dependent parameters. Hyperparameters are tuned using validated metrics, and the model is tested against Beard's assumption that individuals follow the Gompertz law while population-level mortality exhibits a plateau. Using data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), we compare the neural network model with age-only, tree-based, proportional hazards, and boosting models. Our results extend survival modelling with deep learning components, establish robust evaluation tools, and provide comparative insights across modelling approaches, offering a principled foundation for mortality-related product pricing, retirement planning, reserving, and personalised risk management.

Title: Dynamic Mortality Forecasting via Mixed-Frequency State Space Models

Author: Runze Li

Abstract:

Accurate mortality forecasting is critical for public health planning, actuarial risk assessment, and policy development. Traditional models like Lee-Carter rely on annual mortality data, neglecting intra-year variations and real-time insights from modern high-frequency reporting. We bridge this gap with a mixed-frequency state space model that integrates two key components: (1) Lee-Carter-like observation equations linking monthly deaths and annual mortality rates to shared latent monthly factors, ensuring coherence between frequencies, and (2) a SARIMA state equation governing the latent factors to capture trend, seasonality, and autocorrelation in mortality dynamics. Parameters and latent factors are estimated via Kalman Filter/Smoother (KFS) and Expectation-Maximization (EM), with the KFS enabling real-time forecast updates as new monthly data arrives. Applied to U.S. mortality data, the model aligns with long-term trends from existing annual models while uncovering seasonal patterns (e.g., winter peaks). By unifying classical and high-frequency approaches, it enhances forecast accuracy and provides timely risk insights. The framework also allows extensions to multi-population settings, where shared latent factors could capture common trends while preserving population-specific heterogeneity.

SESSION 1B

CAT BOND & RISK TRANSFER

Venue: Colombo B

Chair: Maochao Xu

Title: CRYPTO CAT BONDS: A FRAMEWORK FOR TRANSFERRING CATASTROPHIC BLOCKCHAIN RISK TO CAPITAL MARKETS

Author: Maochao Xu

Abstract:

The rise of decentralized finance has introduced unprecedented risk exposures, with cryptocurrency ecosystems suffering substantial losses from protocol exploits, bridge failures, and smart contract breaches. These events pose systemic challenges to insurers and reinsurers, particularly as traditional underwriting models struggle to accommodate their frequency, severity, and lack of centralized oversight. In this study, we propose a catastrophe (CAT) bond framework designed to transfer extreme crypto-related risks to capital markets. Our design features a double-trigger structure based on monthly maximum and cumulative losses, capturing both short-term shocks and long-term systemic risk. We employ copula-based dependence modeling and incorporate macro-financial risk factors—such as Treasury yields and inflation—into a risk-neutral pricing model. Using large-scale simulations, we generate predictive distributions for bond prices and return rates under multiple trigger regimes, highlighting the trade-offs between investor protection and issuer solvency. To facilitate implementation, we also develop a blockchain-native architecture for on-chain issuance, settlement, and autonomous enforcement of CAT bond terms via smart contracts. This automation reduces reliance on intermediaries and ensures transparency in trigger evaluation and capital flow. Our results demonstrate that crypto CAT bonds are not only theoretically sound but also operationally viable, offering insurers a new tool for managing digital catastrophe risk while opening the door for broader investor participation in the crypto risk landscape.

Title: DESIGN AND PRICING OF CATASTROPHE BONDS FOR PANDEMIC RISK TRANSFER

Author: Chang Zhai

Abstract:

Infectious disease threats to global populations are numerous, varied, and difficult to track, imposing substantial fiscal burdens on governments. Pandemic bonds offer a promising solution by transferring pandemic-related risk to capital markets, yet their effectiveness depends on accurate disease modelling and appropriate pricing. This study integrates artificial intelligence, which has already proven valuable in economics, medicine, and social science, to enhance the epidemiological modelling and actuarial pricing of pandemic bonds. We apply neural networks to infectious disease surveillance data, demonstrating how this approach can improve epidemic prediction and risk assessment. We model healthcare costs across different disease severity levels, capturing the varying economic impacts from mild cases requiring minimal medical expenditure to severe cases necessitating intensive care hospitalisation. Leveraging these disease transmission dynamics and cost structures, we construct a pandemic bond designed to cover government losses during health emergencies. We validate our model using COVID-19 pandemic data from the United States, showing that the proposed pandemic bond would have provided timely capital to offset healthcare and economic costs during the crisis. Our results demonstrate that this financial instrument can serve as an effective risk management tool, providing governments with financial relief during outbreaks and enhanced capacity for future pandemic preparedness.

Title: BETTER PRICES, BETTER DECISIONS: A NEW APPROACH TO CAT BOND PREMIUMS

Author: Yufan Lu

Abstract:

This paper studies the pricing of Catastrophe (CAT) bonds. We show that using spread as the variable to be predicted, as is commonly done in the literature, will artificially increase the in-sample goodness of fit of the model. Furthermore, linear regression models, again commonly used in recent CAT bond pricing literature, tend to lead to non-normally distributed residual terms. As a remedy, we propose a two-part framework that models the risk premium directly using a log-normal GAMLSS, which explicitly accommodates the non-normal and heteroskedastic nature of CAT bond risk compensation. To enhance predictive power beyond standard covariates,

we construct new quarterly, issuance-weighted market indices that capture the CAT bond market's internal dynamics, showing they hold significant predictive information related to market momentum and capacity cycles. We then use a dynamic programming model to show that the improved forecast accuracy and reliable predictive distributions from our approach translate into significant economic value. By enabling a reinsurer to more confidently hedge tail risk, our model facilitates a substantial increase in market participation, unlocking welfare gains unattainable with traditional pricing models.

Title: CATASTROPHE RISK SHARING WITH INSURANCE LEVY UNDER DISTORTED PROBABILITIES

Author: Yiying Zhang

Abstract:

This paper considers a risk-sharing arrangement within catastrophe insurance, where the government implements a first-layer limit insurance by collecting the insurance levy at the time the decision-maker opts for purchasing such a kind of insurance. The levy is structured as an increasing convex function of the coverage cap. The decision-maker employs distorted probabilities, reflecting her ambiguity compared to real-world probabilities, so as to minimize her total risk exposure. This work also accounts for the insurer's potential default, in a case where the indemnities exceed the insurer's regulated capital threshold. Under the well-known risk management measures like VaR and TVaR, we identify the optimal pair, consisting of the optimal indemnity schedule and the coverage cap in the limit insurance. Numerical analyses validate our theoretical results and demonstrate how optimal strategies adapt to the levy structure, solvency constraints, and the risk attitude from the decision-maker's side.

Session 1C

PORTFOLIO OPTIMISATION & RISK METHODS

Venue: Colombo C

Chair: Liyuan Lin

Title: DIVERSIFICATION QUOTIENT BASED ON EXPECTILES

Author: Liyuan Lin

Abstract:

A diversification quotient (DQ) quantifies diversification in stochastic portfolio models based on a family of risk measures. We study DQ based on expectiles, offering a useful alternative to conventional risk measures such as Value-at-Risk (VaR) and Expected Shortfall (ES). The expectile-based DQ admits simple formulas and has a natural connection to the Omega ratio. Moreover, the expectile-based DQ is not affected by small-sample issues faced by VaR-based or ES-based DQ due to the scarcity of tail data. The expectile-based DQ exhibits pseudo-convexity in portfolio weights, allowing gradient descent algorithms for portfolio selection. We show that the corresponding optimization problem can be efficiently solved using linear programming techniques in real-data applications. Explicit formulas for DQ based on expectiles are also derived for elliptical and multivariate regularly varying distribution models. Our findings enhance the understanding of the DQ's role in financial risk management and highlight its potential to improve portfolio construction strategies.

Title: ROBUST MEAN-VARIANCE PORTFOLIO SELECTION PROBLEM WITH LOGARITHMIC RETURNS IN A NON-MARKOVIAN ENVIRONMENT

Author: Ge Wang

Abstract:

In this paper, we study an optimal portfolio selection problem with the mean-variance criterion of the logarithmic return of a portfolio and the ambiguity of the model in a non-Markovian environment. Specifically, we consider a financial market with two investment securities, namely a bond and a stock, where the interest rate of the bond, the appreciation rate and volatility of the stock depend on a stochastic factor process. To incorporate model uncertainty into the drifts of the price process of the stock and the stochastic factor process, we adopt Girsanov's change of measures

for Brownian motions and introduce a penalty term in the mean-variance objective criterion via the relative entropy. This is a time-inconsistent two-person, zero-sum stochastic differential game. Using a backward stochastic differential equation approach, we derive a Nash equilibrium of the game consisting of an equilibrium investment strategy and an equilibrium distortion process. Malliavin calculus is used to represent the second component of the solution of the backward stochastic differential equation. Physics-informed neural networks are used to numerically solve the nonlinear partial differential equation in the Markovian case. Numerical studies based on a threshold-type diffusion model with a stochastic factor are provided.

Title: DYNAMIC TELEMATICS-BASED RISK SCORING VIA FACTOR-AUGMENTED INTEGER-VALUED TIME SERIES WITH MACHINE LEARNING OFFSETS

Author: Xindi Fang

Abstract:

Traditional motor insurance pricing is based on annual premium calculations using static demographic and historical claim data. In our previous work, we investigated the impact of incorporating self-assessed driving risk measures into quarterly frequency models. Building on this foundation, high-frequency telematic data enables more granular analysis of driving risk at daily and weekly intervals.

This research develops a daily risk scoring framework that combines integer-valued time series modelling with machine learning to track individual driver risk profiles in real time and forecast claim frequencies at multiple horizons (daily, weekly, and monthly). We propose a hybrid approach integrating two key innovations: (1) a Multivariate Integer-valued Autoregressive (INAR) process with Zero-Inflated Poisson

(MZIP) structure that accounts for excess zeros across multiple risk margins in near-crash events, minor crashes, and moderate-to-severe crash frequencies; and (2) a machine learning offset where gradient-boosted trees (XGBoost) first learn complex nonlinear relationships between telematics features and a transformer model in capturing the long-term patterns. This framework provides a daily scoring system via a step-wise forecasting mechanism: one-day-ahead predictions from the proposed model feed into weekly and monthly aggregation models. This approach has been found to outperform direct-aggregation baselines by capturing intra-week volatility patterns. The multivariate structure simultaneously models multiple severity levels. In combination, these enable proactive, performance-based premium setting and support daily and weekly policy scoring alongside annual rating structures.

Title: CONTINUOUS-TIME REINFORCEMENT LEARNING FOR ROBUST PORTFOLIO OPTIMISATION

Author: Tetian Madfouni

Abstract:

Financial decision-makers often operate in environments where model parameters are difficult to estimate with confidence and over-reliance on such estimates can lead to fragile strategies. To address this challenge, we study a continuous-time reinforcement learning (RL) framework for robust portfolio optimisation. Specifically, we investigate a power utility ambiguity-averse investor in an incomplete market where we assume all model primitives are unknown and the investor aims to learn an optimal policy through interaction with the market that is robust to market misspecification. To achieve robustness, we develop parametric representations of the value function and policies which can be learned through RL methods. We then develop an actor-critic algorithm to learn the optimal robust policy and value function for the investor through interaction with an environment perturbed by the adversaries. Finally, we conduct both simulation and empirical experiments using stochastic volatility-driven stock price data to demonstrate the efficacy of our algorithm in producing robust policies relative to non-robust RL approaches, traditional RL approaches, and classical robust control approaches.

Session 2A

Mortality Modelling II

Venue: Colombo A

Chair: Jean-Francois Begin

Title: MODELLING SEASONAL MORTALITY: AN AGE–PERIOD–COHORT APPROACH

Author: Jean-Francois Begin

Abstract:

Age–period–cohort (APC) mortality models have become the standard approach in actuarial science to project mortality improvements for uses such as pricing annuities and setting contributions in pension plans. Annual mortality rates are sufficient for such long-term applications; yet, for understanding excess mortality due to, e.g., epidemics and heat waves, annual observations have important limitations, and high-frequency data need to be used. This study introduces a seasonal overlay that can be used in the context of APC models. Based on a periodic spline, this extra layer allows the model to capture seasonal features parsimoniously. In an empirical application, we fit a CBDX variant of the APC family to daily mortality data from the province of Quebec in Canada. Our dataset covers over 3.6 million individuals aged at least 60 between 1996 and 2019. Our results show significant seasonal patterns consistent with the flu season, which are similar between males and females. We also test different parametric models and find that the shape of seasonality remained constant over time for most age groups. As part of a sensitivity analysis, we investigate intra-annual mortality patterns between subgroups and report that the local climate, scheme of urbanization, and individual socio-economic status do not affect seasonal patterns. Excess mortality during 2020–2022 is also explored using our modelling framework.

Title: FORECASTING MORTALITY: LEVERAGING CAUSE-OF-DEATH DATA THROUGH FULLY CONNECTED NEURAL NETWORK

Author: Dion Krisnadi

Abstract:

Accurate mortality model is crucial for informed decision-making and effective risk management. The utilisation of richer data, including multi-country mortality data and socio-economic factors, has been explored to enrich mortality modelling, but cause-of-death data remains a valuable yet underexplored source of information. Poor data quality and complex inter-cause dependencies have posed significant challenges that hinders direct modeling. The widely used Lee-Carter (LC) model struggles to capture complex, non-linear relationships in mortality data, while its extensions often require extensive manual adjustments or restrictive assumptions. In contrast, neural networks offer a promising alternative by easily processing multiple covariates, while automatically uncovering intricate interactions and constructing new features optimized for forecasting. This study aims to leverage neural networks to enhance mortality forecasting using cause-of-death data. We start by modeling the single-year-of-age U.S. cause-of-death data from 1959 to 2017 with a feed-forward fully-connected neural network (FFNN). This architecture has demonstrated superiority over classical stochastic approaches in multi-population all-cause mortality modeling. The cause-specific mortality data is first aggregated into six categories: circulatory, neoplasm, respiratory, digestive, external, and others. We also explore the idea of transfer learning using simulated datasets. The datasets are generated by perturbing the last mortality rate in the training data with a normal random variable with zero mean and a variance estimated from the observations. 5000 time-steps are then generated for each of the six causes and two genders. Empirical analysis was performed across twelve cause-gender groups. The results demonstrate that the pretrained FFNN outperforms classical models, including LC, age-period-cohort (APC), and Renshaw-Haberman (RH), in eight of those groups. Moreover, it is shown that the network effectively captures the cause-age interaction, emphasizing its ability to capture complex mortality patterns. This highlights the potential of deep learning in cause-of-death mortality modelling and offers practical insights in managing risks associated with increasing longevity.

Title: WHAT KAN MORTALITY SAY: SMOOTH AND INTERPRETABLE MORTALITY MODELING USING KOLMOGOROV–ARNOLD NETWORKS

Author: Yuan Zhuang

Abstract:

In machine learning-based mortality models, interpretation methods are well established, and they can reveal structures resembling the age or period effects in traditional mortality models. However, in the reverse direction, using such traditional components to guide the initialization of a neural network remains highly challenging due to information loss during model interpretation. This study addresses this gap by exploring how components from pre-fitted traditional mortality models can be used to initialize neural networks, enabling structural information to be incorporated into a deep learning framework. We introduce Kolmogorov–Arnold Networks (KAN) and first construct two shallow models, KAN[2,1] and ARIMAKAN, to examine their applicability to mortality modeling. We then extend the Combined Actuarial Neural Network (CANN) into a KAN-based Actuarial Neural Network (KANN), in which classical model components calibrated via generalized nonlinear models or generalized additive models are naturally used for initialization. Three KANN variants, namely KANN[2,1], KANNLC, and KANNAPC, are proposed. In these models, neural networks assist in improving the accuracy of traditional models and help refine the original parameter estimates. All KANN-based models can also produce smooth mortality curves as well as smooth age, period, and cohort effects through simple regularization. Experiments on 34 populations demonstrate that KAN-based approaches achieve stable performance while balancing interpretability, smoothness and predictive accuracy. Joint work with Prof. Lianzeng Zhang (Nankai University)

Title: TOWARDS FAIRER RETIREMENT OUTCOMES: HEALTH-RELATED MORTALITY MODELLING

Author: Pramo Samarasinghe

Abstract:

Accurate mortality prediction underpins actuarial practice, informing insurance pricing, retirement income planning, and product design. Building on recent work documenting socio-economic mortality differentials in Australia (Huang, Hui & Villegas, 2025), this study extends the framework by incorporating health-related variables into mortality modelling for retirees. Using the Australian Bureau of Statistics' Personal Level Integrated Data Asset (PLIDA), enriched with Medicare and Pharmaceutical Benefits data, we develop interpretable models that improve

predictive accuracy while maintaining transparency for actuaries, regulators, and product designers. A range of machine learning and statistical techniques, including clustering, survival trees, and Markov processes, are employed to identify health-related subgroups and generate more accurate life expectancy estimates than traditional approaches. By grouping individuals into risk-based cohorts, the approach mitigates adverse selection risks and preserves equity in risk pooling. Preliminary results demonstrate significant gains in accuracy and fairness, with direct implications for fairer retirement product pricing and improved management of longevity risk. To facilitate adoption, the methodology translates complex models into a concise set of health-related questions suitable for insurance forms, bridging actuarial modelling and health data analytics. This work complements existing socio-economic mortality research and provides new insights into health-related mortality, offering a foundation for more accurate, transparent, and equitable retirement outcomes in Australia.

Session 2B

Climate Change & Risk I

Venue: Colombo B

Chair: Rui Zhou

Title: CLIMATE-DRIVEN COASTAL INUNDATION AND VICTORIA'S LAND TRANSFER DUTY RISK

Author: Rui Zhou

Abstract:

Climate change is increasing the frequency and severity of coastal inundation, which threatens not only households but also the fiscal position of the government. Land transfer duty—just over one-quarter of state tax revenue in Victoria—is directly exposed to property market disruptions. We develop a stochastic simulation framework to assess long-term revenue vulnerabilities under various climate scenarios, focusing on the Borough of Queenscliffe. The framework integrates high-resolution storm surge and sea-level rise projections with property valuation data at the mesh block level. Depth-damage functions calibrated from Australian engineering studies translate hazard exposures into building value losses, which are then extended to total capital improved values to capture effects on building and land prices. Market dynamics are incorporated through transaction activity: sales volumes decline when properties are damaged and recover more slowly than prices, consistent with international evidence. Uncertainty in hazard frequency, depth-damage function parameters and market responses is addressed through Monte Carlo simulation, producing probability distributions of cumulative discounted revenue shortfalls through to 2100. Results indicate material and rising fiscal risks over time, with cumulative exposures compounding across the century. By shifting focus from household losses to the fiscal resilience of government revenues, this study highlights an underexplored but critical channel of climate risk. The approach is designed to be scalable across different local government areas and regions, offering a policy-relevant framework for assessing and managing climate-related revenue vulnerabilities.

Title: CLIMATE RISK STRESS TESTING FOR THE AGRICULTURAL SECTOR

Author: Yaxiao Liu

Abstract:

Recent decades have shown that rising global temperatures intensify the frequency and severity of extreme weather and climate events, creating multilayered risks for financial systems worldwide. To better understand these risks, we develop a framework in which a variable of interest Y (e.g., financial returns or crop losses) is modeled as a linear or nonlinear function of covariates capturing climate trends, extremes, and variability. The model can be first estimated with historical data, linking observed climate variables to past outcomes in Y. Future climate projections are then applied to the fitted model, yielding a forward-looking framework that traces potential trajectories of Y under alternative climate scenarios. As a central contribution of this thesis, we apply the framework to the Australian agricultural sector, calibrating the model with national- and state-level farm performance data across 17 crops from 1989 to 2024. By integrating projections from the Coupled Model Intercomparison Project Phase 6 (CMIP6), we conduct stress tests of Australian agricultural performance under alternative climate and socio-economic pathways through 2100, providing insights into the resilience of Australian agriculture and the broader economy.

Title: ANALYSING THE IMPACT OF CLIMATE CHANGE ON REINSURANCE CYCLES: A DYNAMIC FINANCIAL ANALYSIS (DFA) APPROACH

Author: Yanfeng Li

Abstract:

Reinsurance cycles, characterised by fluctuations in reinsurance prices, can have material financial implications. Theories and experiences suggest these cycles are closely tied to reinsurers' capital levels, which could be influenced by climate change through its effects on assets and liabilities. As climate change reshapes the physical and economic landscape, its impact on reinsurance cycles requires further study, yet remains underexplored. We address this gap by proposing a Dynamic Financial Analysis (DFA) framework to assess the impact of climate change on reinsurance cycles, leveraging DFA's strength to model financial interdependencies and market dynamics. Simulation results show varying cyclical behaviours of reinsurance premiums across climate scenarios, driven by the economic growth and physical risk narratives underlying each pathway.

Title: REFINING VULNERABILITY ASSESSMENT IN CATASTROPHE (CAT) MODELS WITH DISTRIBUTIONAL REGRESSION: APPLICATION TO FLOOD DAMAGE FORECASTING

Author: Zherui Li

Abstract:

In recent years, global insured losses from natural catastrophes have been increasingly driven by more frequent, localized, and medium-severity events. This trend is influenced by climate change and socioeconomic factors such as urbanization, posing significant challenges for at-risk individuals, insurers, and regulators. To estimate uncertain losses from perils like floods, insurers typically employ catastrophe (CAT) models that simulate physical hazards and assess the vulnerability of exposed assets. However, conventional models often rely on univariate, deterministic mappings from physical parameters to damage estimates, with limited consideration of the underlying variability in vulnerability. To address this, our project proposes the use of distributional regression and deep learning alternatives to enhance traditional damage assessment techniques. The proposed approach offers three key advantages. First, it enables flexible modeling of the full probability distribution of damage across different hazard intensities. Second, it retains the core structure of traditional models by forecasting damage based on physical hazard attributes, environmental conditions, and property characteristics. Third, it preserves information about aleatoric uncertainty, allowing for the extraction of various distributional functionals—such as quantiles or exceedance probabilities—tailored to different risk management objectives. To demonstrate the application of the proposed method, we develop distributional models to assess the wide variability in flood damage using individual insurance data from the U.S. National Flood Insurance Program (NFIP). Our models allow flood parameters and building features to flexibly influence different aspects of damage distribution. Key model outputs are designed to be interpretable and comparable with existing empirical studies and actuarial CAT model frameworks. Our results highlight the promise of this approach as an alternative to conventional damage assessment methods under evolving climate risks.

Session 2C

Risk Theory & Distributions I

Venue: Colombo C

Chair: Katja Ignatieva

Title: QUANTILE CONNECTEDNESS, TAIL SPILLOVERS, AND SYSTEMIC RISK ACROSS ENERGY AND FINANCIAL MARKETS

Author: Katja Ignatieva

Abstract:

This paper examines volatility spillovers and systemic risk transmission across energy commodities, renewable assets, gold, and equity markets. Using a combination of the Forecast Error Variance Decomposition (FEVD) and quantile-based connectedness measures, we capture both average and tail-specific dynamics of cross-market linkages. The FEVD results reveal persistent roles under typical conditions: brown energy commodities act as consistent net transmitters of volatility, equities as net receivers, gold alternates between transmitter and receiver roles, and renewables remain largely absorbers until more recently. The quantile connectedness framework highlights that these roles intensify or even reverse in the tails, aligning closely with systemic episodes such as the Global Financial Crisis and the COVID-19 collapse. Brown commodities amplify contagion during downturns, equities absorb shocks more strongly in the left tail, gold switches into a transmitter role under crisis-induced price dislocations, and renewables emerge as more active transmitters after 2015, reflecting their growing integration into financial markets. Finally, we apply these insights to portfolio risk management, showing how connectedness-aware portfolios deliver systemic-risk-adjusted measures of Value-at-Risk and Expected Shortfall that better capture contagion during stress. Our findings underscore the importance of tail-specific and factor-augmented approaches for understanding systemic dynamics and designing more resilient risk management strategies

Title: FAIRNESS TESTING FOR INSURANCE PRICING: A STATISTICAL INFERENCE FRAMEWORK

Author: Fei Huang

Abstract:

Ensuring fairness in insurance pricing has become a central concern for regulators, insurers, and the public. Existing approaches often rely on descriptive disparity measures or significance testing without explicit reference to fairness concepts or acceptable tolerances, leading to fragmented practices and ambiguous conclusions. We develop a unified framework that grounds fairness testing in statistical inference. Our framework advances fairness testing along four key dimensions. First, we formalise widely discussed fairness criteria that can be potentially applied to insurance pricing contexts as hypotheses on identifiable estimands. Second, we introduce decision rules that incorporate explicit tolerance thresholds, reflecting regulatory standards in practice. Third, we propose inference procedures with prices as the central target, bridging actuarial practice with fairness guarantees. Fourth, we design a quote-audit protocol that specifies how to collect, test, and validate fairness claims in a manner that is transparent and replicable. By combining inferential rigour with regulatory practicality, our approach delivers a coherent methodology that both regulators and insurers can implement.

Title: INHOMOGENEOUS PHASE-TYPE MODELLING USING NEURAL NETWORK

Author: Mohammad Hossein Nezhadhaghighi

Abstract:

Dense distributional classes are widely used in actuarial practice—for example, mixture density networks—but mixture models can limit interpretability, may struggle to capture heavy tails consistently, and often incorporate covariates in ad-hoc ways.

To address this, a covariate-dependent IPH regression is proposed, pairing a canonical CF1 core with a neural covariate map and a matrix–Weibull time-change to achieve heavy-tail flexibility without sacrificing identifiability, tractability, or phase-level interpretability.

Inference will use likelihood-based training under right-censoring, with structure-aware matrix exponentials and light regularisation to stabilise learning. Validation is ongoing, commencing with synthetic simulations; current prototypes are promising but preliminary, and claims regarding performance, scalability, and robustness

remain to be verified. Some potential applications (E.g. individual loss reserving with incomplete data- censoring and truncation) will be discussed.

This is joint work with Eric Cheung, Patrick Laub and Jae Kyung Woo.

Title: ON THE SUM OF LINDLEY RANDOM VARIABLES: IMPLICATIONS FOR RISK THEORY

Author: Enrique Calderin

Abstract:

This paper investigates the role of the Lindley distribution in risk theory. Specifically, it derives the density function of the sum of n independent and identically distributed Lindley random variables. This density is given in terms of the Tricomi's confluent hypergeometric function. Then, for this family of distributions, some important actuarial quantities are examined, including conditional tail moments of order k, the moment transform of order k, tail risk analysis, and expressions for the distribution of the aggregate claims amount in the collective risk model. Furthermore, as the resulting density is a member of the natural exponential family of distributions, there exists a conjugate family of priors such that, given the data, the posterior distribution is of the same form. We will show that the mean of the predictive distribution can be written as a credibility formula.

Session 3A

LONGEVITY RISK & RETIREMENT INCOME

Venue: Colombo A

Chair: Lingfeng Lyu

Title: FINANCING AGED CARE WITH HOME EQUITY ALLOWING FOR GOVERNMENT AGE PENSION AND AGED CARE SUPPORT

Author: Lingfeng Lyu

Abstract:

This paper addresses the critical funding challenge of long-term care in ageing societies by examining the role of home equity in supporting retiree welfare and complementing the fiscal. This paper focuses on how home equity can enhance retirement savings, enable bequests, support living arrangements, and mitigate aged care risks in the Australian context. A recursive utility framework incorporating housingstate-dependent consumption and wait times for means-tested aged care services is adopted. Numerical experiments reveal that retirees with low to moderate net wealth are less willing to enter residential aged care facilities (RACFs). This is due to home equity being perceived as a hedge against this risk, either through generating rental income for covering RACF fees (positive hedging) or acting as a fallback resource (negative hedging). Numerical illustrations reveal that when home care packages (HCPs) are underfunded and residential care is adequately resourced, wealthier retirees tend to draw more heavily on their home equity during the aged care phase. This behaviour effectively curtails overall expenditures. Furthermore, providing timely HCP access to individuals with lower wealth helps maintain retirees' independence and pension eligibility, without significantly increasing overall government spending. These findings demonstrate the reciprocal relationship between retirees' choices and government spending, underscoring the opportunity to incorporate both demand- and supply-side factors in policy design.

Title: WHAT SHOULD INVESTMENT MODELS SAY ABOUT SUPERANNUATION RETURNS AND ASSET PRICE INFLATION

Author: Anthony Asher

Abstract:

Australia's superannuation system is widely praised for boosting retirement incomes and mobilising capital. There are however under-appreciated consequences: increased pension volatility and inflation of asset prices. The long-term, intergenerational nature of the volatility means that lower returns are likely to be unanticipated, disenchanting retirees and creating political tensions. Inflated asset prices not only exacerbate inequality but also impair innovation. This paper examines historical and projected returns with the evidence for currently inflated asset prices. It considers the capacity of domestic and international economies to absorb superannuation flows, and the political economy of inflated asset prices. In particular, the role of investment analysts in pressurising companies to focus on returns on equity undermines otherwise productive investment. It then explores potential responses—competition reforms, reductions in contributions and investment rules reducing exposure to equities—that may be more acceptable after the next major market correction. Actuarial researchers have a particular role in not perpetuating investment market models that fail to recognise the long term cycles evident in historical returns, and that fail to show that lower interest rates and high share prices suggest lower superannuation returns in future.

Title: LONGEVITY RISK-SHARING PROGRAMS AROUND THE WORLD

Author: Gayani Thalagoda

Abstract:

Longevity risk-sharing programs have emerged as a promising approach to providing lifetime income without the cost of guarantees. These programs offer income for life by sharing longevity risk among participants. Instead of relying on individual risk management or third-party guarantees, participants benefit from mortality credits, which reallocate unspent balances from deceased members to those who live longer. Despite growing interest in such programs, systematic documentation of their design and implementation remains limited. This study compiles a global inventory and develops a classification system for longevity risk-sharing programs. We identify key features that define these programs and evaluate how design elements vary across regulatory and institutional contexts. Although these programs

differ considerably in design and delivery, several key features are common: provider type, whether participation is voluntary or mandatory, lack of full guarantees on minimum payments, scope of investment choice, regulatory setting, and underwriting practices. By cataloguing and comparing existing programs, the study offers practical insights for pension providers, insurers, policymakers, and regulators, and contributes to the development of sustainable retirement income solutions that protect against longevity risk without relying solely on traditional insurance.

Title: PROTECTION, FLEXIBILITY, AND BEQUESTS, SENIORS' RETIREMENT INCOME PREFERENCES EVIDENCE FROM A DISCRETE CHOICE EXPERIMENT

Author: Hengzhe Zhao

Abstract:

Worldwide, financing the retirement incomes, health and aged care needs of an ageing and longer-lived population is a challenging policy question. Demographic changes, longer life expectancies and increased reliance on private retirement savings increases the demand for sustainable and effective retirement income products. This study employs a discrete choice experiment to investigate seniors' preferences for six important retirement income product features: income level, income stability, longevity risk protection, flexibility to withdraw lump sums, ability to make planned bequests and long-term care insurance. Retirement aged Australians chose their best and worst products among three hypothetical retirement income products described by six features. This paper explores retiree preferences for six important RIPR features, examines preference heterogeneity to segment retiree RIPR preferences and investigates explanations for RIPR preferences. Seniors strongly value risk protection and flexibility. They most favour retirement income products that offer full risk protection features and least favour products with no risk protection. However, the level of risk protection provided is less important than the provision of the risk protection feature. Significant preference heterogeneity exists for all six features which implies that RIPR providers cannot cater to retirement income needs with a 'one size fits all' product. Female and poorer retirees are more conservative than their counterparts and gender and wealth are the two retiree characteristics that segment RIPR preferences. Findings suggest that retirement income products that offer risk protection features along with flexibility will enhance retiree welfare.

Session 3B

CLIMATE CHANGE & RISK II

Venue: Colombo B

Chair: Jae Kyung Woo

Title: COINTEGRATION ANALYSIS OF CROP YIELDS AND EXTREME WEATHER FACTORS USING ACTUARIES' CLIMATE INDEX WITH APPLICATION OF BONUS-MALUS SYSTEM

Author: Jae Kyung Woo

Abstract:

The Actuaries Climate Index results from joint research funded by the actuarial professions of the US and Canada. It serves as valuable source of the frequency of extreme weather events and the extent of sea level change in the US and Canada. Using extreme weather data from the ACI and an Error Correction Model, we analyze the long-term comovement of these variables with crop yields. Our analysis suggests that significant weather variables can serve as trigger parameters in the pricing framework of weather-index crop insurance. To address the challenges of weather-index crop insurance while maintaining the advantages of a bonus-malus system (BMS), we propose a transition rule that differentiates between damages caused by severe weather and those arising from policyholder decisions. We further explore the challenges of implementing such a hybrid BMS for crop insurance, where extreme weather outcomes are incorporated into the classical BMS framework. This is joint work with Cheung, E.C.K., Ip, R.H.L., and Tam, H.O.

Title: CLIMATE RISKS AND THEIR INFLUENCE ON ENVIRONMENTAL BELIEFS AND ACTIONS ACROSS AUSTRALIA

Author: Matteo Malavasi

Abstract:

This study examines the impact of chronic and acute climate risks on proenvironmental beliefs and behaviors. Leveraging public datasets, this research investigates whether extreme weather events influence preference formation and result in climate-conscious decisions. We proxy for chronic climate risks using

deviations from long-term temperature and precipitation patterns, while we employ the definition of disasters provided by the Insurance Council of Australia, to capture the impact of acute climate risks. Our analysis then merges data on temperature and rainfall, self-reported climate beliefs, voting preferences, solar panel installation, and disaster events from 2013 to 2022. Our results suggest that chronic and acute climate risks impact pro-environmental beliefs and support for climate actions differently. Beliefs are updated only in the long run, after experiencing chronic climate risks for a sustained period of time, and are only minimally affected by acute disasters. Support for climate-aligned actions, instead, is greater in areas affected by acute disasters immediately after the events, but it diminishes as time passes, providing supporting evidence for a short-lived window of opportunity. Our study provides valuable insights for researchers, policymakers, and community leaders to develop resilient and climate-conscious communities and underscores the importance of timing for advancing climate policies.

Title: BAYESIAN LEARNING OF REGIONAL ECONOMIC IMPACTS OF CLIMATE CHANGE

Author: Shawn Yang

Abstract:

This paper develops a Bayesian learning framework to analyze the deep uncertainty surrounding the economic impacts of climate change across multiple global regions. We disaggregate GDP losses from climate damages to capture regional heterogeneity and incorporate spatial dependence to reflect cross-regional correlations. The framework enables joint learning across regions by leveraging shared information. By characterizing the dynamics of uncertainty reduction, we estimate the years required to reach target confidence levels in damage assessments across regions and sectors. The results indicate that joint learning achieves faster convergence than individual learning when the uncertain parameters follow a multivariate normal distribution. Our empirical analysis is based on the FUND model and Representative Concentration Pathways (RCPs), both of which are adopted by the Intergovernmental Panel on Climate Change (IPCC).

Title: MEASURING SYSTEMIC CLIMATE RISK IN INSURANCE

Author: Eugenia Fang

Abstract:

Climate change poses a long-term threat to the financial system that needs to be evaluated through stress testing. However, current scenarios often fail to reflect compound risk, where climate and market risks materialize simultaneously. This paper applies extreme value analysis to better capture the tail behavior of these risks. Using U.S. insurer data, we design five scenarios to assess conditional expected losses, highlighting both marginal and joint effects of climate and market stress. Findings show that isolating these risks leads to significant underestimation of potential losses. Our approach supports insurers and regulators in enhancing risk management by focusing on extreme yet plausible situations.

Session 3C

INSURANCE PRICING & PRODUCT DESIGN

Venue: Colombo C

Chair: Alan Xian

Title: BEYOND OUR MEANS? - A DISTRIBUTIONAL APPROACH TO ACTUARIAL RESERVING

Author: Alan Xian

Abstract:

Fundamentally, actuaries are asked to put a number to uncertain future events. In recognition of future uncertainty, we often provide a range of reasonable outcomes. As part of standard reserving work, actuaries present a central estimate along with a metric for uncertainty, for example, a quantile of the loss distribution in the form of a risk margin or a risk adjustment. For the purposes of assessing experience, extracting useful operational insights and updating assumptions, there is often much focus on the central estimate and less emphasis placed on the distributional information. Common methods of hindsight analysis tend to compare actual outcomes to that point estimate, with actuarial judgement used to explain differences and determine whether changes in methodology/assumptions are warranted. However, assessment of the forecast distribution provides valuable information by granting a richer understanding of the range of possible outcomes. This inherently accounts for the variability of the predicted estimate, helping to quantify how unusual each new observation is, based on the characteristics of the line of business such tail length, portfolio size and large claims volatility. In this paper, we will show that this information can be readily constructed from work already done in deriving the risk margins/adjustments. Our proposed framework applies established metrics from the field of probabilistic forecasting to assess the distributional performance of actuarial valuations, through a process that integrates easily with standard actuarial valuation pipelines. This information could be used in a number of practical applications, such as experience monitoring, a trigger for reassessment of risk margins/adjustments or as a tool to evaluate the appropriateness of the current valuation assumptions. By integrating probabilistic forecasting into actuarial valuations, actuaries can move beyond mean-based comparisons towards a more robust examination of emerging data. This will

strengthen evidence-based decision making, and will provide a more holistic, quantitative view of how our models are playing out in practice.

Title: AN INTERPRETABLE DEEP LEARNING MODEL FOR GENERAL INSURANCE PRICING

Author: Tu Pho

Abstract:

The rapid advancement of machine learning has provided an opportunity to transform the modeling techniques in actuarial analytics. Novel machine learning methods, especially deep learning, have demonstrated versatile modeling capability and superior predictive performance compared to traditional actuarial approaches such as Generalized Linear Models. However, the widespread adoption of deep learning techniques in the insurance industry is often hindered by the lack of model interpretability, as the intricacies of their inner workings remain obscured behind the complex model architecture. This lack of interpretability is further complicated by the absence of a generally accepted definition of what an interpretable model is. There are also various practical requirements, such as smoothness and monotonicity, that a pricing model in general insurance should possess in addition to being interpretable. This research introduces the Actuarial Neural Additive Model, an inherently interpretable deep learning model for general insurance pricing that offers fully transparent and interpretable results while retaining the strong predictive power of neural networks. This model assigns a dedicated neural network (or subnetwork) to each individual covariate and pairwise interaction term to independently learn its impact on the modeled output while implementing various architectural constraints to allow for essential interpretability (e.g. sparsity) and practical requirements (e.g. smoothness, monotonicity) in insurance applications. The development of our model is grounded in a solid foundation, where we establish a concrete definition of interpretability within the insurance context, complemented by a rigorous mathematical framework. Comparisons in terms of prediction accuracy are made with traditional actuarial and state-of-the-art machine learning methods using both synthetic and real insurance datasets. The results show that the proposed model outperforms other methods in most cases while offering complete transparency in its internal logic, underscoring the strong interpretability and predictive capability.

Title: REIMAGINING MENTAL HEALTH INSURANCE: CO-DESIGNING INCLUSIVE PRODUCT SOLUTIONS FOR AUSTRALIA

Author: Alyona Berkovich

Abstract:

Current insurance products in Australia often fail people with mental health conditions through costly exclusions, premium loadings, and complex claims processes, leading to financial stress and delayed care. At the same time, mental health-related claims have grown rapidly, raising concerns about equity, access, and the sustainability of risk pools. This project seeks to reimagine mental health insurance by co-designing inclusive and scalable product solutions that embed early intervention, such as digital mental health tools, alongside preventative supports to transform mental health coverage in Australia.

The project convenes insurers, regulators, consumer advocates, and people with lived experience to identify product innovations and map regulatory barriers, while employing Markov models to capture transitions across mental health conditions, recovery, and mortality. Socio-economic dimensions such as income, education, and persistence of illness are incorporated to provide an actuarial and behavioural evidence base for prototypes that align with the episodic and recovery-oriented nature of mental health conditions, while addressing affordability and sustainability.

The research contributes a white paper presenting co-designed frameworks, consumer-driven recommendations, and policy options for reform. As the first Australian study to integrate actuarial science, behavioural economics, regulatory insight, and lived-experience design, it moves beyond critique to deliver practical, evidence-informed solutions for equitable and sustainable mental health insurance.

Title: COMPOSITE DISTRIBUTIONS AND THEIR ASSOCIATED RISK MEASURES FOR AUTO-MOBILE INSURANCE CLAIMS DATA

Author: Williams Kumi

Abstract:

Insurance losses comprises of small and large claims rendering single distributions in capable of holistically capturing the different sizes together accurately. Risk measures associated with insurance losses are crucial for determining reserve levels and for assessing solvency. Hence, in estimating risk measures, the right probabilistic distributions have to be carefully fitted in order not to underestimate or over estimate associated parameters. In view of this, this paper employs a two-

component composite distribution to describe automobile insurances losses from Ghana using 11,879 data points. This research fitted 240 composite distributions and results of the top ten are selected and presented based on some goodness of fit criteria. Threshold values and mixing weights for each composite distribution is also estimated and presented. Value at Risk and Tail value at Risk are then estimated and presented for the top ten composite distributions at 95% and 99% security levels.

Session 4A

BEHAVIOURAL & SYSTEMIC FINANCE

Venue: Colombo A

Chair: Eric Ulm

Title: RISK AND TIME PREFERENCES: IMPLICATIONS FROM CONSUMPTION OPTIMIZATION

Author: Eric Ulm

Abstract:

Recent studies have provided evidence for attitudes toward financial risk across time, including inter-temporal correlation aversion, risk aversion over time lotteries, and risk-averse discounting that are not consistent with conventional time-separable utility frameworks. We show that these properties arise as features of the indirect utility over wealth that emerge from the optimization of discounted expected consumption utility subject to conventional budget constraints. As such, it is not necessary to revise standard approaches using time-separable expected consumption utility (e.g., life-cycle modeling) to account for intertemporal analogues of risk aversion for monetary payoffs at different times.

Title: PRICING CARBON EMISSION PERMITS UNDER THE CAP-AND-TRADE POLICY

Author: Ryan Dai

Abstract:

As climate change threats intensify, climate mitigation has become a central focus of government policy. This paper develops a dynamic stochastic general equilibrium model of a closed economy to examine the effects of a regional cap-and-trade system. The economy features multiple energy input sectors that produce either green or brown energy, as well as a final output sector that produces aggregate goods. Both the input and output sectors require energy for production, but only brown energy generates emissions upon use. Emission permits are initially allocated

across sectors and then traded in a competitive permit market. We show that the carbon price emerges as the shadow value of the emissions cap in the social planner's problem and, equivalently, as the equilibrium permit price in the decentralized market.

Title: HOW DO INDIVIDUALS LEARN ABOUT INVESTMENTS IN SELF-INSURANCE AND SELF-PROTECTION OVER TIME?

Author: Sophie Ma

Abstract:

Individuals often lack clear information about the effectiveness of prevention activities and instead rely on personal experience or the observed behaviour of peers. This research develops a dynamic learning framework for prevention, integrating reinforcement learning and social learning—in particular, vicarious learning—within an agent-based simulation. We distinguish between self-insurance, which reduces loss severity, and self-protection, which lowers loss frequency. Simulations over repeated periods show that the adoption rate of self-insurance increases monotonically in the baseline loss probability, reflecting clear and consistent feedback. In contrast, adoption of self-protection exhibits unstable patterns since its benefits are harder to attribute. Social learning accelerates convergence, compresses variation across risk levels, and amplifies coordination effects, producing both rapid uptake and collective collapse of prevention behaviour. These findings explain the "prevention puzzle" from a behavioural perspective and highlight how feedback and social influence can drive systematic under- or over-investment in prevention, offering guidance for designing policies that strengthen private risk management

Title: VALUE OF REORGANISATION

Author: Zhen Dong Chen

Abstract:

In 2024, U.S. bankruptcy courts received about 8,500 Chapter 11 filings, representing a 20% increase from the previous year. We examine whether creditors truly benefit from reorganization during default, given the competing interests of equity holders and creditors. Structural and reduced-form models are widely used in the credit risk literature to analyze

bankruptcy procedures, each with distinct advantages in interpretability and tractability. Traditional structural models implicitly assume that a firm's financial information is fully observable, whereas in practice much of it remains hidden from creditors. This information asymmetry makes the timing of liquidation inaccessible to creditors, as reduced-form models aim to reflect. To address this limitation, we develop a hybrid model that evaluates the added value of potential reorganization to creditors. We identify conditions under which creditors benefit from a firm's decision to reorganize upon default and derive a semi-analytical expression for this added value. Combined with simulation techniques, this yields an efficient computational scheme. Extensive numerical experiments validate our theoretical findings.

Session 4B

PENSION FINANCE & CDC

Venue: Colombo B

Chair: Ping Chen

Title: OPTIMAL INVESTMENT-BENEFIT ALLOCATION FOR A COLLECTIVE DEFINED CONTRIBUTION PLAN WITH GUARANTEED REPLACEMENT RATIO

Author: Ping Chen

Abstract:

This paper studies the integration of a guaranteed benefit payment within a Collective Defined Contribution (CDC) fund, which traditionally provides only a target benefit allocation. We develop an optimal investment-benefit framework tailored to CDC funds, accounting for the influence of salary inflation on contributions from active workers and benefits distributed for retirees. The fund trustee manages a diversified portfolio consisting of a risk-free asset, an inflation-linked bond, and equities. To address the differing risk preferences of active members and retirees, the optimization objective incorporates two Constant Relative Risk Aversion (CRRA) utility functions. Using Legendre transform techniques and dynamic programming, we derive explicit strategies for optimal investment and benefit distribution. Numerical illustrations highlight how demographic characteristics, financial market conditions, and initial parameters shape outcomes within this model. The analysis reveals key insights: on the benefit side, populations with a lower dependency ratio (fewer retirees relative to workers) are more likely to achieve benefit allocations exceeding the guaranteed level. On the investment side, the allocation to risky assets is strongly influenced by the differing risk tolerances of working members and retirees, emphasizing the importance of balancing preferences within the fund's management strategy.

Title: CAN IMPROVING LONGEVITY LITERACY MOTIVATE INTEREST IN LIFE ANNUITIES?

Author: Jaimin Yan

Abstract:

Longevity literacy is important for retirement planning and financial well-being, as individuals need to understand their lifespan to make retirement financial decisions. We con- ducted an online experiment for 1,589 Australians aged 50 to 75 to examine whether and to what extent di↵erent types of information designed to enhance longevity literacy promote longevity belief updating and influence interest in life annuities. We found that around 38% of the relevant sub-sample updated their longevity beliefs following the presentation of “objective” and “personalised” longevity information. Belief update patterns varied across information types. Our findings also showed that providing objective life expectancy infor- mation increased interest in annuities among those who updated their life expectancy beliefs upward. In contrast, eliciting longevity beliefs or providing information on personalised life expectancy, survival probability, or financial consequences did not significantly a↵ect inter- est. Our results inform strategies for policymakers, pension funds, product providers, and households to improve longevity literacy and retirement decision-making.

Title: IMPROVING PENSION WELFARE THROUGH A REINVESTMENT OPTION

Author: Darcy Harcourt

Abstract:

We explore a pension design allowing pensioners the option to reinvest a portion of their pension income back into their pension, effectively buying additional units of an actuarially fair annuity. This, in a sense, extends upon the US Social Security system’s Delayed Retirement Credits, which increase retirement benefits for those who elect to delay receiving them. We show that, for pensioners with exceptional life-expectancy, exercising this option to reinvest will be optimal early in retirement and we quantify the extent to which pensioners might utilise this option.

Session 4C

RISK THEORY & METHODS II

Venue: Colombo C

Chair: Colin Priest

Title: TURNING BLOOM UPSIDE DOWN: ACTUARIAL EDUCATION IN THE AGE OF AUTOMATABLE MODELLING

Author: Colin Priest

Abstract:

This paper argues that the mechanics of actuarial modelling are now largely automatable with large language models (LLMs), shifting the locus of actuarial value to adaptable human capabilities: creativity, critical thinking, communication, collaboration, character, competence, and confidence. Using two case studies: (1) insurance claims reserving stress tests via LLM-generated synthetic data and (2) reputation-damage risk modelling for Qantas using multi-source unstructured data, this paper shows how work becomes less mechanical and more judgement-intensive, and how fast change is emerging in actuarial use cases. Each case follows a RAG-lite → LLM reasoning/simulation → domain oversight pipeline and highlights skill shifts from low-level technical detail to governance, verification, stakeholder modelling, and communication. Rather than contradicting Bloom, this paper flips its common usage: assessment centres on observed expert process (planning, critique, adaptation) and metacognitive evidence, using prompt-driven reasoning artefacts as the primary proof of high-level actuarial thinking.

Title: CAPITAL ALLOCATION AND TAIL CENTRAL MOMENTS FOR THE MULTIVARIATE NORMAL MEAN-VARIANCE MIXTURE DISTRIBUTION

Author: Soon Wei Tan

Abstract:

Capital allocation is a procedure to allocate a total capital reserve into each individual risk components. While the conditional tail expectation (CTE)-based capital allocation is popular, its insufficiency in capturing the tail behaviour of losses necessitates a more accurate approach. In this paper, we introduce a capital allocation method based on the tail central moment (TCM) such as the tail variance. Together with the CTE, the TCM-based capital allocation method better reflects the risk profile in the tail region. We derive analytical formulas of the aggregate risk's

TCM and its allocation for the class of multivariate normal mean-variance mixture distributions, which is extremely flexible and has numerous applications in insurance and finance. An empirical analysis shows that, combining the TCM-based and CTE-based capital allocation methods better reflects the tail behaviour of equity losses than the CTE-based capital allocation method.

Title: UNCERTAINTY-AWARE NEURAL NETWORKS FOR ACTUARIES

Author: Tian (Eric) Dong

Abstract:

Reliable actuarial decisions require calibrated treatment of aleatoric (data) and epistemic (model) uncertainty. Building on distributional regression models used in practice (e.g., GAMLSS, MDNs, and DRNs), we adopt a function-space perspective and show how functional priors can encode expert knowledge regarding key distributional properties. Brief examples illustrate how this approach can improve probabilistic forecasts under proper scoring rules and result in better quantification of aleatoric and epistemic components. The talk distils practical guidance for actuaries and shares early experience with uncertainty-aware Bayesian neural networks in risk-sensitive settings.

Title: STOCHASTIC DOMINANCE FOR LINEAR COMBINATIONS OF INFINITE-MEAN RISKS

Author: Yuyu Chen

Abstract:

In this paper, we establish a sufficient condition to compare linear combinations of independent and identically distributed (iid) infinite-mean random variables under usual stochastic order. We introduce a new class of distributions that includes many commonly used heavy-tailed distributions and show that within this class, a linear combination of random variables is stochastically larger when its weight vector is smaller in the sense of majorization order. We proceed to study the case where each random variable is a compound Poisson sum and demonstrate that if the stochastic dominance relation holds, the summand of the compound Poisson sum belongs to our new class of distributions. Additional discussions are presented for stable distributions.

Session 5A

LONGEVITY & ANNUITIES

Venue: Colombo A

Chair: Katja Hanewald

Title: COHORT TRENDS IN INTRINSIC CAPACITY IN EUROPE

Author: Katja Hanewald

Abstract:

This paper examines cohort trends in intrinsic capacity (IC), a composite measure of physical and mental capacities central to the World Health Organisation's approach to healthy ageing. We analysed panel data from ten countries that participated in all regular waves of the Survey of Health, Ageing and Retirement in Europe (SHARE) between 2004 and 2022. Using confirmatory factor analysis, we estimated a general intrinsic capacity factor from a bifactor model and five subdomain scores from a correlated five-factor model. We tested longitudinal measurement invariance across waves. Multilevel growth curve models with random intercepts and random age slopes quantified cohort differences in initial level and in rates of change. We find that more recent birth cohorts enter older age with higher levels of IC and experience slightly slower rates of decline, particularly in cognitive and locomotor domains. These findings extend previous work in England and China, suggesting that generational improvements in functioning are occurring across diverse European settings. The results have implications for modelling longevity risk and healthy life expectancy, as well as for the design of retirement and long-term care systems that reflect changing functional capacity in later life.

Title: DECUMULATION STRATEGY WITH LONG-TERM CARE INSURANCE AND GUARANTEED MINIMUM DEATH BENEFIT

Author: Yuxin Zhou

Abstract:

With the global shift from defined benefit to defined contribution pension systems, retirement planning is now fully borne on individuals elevating their exposure to longevity, health, and market risks. This transition has prompted more precautionary

saving behaviour, as retirees become more conservative in fully consuming their wealth. This research proposes a decumulation strategy which combines long-term care insurance (LTCI) and guaranteed minimum death benefit (GMDB) purchased at retirement with a withdrawal-then-rebalance investment approach. Within this framework, the retirement fund is modelled using a regime-switching structure, while a target volatility strategy detects asset allocation to smooth wealth dynamics and reduces the likelihood of extreme losses. The LTCI covers late-life healthcare costs, whereas the GMDB secures a minimum bequest, thereby supporting both consumption confidence and legacy objectives. Numerical experiments compare consumption patterns under this strategy with default drawdown strategies on account-based pension schemes. Results reveal that the proposed strategy provides smoother long-term consumption and better resilience to adverse financial shocks. Sensitivity analyses further explore variations in insurance allocation ratios, health state transitions, and target volatility levels. Preliminary results suggest that moderate volatility targets strike an effective balance between risk and sustainability, and that the strategy remains robust across different health scenarios.

Title: OPTIMAL HEDGING OF LONGEVITY RISKS FOR GROUP SELF-ANNUITY PORTFOLIOS

Author: Yawei Wang

Abstract:

This paper proposes a dynamic longevity risk hedging strategy for smooth survival benefit profiles of group self-annuity (GSA) schemes in the presence of population basis risk. The fund manager of GSA acts on behalf of fund participants in selecting the optimal hedge. The hedging framework is formulated as a mean-variance optimisation problem, which serves as a theoretical framework for selecting the optimal hedging strategy. The hedging mechanism involves trading standardised longevity-linked securities dynamically. A semi-analytic solution to the optimal hedge ratio is derived, which enhances the numerical implementation of the strategy. Furthermore, a risk decomposition method is developed, enabling hedging of various sources of risks, such as longevity and investment risks. Numerical illustrations highlight that the hedging strategy effectively mitigates variability in survival benefits. Meanwhile, a holistic risk management framework utilising the longevity risk hedging strategy and a target volatility investment strategy increases the fund's return per unit of risk.

Session 5B

RESERVING & INSURANCE PRICING

Venue: Colombo B

Chair: Greg Taylor

Title: CHAIN LADDER IS NOT PRESERVED UNDER AGGREGATION OF CALENDAR PERIODS

Author: Greg Taylor

Abstract:

The chain ladder model is defined by a set of assumptions about the claim array to which it is applied. It is, in practice, applied to claim arrays whose data relate to different frequencies, e.g. yearly, quarterly, monthly, weekly. There is sometimes a tacit assumption that one can shift between these frequencies at will, and that the model will remain applicable. It is not obvious that this is the case. One needs to check whether a model whose assumptions hold for annual data will continue to hold for a quarterly (for example) representation of the same data. The present paper studies this question in the case of preservation of calendar periods, i.e. (in the example) annual calendar periods are dissected into quarters. The study covers the two most common forms of chain ladder model, namely the Tweedie chain ladder and Mack chain ladder. The conclusion is broadly, if not absolutely, negative. Certain parameter sets can indeed be found for which the chain ladder structure is maintained under a change of data frequency. However, while it may be technically possible to maintain the chain ladder model under such a change to the data, it is not possible in any reasonable, practical sense.

Title: Chain ladder and data granularity

Author: Greg Taylor

Abstract:

The effect of data granularity on the prediction error of the chain ladder is considered. The changes of granularity under consideration here are those that aggregate or disaggregate development periods. Both Poisson and Mack chain ladders are examined. The question of an optimal granularity is discussed and

resolved. The required treatments of the two named forms of chain ladder are quite different. The end results are similar for the two though, interestingly, not identical

Title: OPERATIONS, RISKS, AND INSURANCE FOR EV-SHARING SYSTEMS

Author: Sizhe Chen

Abstract:

Electric-vehicle (EV) sharing platforms jointly set prices, fleet sizes, and risk-adjusted insurance premiums to meet customer demand. To provide a rigorous approach to studying the problem, we formulate it through the lens of a Stackelberg game between a customer and the company. Specifically, the company is the leader and aims to set membership fees, usage prices, a usage-based insurance (UBI) premium, and fleet size based on customer demand. The customer is the follower and decides on an optimal travel time by maximizing this utility. Three types of customers with different risk preferences represented by quadratic, exponential, and prospect-theoretic S-shaped utilities are considered. The quadratic and exponential utilities describe risk-averse preferences. The S-shaped utility is a behavioural type of utility and represents a mix of risk-engaging and risk-averse behaviour. For each type, we derive a closed-form expression for the trip length that maximizes utility. The leader's problem combines (i) a closed queueing network linking fleet size to usage time and (ii) a UBI premium case study built on telematics data and trained by gradient-boosting algorithms—GBM, LightGBM, etc. It is found that CatBoost achieves the most accurate premium predictions. Using backward induction, we obtain an explicit-form Stackelberg equilibrium that determines segment-specific tariffs endogenously. The numerical results confirm the equilibrium, demonstrating that intent- aware tariffs increase profit, highlighting the importance of behaviour-centric, data-driven design for sustainable and resilient EV-sharing operations.

Session 5C

RESERVING & INSURANCE PRICING

Venue: Colombo C

Chair: Eric C.K Cheung

Title: MODELING DISCRETE COMMON-SHOCK RISKS THROUGH MATRIX DISTRIBUTIONS

Author: Eric C.K Cheung

Abstract:

In this presentation, we introduce a novel class of bivariate common-shock discrete phase-type (CDPH) distributions to describe dependencies in loss modelling, with an emphasis on those induced by common shocks. By constructing two jointly evolving terminating Markov chains that share a common evolution up to a random time corresponding to the common shock component, and then proceed independently, we capture the essential features of risk events influenced by shared and individual-specific factors. We provide explicit expressions for the joint distribution of the termination times and demonstrate various class and distributional properties such as closure under mixtures and sums. We also consider random sums where aggregate claims are sums of continuous phase-type random variables with counts determined by these termination times, and show that their joint distribution belongs to the multivariate phase-type or matrix-exponential class. The applicability of our models is illustrated through simulation studies and an application to bivariate insurance claim frequency data. In particular, via an EM fitting algorithm we are able to estimate the latent common shock component present in a bivariate distribution or dataset. This is joint work with Martin Bladt, Oscar Peralta and Jae-Kyung Woo.

Title: CORRECTING CREDIBILITY PREMIUMS USING INTEGRATED CANN WITH TELEMATICS DATA

Author: Mohamed Hanafy Kotb Ibrahim

Abstract:

Traditional motor insurance pricing relies on static demographics that fail to capture actual driving behavior. We present an integrated framework combining Combined Actuarial Neural Networks (CANN) with multi-task learning (MTL) with telematics data to jointly model claim frequency (zero-inflated negative binomial) and severity

(gamma distribution). To maintain interpretability, which is essential for actuarial applications, we embed a gated feature selection mechanism that identifies key behavioral risk predictors during training. We extend beyond the narrow “near-miss” events in existing literature, which only consider discrete variables, by introducing telematics intensities. These intensities are integrated with traditional claims history data through our introduced Driving Behavior Credibility framework, which applies Bayesian credibility to combine frequency, severity, and telematics intensities. Using multivariate random effects modeling, we capture dependencies among these dimensions, enabling nuanced premium adjustments that distinguish safe from risky drivers. Our credibility framework demonstrates substantial improvements in risk differentiation. Among claim-free drivers, who are typically treated uniformly in traditional models with 0.85× adjustments, our approach yields correction factors ranging from 0.7× (safest quintile) to 1.9× (riskiest quintile). This enables dynamic pricing that reflects both backward-looking claims history and forward-looking behavioural indicators.

Title: OPTIMAL RELATIVITIES IN A BONUS-MALUS SYSTEM UNDER FREQUENCY-SEVERITY DEPENDENCE AND DIFFERENT OBJECTIVE FUNCTIONS

Author: Kelvin Tang

Abstract:

Automobile insurers in many countries use a Bonus-Malus System (BMS) that relies primarily on policyholders’ claim frequency to determine merit ratings, assuming independence between claim frequency and severity. With all claims being penalised regardless of claim size, a rational policyholder may withhold small claims to prevent any larger increases to their premium. Park and colleagues[1] found that this behavioural aspect known as bonus hunger can induce dependence in the reported frequency and severity of claims, even when the original processes are independent. Thus, differentiating the claims by their severity also plays an important role in separating the risks and improving the overall efficacy of the BMS. We consider a bivariate random effects model allowing for dependence between frequency and severity. In addition to the traditional mean squared error objective function for calculating the optimal relativities, we propose new symmetric and asymmetric absolute error objective functions. The resulting optimal relativities can be interpreted as statistical functionals for the asymptotic distribution of risk within the Bonus-Malus levels, offering a novel approach to assessing the performance of the BMS.