The Ohio State University

College of Arts and Sciences

61st Actuarial Research Conference

Program and Abstracts

Columbus, Ohio, USA
July 21 – 24, 2026

Venue Information

- Host: **The Ohio State University**, Columbus, Ohio.
- Conference Venues:
  - July 21: Pfahl Executive Education Building (Pfahl Hall 140)
  - July 22–23: Ohio Union
  - July 24: Timashev Family Music Building
- **Please note that a different conference venue will be used on July 24 (Timashev Family Music Building) than on July 22–23 (Ohio Union).**
- The room names listed in the schedule below correspond to the venue assignments for each specific day.
- Additional information, including reception and banquet venues as well as dining locations, is available at https://math.osu.edu/2026ARC/arc-venues-and-locations.

Wi-Fi Information

- **eduroam** is available throughout the venue to visitors from eduroam-member institutions.
- **WIFI@OSU** is available for all attendees.

Presenter Symbols

- **(s)** denotes a student presenter.
- **(s, r)** denotes a student presenter participating in the competition for the Ricardas Zitikis International Research Prize.

Jul 21

Virtual Option Available

A virtual option is available for the July 21 workshops.
Zoom link: https://osu.zoom.us/j/96487802184?pwd=Azf0sOeWKiu6fzV4fupFoTtke3mXzS.1.
Meeting ID: 964 8780 2184
Password: 349003

1:20 p.m. – 2:50 p.m.	**Workshop I: Regulatory Challenges for AI in Insurance** Moderator: Michelle Xia (Northern Illinois University) Panelists: • Lori Dashewich (Constellation Insurance, Senior Vice President, Chief Financial Officer) • Fei Huang (UNSW) • Scott Shepherd (Constellation Insurance, Senior Vice President, Chief Risk Officer) • Shontael Starry (Nationwide, AI/Data Ethicist)	Pfahl Hall 140
2:50 p.m. – 3:10 p.m.	Coffee Break	

3:10 p.m. – 4:40 p.m.	**Workshop II: Offshore Reinsurance in Life Insurance** Moderator: Martin Molloy (Ohio State University) Panelists: • Lori Dashewich (Constellation Insurance, Senior Vice President, Chief Financial Officer) • Matt Elston (ODI, Chief Life Actuary) • Kyeonghee Kim (Florida State University, Assistant Professor) • Scott Shepherd (Constellation Insurance, Senior Vice President, Chief Risk Officer) • Philip Wunderlich (Nationwide, AVP)	Pfahl Hall 140
5:00 p.m. – 7:00 p.m.	Reception	Blackwell Pavilion

Jul 22

8:30 a.m. – 9:00 a.m.	Breakfast	Round Meeting Room
9:00 a.m. – 9:20 a.m.	**Opening Remarks**	Cartoon Room
9:20 a.m. – 10:20 a.m.	**Plenary Session I** Actuarial Research Funding Landscapes: Opportunities and Guidance Speaker: Moderator: Sherry Chan (EY) | Panelists: Morgan Bugbee (CAS), Ian Duncan (SOA), Steve Jackson (Academy)	Cartoon Room
10:20 a.m. – 10:50 a.m.	Coffee Break	

Parallel Sessions 22A

	Academy Award for Research	Cartoon Room
10:50 a.m. – 12:20 p.m.	Access and Affordability: Finalists from the 2026 Award for Research Speaker: Moderator: Susan Kent | Presenters: Olivier Cote (PhD candidate, Laval University, Montreal, CAN; Shimeng Huang, PhD, ASA, Assistant Professor of Actuarial Science, Purdue) | Discussants: Steve Jackson (Academy Director of Research); Kim Ferrero (Academy Assistant Director of Research)	
	Health Insurance I Chair: Margie Rosenberg	Barbie Tootle Room
10:50 a.m. – 11:20 a.m.	A Mean Field Game to Study Selection in the ACA Marketplace Speaker: Yaniel Rivera Vega (s, r), University of Wisconsin - Madison	
11:20 a.m. – 11:50 a.m.	Are All Social Determinants of Health the Same? Latent Class Modeling by Age Groups Reveals Differences Among the Generations Speaker: Margie Rosenberg, UW-Madison	
11:50 a.m. – 12:20 p.m.	Diabetes Progression Modeling Speakers: Jeff Lin (s), University of California, Santa Barbara; and Leo Zhang, University of California, Santa Barbara	

	Insurance Economics I Chair: Wenchu Li	Hays Cape Room
10:50 a.m. – 11:20 a.m.	Health Risk Aversion in Dynamic Economic Models Speaker: Univa Song, Bentley University	
11:20 a.m. – 11:50 a.m.	Signals in the Smoke: Life Insurers' Portfolio Adjustments to Wildfire Risk Speaker: Wenchu Li, St. John's University	
11:50 a.m. – 12:20 p.m.	Exploratory Self Protection and Self Insurance Under the Mean Variance Criterion Speaker: Austin Riis-Due (s), University of Waterloo	
	Statistical and Machine Learning I Chair: Chengguo Weng	Interfaith Prayer Reflection Room
10:50 a.m. – 11:20 a.m.	Amortized Bayesian Inference for High Quantiles: Quantilepfn Speaker: Chengguo Weng, University of Waterloo	
11:20 a.m. – 11:50 a.m.	From Final Answers to Verified Reasoning: Evaluating LLMs on Actuarial Exams Speaker: Vajira Manathunga, Middle Tennessee State University	
11:50 a.m. – 12:20 p.m.	A Stable Transparent Model for Pricing in P&C Insurance Speaker: Félix Côté (s), Université Laval	
	P&C Insurance I Chair: Carlos Matos	Rosa M. Ailabouni Room
10:50 a.m. – 11:20 a.m.	Macroeconomic Determinants of Property and Casualty Insurance Premiums: an R-Based Statistical Analysis Speaker: Hang Su (s), Central Washington University	
11:20 a.m. – 11:50 a.m.	Bridging the Reserving Gap: Incorporating Underwriting Cohorts Into Glm-Based Ibnr Estimation Speaker: Carlos Matos, Faculdades Metropolitanas Unidas (FMU)	
11:50 a.m. – 12:20 p.m.	Multiperil CAT Bonds: Modeling, Pricing, and Risk Management Speaker: Anastasiia Kozlova (s), Purdue University	
	Dependence Modeling I Chair: Lei Hua	Senate Chamber
10:50 a.m. – 11:20 a.m.	Weighted Risk Aggregation Under Long-Memory Dependence Speaker: Elina Moldavskaya, Technion — Israel Institute of Technology	
11:20 a.m. – 11:50 a.m.	An Ultrafast Way of Assessing Bivariate Tail Dependence and Tail Asymmetry Speaker: Lei Hua, Northern Illinois University	
	Life Insurance Chair: Yechao Meng	Suzanne M. Scharer Room

10:50 a.m. – 11:20 a.m.	Covariates Identification of Lapse Rates in Life Insurance Using Generalized Linear Model via Adaptive Elastic Net and Its Oracle Properties. Speaker: Emmanuel Boamah (s, r), Student member of SOA/Graduate student-Missouri University of Science and Technology	
11:20 a.m. – 11:50 a.m.	Impact of Basis Risk on Variable Annuity Reserves and Capital Requirements Speaker: Minsik Kim (s), Fox School of Business, Temple University	
11:50 a.m. – 12:20 p.m.	Impact of Climate Change on Human Mortality Improvement: a Varx-L Framework Speaker: Yechao Meng, University of Prince Edward Island	
12:20 p.m. – 1:50 p.m.	Lunch	Traditions at Scott
1:50 p.m. – 2:50 p.m.	**Plenary Session II** What Is a Life Worth? Multi-State Actuarial Models for Valuing Health and Longevity Speaker: Daniel Bauer, University of Wisconsin–Madison	Cartoon Room
2:50 p.m. – 3:10 p.m.	Coffee Break	
	Parallel Sessions 22B	
	Professionalism	Cartoon Room
3:10 p.m. – 4:40 p.m.	Actuarial Sins: Discussion of Items All Actuaries Need to Be Aware of… and Need to Avoid Speakers: Kathy Olcese, Retired; Josh Taub, The Infinite Actuary; and Bethany Coffey, Nationwide	
	Statistical and Machine Learning II Chair: TBA	Barbie Tootle Room
3:10 p.m. – 3:40 p.m.	A Non-Likelihood Framework for Generalized Linear Models Parameter Estimation Speaker: Godfred Ahenkroa Kesse (s, r), University of Central Florida	
3:40 p.m. – 4:10 p.m.	Agentic Ai: the Latest AI Buzz Phrase; What It Is, How It Works, and Where It Is Used Speaker: Arnold Shapiro, Penn State University	
	Dependence Modeling II Chair: TBA	Hays Cape Room
3:10 p.m. – 3:40 p.m.	Multi-Dimensional Value-At-Risk – Its Role and Properties in Managing Risks of Dependent Business Lines Speaker: Mengqi Wang (s, r), Western University	
3:40 p.m. – 4:10 p.m.	Rank-Based Sequential Tests for Copula Speaker: Yinhuan Li, University of Waterloo	
4:10 p.m. – 4:40 p.m.	Sequential E-Backtesting for Tail Risk Governance of Option-Embedded Insurance Liabilities Speaker: Rui Zong, Transamerica	
	Health Insurance II Chair: Rob Lieberthal	Interfaith Prayer Reflection Room

3:10 p.m. – 3:40 p.m.	A Longitudinal Attribute-Conditioned Neural Network for Modeling Health-State Transition Probabilities in Temporally Irregular Data Speaker: Bright Manu (s, r), Arizona State University	
3:40 p.m. – 4:10 p.m.	Survival Heterogeneity in U.S. Hospice Patients: a Retrospective Cohort Study Speaker: Ian Duncan, University of California Santa Barbara	
4:10 p.m. – 4:40 p.m.	Evaluating Representativeness in Healthcare Claims Data Speaker: Rob Lieberthal, Lieberthal & Associates, LLC	
	Risk Modeling and Measurement I Chair: Zinoviy Landsman	Rosa M. Ailabouni Room
3:10 p.m. – 3:40 p.m.	Continuous Time Optimal Insurance With Prevention Efforts and Price Incentives Speaker: Evan Cribbie (s, r), York University	
3:40 p.m. – 4:10 p.m.	Reducing Uncertainty in Linear Regression via a Minimum Variance Risk Functional: Applications to Actuarial Problems Speaker: Zinoviy Landsman, Actuarial Recearch Center, University of Haifa	
4:10 p.m. – 4:40 p.m.	Enhancing Insurance Pricing Stability: The Robust Quadratic Credibility Speaker: Qian Zhao, Robert Morris University	
	Mortality and Longevity Modeling Chair: Kenneth Zhou	Senate Chamber
3:10 p.m. – 3:40 p.m.	Structured Dispersion Modeling for Mortality Data Using a Conway-Maxwell-Poisson Specification Speaker: Emiliano Valdez, University of Connecticut	
3:40 p.m. – 4:10 p.m.	A Tale of Two Pathways to Gompertz Mortality: Reliability and Vitality From an Actuarial Perspective Speaker: Kenneth Zhou, University of Waterloo	
4:10 p.m. – 4:40 p.m.	Structural Changes in Persistence of Mortality Speakers: Wanying Fu, Lebanon Valley College; and Barry Smith, Lebanon Valley College	
	P2P Insurance and Risk-Sharing Chair: Jiajie Yang	Suzanne M. Scharer Room
3:10 p.m. – 3:40 p.m.	Risk and Premium Sharing in the Distributed Insurance Speaker: Jiajie Yang, Bowling Green State University	
3:40 p.m. – 4:10 p.m.	Intertemporal Risk Sharing in Distributed Insurance Speaker: Youxi Zhang (s, r), Tsinghua University	

Jul 23

8:30 a.m. – 9:20 a.m.	Breakfast	Round Meeting Room

9:20 a.m. – 10:20 a.m.	**Plenary Session III** A Way of Quantifying Cyber Risk: from Model Building to Product Pricing Speaker: Phillip Yam, The Chinese University of Hong Kong	Cartoon Room
10:20 a.m. – 10:50 a.m.	Coffee Break	

Parallel Sessions 23A

	CAS Research I	Cartoon Room
10:50 a.m. – 11:20 a.m.	A Modular Framework for Casualty Catastrophe Modeling Speakers: Rob Lieberthal, Lieberthal & Associates, LLC; and Jeffrey Zheng, Temple University	
11:20 a.m. – 11:50 a.m.	Entity-Specific Cyber Risk Assessment Using Insurtech Empowered Risk Factors Speaker: Jiayi Guo (s, r), University of Illinois Urbana-Champaign	
11:50 a.m. – 12:20 p.m.	Quantifying Social Inflation in Liability Insurance With Advanced Statistical Methods Speaker: Fang Yang, Georgia State University	
	Health Insurance III Chair: Carol Troy	Barbie Tootle Room
10:50 a.m. – 11:20 a.m.	An Empirical Analysis of Medical Malpractice Payment Severity and Tail Risk Using the National Practitioner Data Bank Speakers: David Dussey (s), Middle Tennessee State University; and Kelvin Ansah, Middle Tennessee State University	
11:20 a.m. – 11:50 a.m.	Functional Decline and the Dynamics of Informal Care: Evidence From Nhats Speaker: Carol Troy, Tunghai University International College	
11:50 a.m. – 12:20 p.m.	Pricing Climate Risk in Health Insurance: a Dynamic Actuarial Model for an Environmentally Driven Infectious Disease (Valley Fever) Speaker: Trevor Reckell (s, r), Arizona State University	
	Loss Reserving and Ratemaking Chair: Nii Okine	Hays Cape Room
10:50 a.m. – 11:20 a.m.	Loss Reserving With Generalized Linear Models and Textual Description of Claims Speaker: Nii Okine, Appalachian State University	
11:20 a.m. – 11:50 a.m.	Predictive Modeling Frameworks for P&C Personal Lines Insurance Pricing and Reserving Speaker: David Han, UT San Antonio	
11:50 a.m. – 12:20 p.m.	The Optimal Combination of Reinsurance and Index Insurance Speaker: Jiandong Ren, Western University	
	Digital Accessibility	Interfaith Prayer Reflection Room

10:50 a.m. – 12:20 p.m.	Practical Digital Accessibility for Actuarial Science Instructors Speaker: Dan Poole, The Ohio State University	
	Education and Professional Development Chair: Bjørn Kjos-Hanssen	Rosa M. Ailabouni Room
10:50 a.m. – 11:20 a.m.	Interest: a Library for Formalized Financial Math and Actuarial Science Speaker: Bjørn Kjos-Hanssen, University of Hawaii at Manoa	
11:20 a.m. – 11:50 a.m.	Rethinking Actuarial Education in a Global World: the Role of Actuarial Education Companies Speakers: Gabriel Necoechea, ACTEX Learning; and Bill Marella, ACTEX Learning	
11:50 a.m. – 12:20 p.m.	From Calculus I to Credentialed Actuary: Where We Lose Students and How to Fix It Speaker: Kevin Doran, University of Alabama	
	Quantitative Finance I Chair: Bin Zou	Senate Chamber
10:50 a.m. – 11:20 a.m.	Optimal Investment, Consumption, and Insurance Strategies Under Claim Habit: Claim Habit Accounts for Deductible Speaker: Shansong Huang (s), University of Connecticut	
11:20 a.m. – 11:50 a.m.	Log-Optimal Portfolio Construction for Binary Options With Combinatorial Constraints Speaker: Bin Zou, University of Connecticut	
	Statistical and Machine Learning III Chair: Xing Wang	Suzanne M. Scharer Room
10:50 a.m. – 11:20 a.m.	Multi-Output Extreme Spatial Model for Complex Production Systems Speaker: Xing Wang, Chinese Academy of Sciences	
11:20 a.m. – 11:50 a.m.	An Age Grouping Framework for Multi-Population Mortality Modeling Speaker: Cezar Campeanu (s), University of Prince Edward Island	
11:50 a.m. – 12:20 p.m.	Modeling Spatially Compounding Events With Graph Neural Network Speaker: Shimeng Huang, Purdue University	
12:20 p.m. – 1:50 p.m.	Lunch	Traditions at Scott
1:50 p.m. – 2:50 p.m.	**Plenary Session IV** The Intersection Between Health Equity and Risk Adjustment in Medicaid Speaker: Erica Baird, Milliman	Cartoon Room
2:50 p.m. – 3:10 p.m.	Coffee Break	
	Parallel Sessions 23B	
	Blockchain, Telematics, and InsurTech Chair: Xiaochen Jing	Cartoon Room

3:10 p.m. – 3:40 p.m.	Dynamic Optimal Staking in Decentralized Insurance Speaker: Xiaochen Jing, University of Illinois Urbana-Champaign	
3:40 p.m. – 4:10 p.m.	Optimal Risk Sharing in Multi-Period Peer-To-Peer Insurance Speaker: Dung Pham (s), Bowling Green State University	
4:10 p.m. – 4:40 p.m.	Incorporating Heart Rate Variability Into Insurance Pricing: Evidence From Simulation and Wearable-Derived Data Speaker: Adrian O Hagan, University College Dublin	
	Optimal Control and Optimization Chair: Ibukun Amusan	Barbie Tootle Room
3:10 p.m. – 3:40 p.m.	Robust Optimal Portfolio in a Mixture Setting With Partial Ambiguity Speaker: Tianrun Wang (s), University of Iowa	
3:40 p.m. – 4:10 p.m.	Pricing Forward Start Options Under an Additive-Multiplicative Stochastic Volatility Model Speaker: Ibukun Amusan, Austin Peay State University	
4:10 p.m. – 4:40 p.m.	Optimal Loss Reporting Under Bonus-Malus Systems Speaker: Yi Wu (s, r), University of Connecticut	
	Risk Modeling and Measurement II Chair: Natalia Humphreys	Hays Cape Room
3:10 p.m. – 3:40 p.m.	Statistical Characteristics of Declines and Rises in the U.S. Stock Market Speaker: Min Shu, Central Michigan University	
3:40 p.m. – 4:10 p.m.	Queuing Systems in Actuarial Science: Theory and Applications Speaker: Natalia Humphreys, University of Texas at Dallas	
4:10 p.m. – 4:40 p.m.	Business Interruption Risk Modeling Framework for Polymetallic Nodule Deep Sea Mining Speaker: Mobasshira Zaman (s), School of Computing and Augmented Intelligence, Arizona State University, USA	
	P&C Insurance II Chair: Jackson Lautier	Interfaith Prayer Reflection Room
3:10 p.m. – 3:40 p.m.	Injury Risk Management in the National Basketball Association: an Actuarial Approach Speaker: Jackson Lautier, Bentley University	
3:40 p.m. – 4:10 p.m.	Robust Quantile Least Squares for Learning Loss Severity Models With Incomplete Data Speaker: Mohammed Adjieteh, Appalachian State University	
4:10 p.m. – 4:40 p.m.	Semi-Supervised Machine Learning Algorithms for Fraud Detection Using Imperfect Fraud Labels From Claims Analytics Speaker: Michelle Xia, Department of Statistics and Actuarial Science, Northern Illinois University	
	Health Insurance IV Chair: Ramzi Abujamra	Rosa M. Ailabouni Room

3:10 p.m. – 3:40 p.m.	Valuing and Managing Value-Based-Care Contracts: A Latent-State Decision Framework under Treatment Heterogeneity and Uncertainty Speaker: Ramzi Abujamra, ActuariAI LLC	
3:40 p.m. – 4:10 p.m.	Funding Relief and Pension Behavior: Evidence From the American Rescue Plan Speaker: Xuan Tang (s), Temple University	
	SOA and CAS Education	Senate Chamber
3:10 p.m. – 3:55 p.m.	Update on Society of Actuaries Education Speaker: Stuart Klugman, Society of Actuaries	
3:55 p.m. – 4:40 p.m.	Pathway to P/C Success: Exploring 2026 CAS Opportunities Speakers: Maggie Lyons, Casualty Actuarial Society; and Margaret Gaddy, Casualty Actuarial Society	
	Statistical and Machine Learning IV Chair: Jackie Siaw Tze Wong	Suzanne M. Scharer Room
3:10 p.m. – 3:40 p.m.	Efficient and Interpretable Transformer for Counterfactual Fairness Speaker: Panyi Dong (s, r), University of Illinois Urbana-Champaign	
3:40 p.m. – 4:10 p.m.	Geometric Power-Distance Tilted Kernel Density Estimation for Heavy-Tailed Distributions Speaker: Jackie Siaw Tze Wong, University of Essex	
4:10 p.m. – 4:40 p.m.	CTE Induced Premium Principles and Properties Speaker: Linjiao Wu, Appalachian State University	
4:40 p.m. – 5:00 p.m.	**Industry Insights - At the intersection of policy, regulation, and actuarial practice: Research at the American Academy of Actuaries** Speakers: • Becky Sheppard, Vice-Chair of the Academy Research Committee, Chair of the Academy Health Equity Committee • Julie Goodwin, Academy Senior Research Analyst	Cartoon Room
5:00 p.m. – 8:00 p.m.	Banquet	Vitria on the Square

Jul 24

8:30 a.m. – 9:20 a.m.	Breakfast	N160
9:20 a.m. – 10:20 a.m.	**Plenary Session V** The Fair Pricing Playbook: A Practical Framework for Responsible AI in Algorithmic Pricing Systems Speaker: Fei Huang, UNSW Business School	Weigel Auditorium
10:20 a.m. – 10:50 a.m.	Coffee Break	
	Parallel Sessions 24A	
	Quantitative Finance II Chair: Krzysztof Ostaszewski	N300

10:50 a.m. – 11:20 a.m.	Risk-Neutral Valuation with a Non-Traded Fractional Brownian Underlying Speaker: Jayen Tan (s, r), Cornell University	
11:20 a.m. – 11:50 a.m.	Regime Changes and Bubble Status in Global Stock Markets Post-2020 Crash Speaker: Min Shu, Central Michigan University	
11:50 a.m. – 12:20 p.m.	Investments in Municipal Bonds and Asset-Liability Management by Property/casualty Insurance Companies in Illinois Speakers: Krzysztof Ostaszewski, Illinois State University; and Tice Sirmans, Illinois State University	
	Catastrophic Risk Modeling Chair: Wei Wei	N310
10:50 a.m. – 11:20 a.m.	From Steps to Smooth: the Optimal Shape of Catastrophe Bond Payouts Speaker: Wei Wei, University of Illinois Urbana-Champaign	
11:20 a.m. – 11:50 a.m.	Hedging Geopolitical Risk: a Stochastic Regime and Optimization Framework Speaker: Hossam Mohamed (s), Cairo University	
11:50 a.m. – 12:20 p.m.	Temporal Hierarchical Forecasting of U.S. Billion-Dollar Disaster Costs and Frequencies: an Actuarial Application Speakers: Simon Atoyire, Department of Statistics, Miami University, Oxford, Ohio; and Tatjana Miljkovic, Department of Statistics, Miami University, Oxford, Ohio	
	Retirement and Pension Mathematics Chair: Kristen Moore	N408
10:50 a.m. – 11:20 a.m.	An Economic Scenario Generator for Retirement Modeling Speaker: Brian Hartman, Brigham Young University	
11:20 a.m. – 11:50 a.m.	Collar Stabilization Buffers and Basis Risk in Group Self-Annuitization Schemes Speaker: Jean-François Bégin, Simon Fraser University	
11:50 a.m. – 12:20 p.m.	Buying Time: Optimal Service Purchase and Retirement Timing in Defined Benefit Plans Speaker: Kristen Moore, University of Michigan	
	Climate Risk and Sustainability Chair: Zhongyi Yuan	N410
10:50 a.m. – 11:20 a.m.	Pricing Parametric Hydropower Insurance Under Spatial Drought Correlation: a Vine Copula Approach for the Southwestern United States Speaker: Mohak Dwarkadhish Sharma (s, r), Arizona State University	
11:20 a.m. – 11:50 a.m.	Pricing of Temperature Derivative Under Stochastic Volatility Jump Model Speaker: Yasintorn Wongwoottisaroch (s, r), University of Illinois at Urbana-Champaign	
11:50 a.m. – 12:20 p.m.	Financed Emissions, Internal Carbon Charges, and Market Equilibrium Speaker: Zhongyi Yuan, Penn State	

	CAS Research II	N504
10:50 a.m. – 11:20 a.m.	Leveraging LLMs for Unstructured Claims Data Analysis Speaker: Rob Lieberthal, Lieberthal & Associates, LLC	
11:20 a.m. – 11:50 a.m.	What Do We Know About Cyber Risk Reserving? First Insights from Bayesian Nowcasting of Data Breach IBNR Speaker: Maochao Xu	
12:20 p.m. – 12:30 p.m.	**Closing Remarks**	Weigel Auditorium
12:30 p.m. – 1:30 p.m.	Boxed Lunches	N160

Workshop Overviews

Workshop I: Regulatory Challenges for AI in Insurance

Moderator: Michelle Xia (Northern Illinois University)
Panelists:

- Lori Dashewich (Constellation Insurance, Senior Vice President, Chief Financial Officer)
- Fei Huang (UNSW)
- Scott Shepherd (Constellation Insurance, Senior Vice President, Chief Risk Officer)
- Shontael Starry (Nationwide, AI/Data Ethicist)

AI is rapidly reshaping underwriting, pricing, claims, and distribution, but regulators are emphasizing that AI-enabled decisions must still comply with long-standing insurance standards, especially prohibitions on unfair discrimination and unfair/deceptive practices, creating new expectations for how insurers govern, test, and document models across their full life cycle.

Workshop II: Offshore Reinsurance in Life Insurance

Moderator: Martin Molloy (Ohio State University)
Panelists:

- Lori Dashewich (Constellation Insurance, Senior Vice President, Chief Financial Officer)
- Matt Elston (ODI, Chief Life Actuary)
- Kyeonghee Kim (Florida State University, Assistant Professor)
- Scott Shepherd (Constellation Insurance, Senior Vice President, Chief Risk Officer)
- Philip Wunderlich (Nationwide, AVP)

The rapid growth of offshore (especially Bermuda-based) reinsurers and asset intensive reinsurance (AIR) reflects a global shift toward Solvency II–style economic solvency frameworks, which differ from traditional U.S. statutory rules in their market-consistent treatment of liabilities, capital, and asset–liability interactions. Bermuda’s Solvency II equivalence and economic balance sheet approach (best estimate liabilities plus risk margin) make it a natural hub for these transactions, enabling insurers to achieve capital efficiency and greater flexibility in allocating to complex, illiquid assets such as private credit and structured products.

Plenary Session Abstracts

Actuarial Research Funding Landscapes: Opportunities and Guidance

Moderator: Sherry Chan (EY) | Panelists: Morgan Bugbee (CAS), Ian Duncan (SOA), Steve Jackson (Academy)

This plenary session brings together representatives from organizations that support actuarial and related research to discuss current funding opportunities, proposal priorities, and effective strategies for developing competitive applications. Panelists will share perspectives on what distinguishes strong proposals, common challenges in the review process, and ways researchers can better align their ideas with available funding programs. The session is intended to provide practical guidance for faculty, students, and researchers seeking to navigate the evolving landscape of actuarial research support.

What Is a Life Worth? Multi-State Actuarial Models for Valuing Health and Longevity

Daniel Bauer, University of Wisconsin–Madison

The Value of Statistical Life (VSL) is one of the most consequential numbers in public policy, shaping investments in medical research, environmental protection, and pandemic preparedness, and underlying cost-effectiveness thresholds in health systems around the world. Yet VSL is largely absent from actuarial training and research — even though the models economists use to derive it are close cousins of the models actuaries build every day. In this talk, I will introduce VSL and its generalization, the Value of Statistical Illness (VSI), and show how actuarial tools — continuous-time multi-state models, life contingent valuation, and life-cycle optimization under incomplete markets — can be combined to produce novel frameworks for valuing health and longevity. I will illustrate with recent results explaining why people pay more per quality-adjusted life-year when sick, and why conventional valuations of medical advances can substantially overstate aggregate welfare gains.

A Way of Quantifying Cyber Risk: from Model Building to Product Pricing

Phillip Yam, The Chinese University of Hong Kong

As a major challenge in emerging risk modelling in FinTech and InsurTech, the actuarial community is so eager for more effective methods in predicting claim numbers/severities of cyber attacks based on limited real data; indeed, conventional statistical tools fail to apply for these cyber risk datasets due to the dominant presence of categorical covariates. To address this challenge, our talk proposes a novel superposed marked Hawkes process integrating categorical covariate information to infer hidden clustering structures; particularly, by employing classifiers such as CIBer, CART, and MLP, we iteratively optimize both model parameters and cluster partitions using common machine learning tools, such as mini-batch stochastic gradient descent method. The effectiveness of this approach is demonstrated through empirical studies with benchmark cyber risk datasets, leading to notably improven prediction for frequencies (also for severities). Meanwhile, we can also provide a statistical diagnosis of the underlying model parameters. Last but not least, with this new process, all existing pricing methods should be revisited; while we here highlight the use of Fourier-COS method to effectively price different insurance products against cyber risk, namely via a finite series involving the Laplace functional of the corresponding compound process.

The Intersection Between Health Equity and Risk Adjustment in Medicaid

Erica Baird, Milliman

Persistent health disparities have prompted increased attention to health equity among federal and state policymakers. State Medicaid agencies, as major purchasers of care for diverse and often underserved populations, are uniquely positioned to influence equity through financing and policy decisions. To support these efforts, we examined how clinical, demographic, geographic, and social factors—including race and ethnicity—are associated with patterns of healthcare utilization in Medicaid populations. A central challenge in this work is the incomplete and inconsistent collection of race and ethnicity data, which constrains the measurement and interpretation of inequities. Prior to this analysis, and through research sponsored by the Society of Actuaries Research Institute, we conducted a separate line of research evaluating racial and ethnic imputation methods currently in use, including Bayesian Improved Surname Geocoding (BISG), with a case study using Medicaid data. This earlier work provided an important perspective on the strengths, limitations, and appropriate applications of imputation algorithms in actuarial research. Together, these complementary research streams highlight the interplay between methodological choices and equity analysis. This presentation reflects on how advances in data and modeling—when applied thoughtfully—can help actuaries and policymakers better understand disparities, while underscoring the limitations and challenges associated with the use of imputed race and ethnicity data in equity-focused decision-making.

The Fair Pricing Playbook: A Practical Framework for Responsible AI in Algorithmic Pricing Systems

Fei Huang, UNSW Business School

Advances in AI and data science are transforming insurance pricing, enabling increasingly granular risk assessment and improved predictive accuracy. However, these developments raise fundamental challenges for fairness, transparency, and accountability. Pricing models can inadvertently embed indirect discrimination through complex data relationships and opaque algorithms, creating tensions between actuarial principles, regulatory requirements, and societal expectations. Regulators are responding, for example, the EU AI Act classifies insurance risk assessment as a high-risk AI application, and proposals in Colorado, New York, and other jurisdictions now require insurers to test pricing algorithms for unfair discrimination. This talk presents The Fair Pricing Playbook (fair.feihuang.org), an open-source practical framework that translates research from actuarial science, economics, statistics, and machine learning into a concrete four-step workflow: defining a fairness criterion appropriate to the regulatory context, building a fair pricing model that meets it, measuring the welfare implications for consumers and the firm, and auditing a deployed system. Drawing on recent work in anti-discrimination insurance pricing, fairness testing, and welfare analysis, the talk examines how fairness objectives can be meaningfully and responsibly integrated into modern data-driven pricing systems, and highlights open research and policy challenges for the actuarial profession.

Parallel Session Abstracts

A Mean Field Game to Study Selection in the ACA Marketplace

Yaniel Rivera Vega (s, r), University of Wisconsin - Madison

Health insurance markets with regulatory restrictions on risk-based pricing face a fundamental tension: limiting the extent to which premiums can reflect individual health status encourages insurers to cherry-pick healthy enrollees through plan design. The Affordable Care Act addresses this through risk adjustment transfers, but does it work? This paper builds a mean field game model where insurers dynamically compete over premiums and benefit generosity while their risk pools evolves stochastically to derive the necessary and sufficient conditions for eliminating selection incentives. Solving the coupled Hamilton-Jacobi-Bellman and Fokker-Planck system yields a strong neutrality result: selection incentives vanish if and only if the marginal risk adjustment transfer exactly offsets the marginal claims cost. When this condition fails, the market competition drives a persistent drift in the aggregate risk pool that does not self-correct.

Are All Social Determinants of Health the Same? Latent Class Modeling by Age Groups Reveals Differences Among the Generations

Margie Rosenberg, UW-Madison

Social Determinants of Health (SDOH) “are the conditions in the environments where people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks”. (Healthy People 2030) Broad categories of variables commonly used in studies are those relating to economic stability and one’s physical environment. In this initial work, more than 60 SDOH variables from the 2021 Medical Expenditures Panel Study are used to classify different generations of individuals into latent classes. The classes indicating the most important characteristics and themes across the generations are compared and contrasted. Some variables (or themes) may be more important to some generations than others. The purpose of the study is to show similarities and differences. The results will be used as input in models to connect SDOH to access and utilization of health care. Different components of SDOH could lead to differential impact on downstream outcomes and would be quantified. Investment in interventions to improve basic SDOH needs could help improve the health of communities.

Diabetes Progression Modeling

Jeff Lin (s), University of California, Santa Barbara; with Leo Zhang, University of California, Santa Barbara

Diabetes progression is a major clinical and financial concern, as worsening glycemic control is associated with increased complication risk and higher healthcare expenditures. Understanding how patients transition between glycemic states over time is essential for effective risk stratification and intervention planning. In this study, we analyze longitudinal clinical and behavioral data from Vitality Health to examine transitions between glycemic states and identify predictors of progression among individuals with Type 2 diabetes. We defined four glycemic states based on standard HbA1c thresholds (Healthy, Prediabetic, Diabetic, and Severe Diabetic) and constructed one-year transition pairs to model movement between states. After excluding patients without valid HbA1c measurements, individuals diagnosed with Type 1 diabetes, and those lacking sufficient longitudinal follow-up, we obtained a cleaned cohort suitable for longitudinal analysis. Transition dynamics were estimated using a Multi-State Markov Model (MSM), which provided transition intensities and one-year transition probabilities between glycemic states. In addition, we implemented an ordinal regression model with L1 regularization (ordinalNet) to predict next-year glycemic status. The ordinal model achieved approximately 67% predictive accuracy on the test set, indicating that demographic and clinical characteristics contribute meaningfully to forecasting disease progression.

Health Risk Aversion in Dynamic Economic Models

Univa Song, Bentley University

In dynamic economic models with health risk, health often is not an attribute of the utility function but its evolution shapes consumption and other decisions. This paper develops a framework for studying preferences over health risks in such settings, by defining health risk aversion through concavity of the value function with respect to health states. We discuss implications of health risk aversion, which we find to be intuitive and significant, and we analyze primitives that yield health risk aversion. We document that the interaction of survival prospects under different health states and optimal consumption paths shape preferences over the health states in non-trivial, though systematic, ways.

Signals in the Smoke: Life Insurers' Portfolio Adjustments to Wildfire Risk

Wenchu Li, St. John's University

Wildfire smoke imposes mortality risks that extend beyond physically damaged regions, exposing populations in downwind areas to elevated PM2.5 concentrations with health consequences that accumulate over long horizons. Unlike property losses associated with direct wildfire damage, these diffuse and persistent impacts may put pressure on life insurers’ liability and capital management before excess mortality claims are realized. This paper investigates whether and how life insurers adjust their investment portfolios in response to predicted wildfire smoke exposure, and how these adjustments vary across insurers with different product mixes, operating regions, and capital sufficiency. We construct insurer-specific wildfire smoke exposure measures by combining smoke PM2.5 predictions with direct premiums written, separating by life insurance and annuity lines to account for opposing liability implications. We further examine how capital sufficiency shapes the direction of portfolio adjustment, with capital-constrained insurers expected to reach for yield and well-capitalized insurers expected to shift toward higher-quality assets. By investigating portfolio adjustments prior to the realized claims impact, this paper provides early evidence on whether regulatory capital pressure transmits catastrophe-related long-term health risks into life insurers’ portfolio management decisions.

Exploratory Self Protection and Self Insurance Under the Mean Variance Criterion

Austin Riis-Due (s), University of Waterloo

This paper proposes a Reinforcement Learning (RL) approach to the optimal joint insurance and self insurance with self protection problem when the policyholder faces uncertainty about the effectiveness of their effort action to impact their loss frequency and severity. To this end, we first formulate an exploratory version of the problem as a relaxed stochastic control problem. We then derive the closed-form equilibrium policy under the continuous-time mean-variance criterion. This is achieved through a formal verification theorem and solving classical solutions of a system of exploratory extended Hamilton-Jacobi-Bellman (EEHJB) equations. We establish an RL algorithm to learn a parametric form of the loss frequency and severity parameters as they depend upon the effort action and analyze convergence.

Amortized Bayesian Inference for High Quantiles: Quantilepfn

Chengguo Weng, University of Waterloo

Accurate estimation of extreme high quantiles is essential for Value-at-Risk assessment and solvency regulation, yet remains challenging in data-scarce settings. Classical Extreme Value Theory methods rely on asymptotic approximations and subjective threshold selection, leading to instability and bias–variance trade-offs in small samples. We propose QuantilePFN, a novel framework based on amortized Bayesian inference using Prior-Fitted Networks (PFNs). A Transformer is pre-trained on a hierarchical prior built from Gamma-Scaled Phase-Type distributions, enabling it to learn realistic heavy-tail behaviors. Once trained, QuantilePFN performs end-to-end inference directly on raw data, automatically adapting to tail structure without manual tuning. Extensive experiments show that QuantilePFN consistently outperforms POT-GPD and Hill estimators in mean absolute and squared error for sample sizes up to 1,000, providing a principled and automated solution for high-quantile estimation in limited-data regimes.

From Final Answers to Verified Reasoning: Evaluating LLMs on Actuarial Exams

Vajira Manathunga, Middle Tennessee State University

Large Language Models (LLMs) have demonstrated strong performance on a wide range of professional examinations, raising important questions about their capabilities in multi-step quantitative reasoning. This talk uses actuarial exams as a rigorous testbed to evaluate not only whether LLMs can produce correct final answers, but also whether their intermediate reasoning steps are logically sound and mathematically reliable. We first examine the baseline performance of a leading LLM across a broad collection of SOA and CAS actuarial exam questions. While final-answer accuracy provides an initial measure of capability, it does not fully capture reasoning quality. A correct answer may mask flawed logic, and an incorrect answer may result from a single computational error within an otherwise valid solution. To address this limitation, we introduce a stepwise reasoning verification framework based on probabilistic entailment. The framework evaluates each reasoning step by conditioning on plausible configurations of earlier sound or unsound steps and summarizes reliability through an entailment stability score. A central feature of the framework is its attention to evaluation robustness. Since LLM-as-a-judge methods can suffer from biases, the proposed approach incorporates a multi-stage debiasing pipeline and ensemble-based judging. We also present theoretical guarantees, including deterministic lower bounds, probabilistic concentration results, and Monte Carlo estimation procedures for scalable implementation.

A Stable Transparent Model for Pricing in P&C Insurance

Félix Côté (s), Université Laval

Black box models are deployed across many domains due to their high predictive power. In high-stakes sectors such as insurance, however, predictive performance is not the sole criterion of interest. It is often necessary to interpret the behavior of models in production and to ensure that these interpretations remain consistent across retrainings. To meet these objectives, an effective approach is to use models that are both transparent and structurally stable. We define the notions of stability and transparency within a machine learning framework. We also propose a metric to quantify the structural stability of a subset of transparent models that are particularly relevant in actuarial science. Finally, we present a case study conducted on real actuarial data to identify a model that is transparent, stable, and performant.

Macroeconomic Determinants of Property and Casualty Insurance Premiums: an R-Based Statistical Analysis

Hang Su (s), Central Washington University

Since the emergence of modern insurance in the 19th century, the industry has become a cornerstone of economic activity, providing financial protection for individuals and businesses against a wide range of risks, from automobile operations to real estate ownership. In recent years, however, significant macroeconomic pressures—including elevated inflation, unexpected tariff increases, fluctuating Federal Reserve interest rates, and rising labor costs—have disrupted traditional pricing structures, contributing to the growing unaffordability of property and casualty (P&C) insurance. This presentation examines the quantitative effects of key macroeconomic indicators on P&C insurance premiums. Using multivariate statistical models developed in R, the study analyzes historical market data to isolate and evaluate the influence of inflation, tariff rates, interest rate changes, and labor cost growth on insurance pricing. By integrating macroeconomic theory with actuarial modeling, this research seeks to provide insight into the economic forces driving premium increases and to explore potential risk-modeling adjustments that may help reduce consumer cost burdens while maintaining insurer solvency.

Bridging the Reserving Gap: Incorporating Underwriting Cohorts Into Glm-Based Ibnr Estimation

Carlos Matos, Faculdades Metropolitanas Unidas (FMU)

Traditional reserving methods in actuarial science, such as the Chain Ladder and Generalized Linear Model (GLMs), typically estimate incurred but not reported claims (IBNR) using development triangles aggregated by accident year and development period. These approaches, however, often overlook the influence of portfolio management decisions—such as underwriting strategy shifts, pricing adjustments, or changes in acceptance criteria—which can materially affect claim development patterns. This study proposes an enhancement to the standard GLM reserving framework by incorporating a categorical variable representing the underwriting cohort or subscription year, serving as a proxy for internal portfolio management actions. Using a transportation insurance portfolio as a case study, the results show that including underwriting cohort information improves both the accuracy and interpretability of IBNR estimates, as measured by out-of-sample prediction error and standard model diagnostics. The proposed approach enhances consistency between underwriting and reserving functions and provides actuaries with a structured and transparent way to integrate business knowledge into the reserving process, bridging the gap between technical estimation and risk-informed decision-making.

Multiperil CAT Bonds: Modeling, Pricing, and Risk Management

Anastasiia Kozlova (s), Purdue University

Climate-driven multi-peril catastrophe losses continue to rise, intensifying the risks borne by U.S. insurance markets. While multi-peril issuances form a non-trivial share of the catastrophe (CAT) bond market, through which insurers and reinsurers transfer such risks to capital-market investors, academic work on their modeling and pricing has remained largely confined to single-peril settings. We propose a unified framework for modeling multi-peril catastrophe losses that jointly captures spatial, temporal, and cross-peril dependence. Marginal losses are specified through a two-part model consisting of a logit component for zero-loss occurrence and a lognormal component for positive amounts, to accommodate zero-inflation and heavy tails. Dependence is modeled with a Gaussian copula whose closed-form dispersion matrix combines AR(1) temporal persistence, exponential spatial decay, and contemporaneous cross-peril correlation. The framework is estimated by composite pairwise likelihood on SHELDUS annual state-level direct loss data for floods, wildfires, and combined storms. Building on this loss model, we illustrate how multi-peril CAT bonds can be priced and deployed as a risk management tool for a representative insurer, demonstrating the value of a joint multi-peril perspective across modeling, pricing, and risk management.

Weighted Risk Aggregation Under Long-Memory Dependence

Elina Moldavskaya, Technion — Israel Institute of Technology

Many insurance and financial risk models involve cumulative losses or risk indicators observed over long time periods. In such settings, observations may be dependent over long horizons, and past values can continue to influence future fluctuations. I will discuss weighted sums of nonlinear functions of long-memory Gaussian sequences, where the weights may represent changing exposure, portfolio weighting or different importance of observations over time. The main question is how large the long-term pathwise fluctuations of such weighted aggregates can be. The results describe iterated-logarithm type scales for these sums and show how the combination of long-range dependence, nonlinear transformations, and deterministic weights changes the asymptotic size of accumulated risk.

An Ultrafast Way of Assessing Bivariate Tail Dependence and Tail Asymmetry

Lei Hua, Northern Illinois University

In this talk, I will discuss an amortized neural inference approach to assess the strength of tail dependence and the degree of asymmetry between the upper and lower tails based on a proposed unified tail dependence parameter for copulas. Extensive simulation studies are conducted for amortized inference with neural Bayes estimators of two full-range tail dependence copulas, to understand its performance under different situations, including training and inference speeds, comparisons of different methods for generating samples for training, comparisons between neural Bayes estimators and maximum likelihood estimators, performance for different sample sizes, performance for assessing tail dependence and tail asymmetry simultaneously, and modeling capacities in various misspecified situations. The proposed method has an ultrafast inference speed and is universally applicable and interpretable, making it useful for many real-world applications. An accompanying R package FastTail is also developed. To demonstrate its usefulness, we conducted an empirical study on stocks and ETFs from 2011 to 2025. The proposed GGEE-GARCH model using the neural Bayes estimators outperformed other commonly used copula GARCH models in predicting the next day Value-at-Risk. While the amortized neural inference approach is implemented for full-range tail dependence copulas, it can be useful for other parametric copulas with intractable likelihood functions, opening windows of opportunities for future development of new copula families with flexible dependence patterns.

Covariates Identification of Lapse Rates in Life Insurance Using Generalized Linear Model via Adaptive Elastic Net and Its Oracle Properties.

Emmanuel Boamah (s, r), Student member of SOA/Graduate student-Missouri University of Science and Technology

Abstract Lapse risk constitutes a critical financial and strategic challenge in the life insurance industry, significantly affecting insurer profitability, solvency, and portfolio stability. A lapse occurs when a policyholder prematurely terminates an insurance contract, disrupting expected cash-flow patterns and potentially generating losses through unamortized acquisition costs and adverse changes in portfolio risk composition. Accurate identification of the drivers of lapse behavior is therefore essential for actuarial pricing, reserving, and enterprise risk management. Traditional approaches to lapse modeling frequently rely on generalized linear models (GLMs). Although these models are interpretable and widely used in actuarial practice, they may perform poorly in modern data environments characterized by a high-dimensional set of covariates, including policy attributes, economic indicators, and behavioral factors, which are often highly correlated. Penalized regression techniques offer a promising solution to these challenges. This study proposes the use of the Adaptive Elastic Net (AEN) for covariate identification and prediction of life insurance lapse rates. The AEN combines the strengths of Lasso and Ridge regression by introducing a weighted penalty that simultaneously encourages sparsity and effectively handles multicollinearity among predictors. Importantly, the adaptive weighting structure enables the estimator to satisfy the oracle property under suitable conditions, allowing consistent identification of relevant covariates and efficient estimation of their effects. Using simulated high-dimensional life insurance portfolio data, the proposed framework evaluates the performance of the Adaptive Elastic Net relative to the Adaptive Lasso. Model performance is assessed using predictive accuracy. Results demonstrate that the Adaptive Elastic Net more effectively identifies a parsimonious set of significant lapse drivers while mitigating multicollinearity and reducing overfitting. These findings highlight the practical value of the Adaptive Elastic Net as a robust statistical tool for lapse risk modeling, providing actuaries with improved methods for risk assessment and supporting more informed decision-making in life insurance portfolio management.

Impact of Basis Risk on Variable Annuity Reserves and Capital Requirements

Minsik Kim (s), Fox School of Business, Temple University

Variable annuities (VAs) are popular personal retirement savings vehicles that commonly include complex long-term guarantees. These guarantees are written on the underlying mutual funds and thereby expose insurers to substantial amounts of systematic financial risk. While hedging is crucial for insurers' risk management strategy, it is often complicated by basis risk—the discrepancy between the returns of the underlying mutual funds and those of hedging instruments. Several studies propose methods to reduce basis risk in VAs. We complement existing literature by quantifying the financial impact of basis risk on statutory reserves and risk-based capital under current U.S. regulatory standards (VM-21 and C-3 Phase II). These regulations allow insurers to reduce capital requirements if they implement a clearly defined hedging strategy (CDHS). However, insurers must consider the impact of basis risk when modeling the potential effectiveness of the CDHS. With less basis risk, the value of the hedging position can better track the value of the insurers' VA liabilities, which leads to lower reserve and capital requirements, thus yielding direct financial savings (in addition to lowering their risk exposure). Using the NAIC Generator of Economic Scenarios and other prescribed assumptions, we assess the value of VA assets and liabilities across various market paths. To ensure computational efficiency for large portfolios, we utilize the recursive dynamic programming approach proposed by Moenig (JRI, 2021) instead of intensive nested Monte Carlo simulations. This framework allows us to efficiently compute requirements for diverse VA portfolios under varying levels of basis risk. Our study contributes to the academic literature on VAs and provides practical insights for insurers to make informed decisions regarding their hedging strategies and capital management.

Impact of Climate Change on Human Mortality Improvement: a Varx-L Framework

Yechao Meng, University of Prince Edward Island

Climate change is increasingly recognized as an influential factor on population dynamics, yet its impact on mortality remains insufficiently understood. Existing studies largely focus on single climate factors—typically temperature—while overlooking the joint effects of multiple interrelated variables, as well as heterogeneity across age groups, genders, and regions. This project develops a comprehensive framework to incorporate multiple interdependent climate trends and weather characteristics into mortality modelling. It aims to quantify climate impacts on mortality improvement, examine demographic heterogeneity, and explore how climate risks influence dependencies across mortality outcomes. Methodologically, the project extends the vector autoregression (VAR) framework by integrating multiple climate predictors and employing regularization techniques for both sparse representation and efficient estimation in high-dimensional settings. The proposed approach provides interpretable insights into both individual and joint climate effects, while improving the accuracy and flexibility of mortality forecasts.

A Non-Likelihood Framework for Generalized Linear Models Parameter Estimation

Godfred Ahenkroa Kesse (s, r), University of Central Florida

GLMs are essential in statistical modeling in a wide variety of fields, and Maximum Likelihood Estimation (MLE) is often the standard parameter estimation method. Nevertheless, MLE can perform poorly in model misspecification or when the observations are heavy-tailed, thus giving unstable parameter estimates. This study proposes a non-likelihood framework based on L-estimators constructed from linear combinations of order statistics for GLMS. The methodology divides the predictor variable into localized clusters based on either K-means clustering or subjective binning, which describes the local behavior of the conditional mean. Weighted linear combinations of order statistics of the response variable within such regions are then used to obtain L-estimating equations. The weighting scheme is specified by a density function on the unit interval (0, 1) where the contribution of various regions of the ordered sample to the estimator can be flexibly adjusted. The Kumaraswamy density is chosen as the weighting function in this study due to its mathematical tractability and convenient parametric form. In this proposal we developed the method for Gamma GLM parameter estimation with a single predictor variable. Monte Carlo simulation outcomes indicate that the proposed L-estimation method yields more stable and efficient estimates of the parameters when compared to MLE, especially when data contamination exists. To assess tail risk during contamination, we focus on the left side of the distribution and thus restrict the effect of extreme right-tail outcomes. Under this weighting scheme, the proposed estimator more accurately captures the underlying Gamma-driven risk structure. Conversely, the MLE and contaminated empirical version deliver systematically increased Value-at-Risk (VaR) and Tail Value-at-Risk (TVaR) estimations, which depict their vulnerability to extreme values.

Agentic Ai: the Latest AI Buzz Phrase; What It Is, How It Works, and Where It Is Used

Arnold Shapiro, Penn State University

During ARC 2025, I presented an overview of the technical concepts and training approaches that power Generative Pre-trained Transformer (GPT) models, which at the time was the hot AI topic. Since then, Agentic AI has come to the forefront. While often discussed together, GPT models and Agentic AI are distinctly different. In a nutshell, the distinction between the two is that GPT models create content, while Agentic AI, which can use that content, autonomously executes tasks. This presentation discusses Agentic AI: what it is, how it works, and where it is used. The potential topics addressed include: AI agents, multi-agent AI systems, autonomy, goal directed behavior, tool use, context awareness, chain of thought, execution loop, orchestration layer, memory systems, and agentic AI actuarial applications. The presentation will conclude with a commentary.

Multi-Dimensional Value-At-Risk – Its Role and Properties in Managing Risks of Dependent Business Lines

Mengqi Wang (s, r), Western University

Value-at-Risk (VaR) is a cornerstone of regulatory capital determination under Basel and Solvency II. While the dependence structure across Lines of Business (LoBs) enters the computation of aggregate VaR through the joint loss distribution, the resulting scalar collapses the joint tail configuration into a single number, and therefore does not provide a principled basis for allocating the aggregate capital requirement across these LoBs without additional assumptions. This motivates multivariate extensions of VaR. In this work, we investigate multivariate VaR boundaries for dependent LoBs and the associated problem of allocating regulatory capital across them. We identify the boundary of the upper-orthant VaR set for a Multiplicative Background Risk Model with heavy-tailed components and then apply the concept of the path of maximal tail dependence - the direction of strongest joint tail co-movement - to identify a single allocation point from the boundary. We then analyse the properties of this allocation rule.

Rank-Based Sequential Tests for Copula

Yinhuan Li, University of Waterloo

Data in fields such as finance, insurance, and environmental science rarely arrive in a single, static batch; they stream over time. Traditional statistical tests for dependence structures are ill-equipped for this reality, as their validity breaks down if an analyst monitors the data stream or decides to stop the experiment early based on accumulating evidence. We introduce a novel approach for copula testing based on e-values. Our primary tools for this task are sequential ranks, e-values and a multivariate histogram estimator. Our method provides finite-sample guarantees for type-I error control, yielding an anytime-valid test. To address computational challenges with large datasets, we propose efficient approximations. Through simulation studies, we illustrate the power of our method. We achieve more power in settings with few observations than in the most common copula testing procedures. Applications to real datasets further highlight its practical utility.

Sequential E-Backtesting for Tail Risk Governance of Option-Embedded Insurance Liabilities

Rui Zong, Transamerica

Value-at-Risk (VaR) backtesting is widely used for model validation, but conventional breach-count tests may provide limited early-warning information when tail risk deteriorates rapidly. This study applies sequential e-backtesting to monitor tail-risk models for a stylized option-embedded insurance liability portfolio using 2015–2025 market data. Historical VaR, Filtered VaR, and Regime VaR are compared. Results show that Filtered VaR and Regime VaR reduce clustered breaches and improve alarm precision relative to Historical VaR. Sequential e-process alarms occur less frequently than standard VaR breaches, but are concentrated in economically meaningful stress episodes such as the 2020 COVID shock. The findings suggest that conventional backtesting and sequential e-backtesting serve complementary governance roles, with e-process monitoring providing a selective escalation layer for model risk oversight.

A Longitudinal Attribute-Conditioned Neural Network for Modeling Health-State Transition Probabilities in Temporally Irregular Data

Bright Manu (s, r), Arizona State University

By fusing latent trajectory representation learning, irregular time encoding, and adaptive attribute-conditioned attention, we develop Longitudinal Attribute Neural Network (LANTERN) for Temporal Evolution Modeling of Health-State Transition Probabilities in Irregular Longitudinal Data. The accurate estimation of health-state transition probabilities is fundamental to long-term care insurance (LTCI) pricing, reserving, and solvency assessment. Classical actuarial multi-state models typically impose parametric structures such as first-order Markov dependence and proportional hazard assumptions, which may limit flexibility in the presence of nonlinear aging dynamics, heterogeneous covariate effects, and irregular observation intervals common in longitudinal survey data. In contrast, LANTERN is a structured probabilistic model for estimating next-visit multi-state transition probabilities from irregular longitudinal data all while preserving compatibility with actuarial projections. The model captures history dependence and irregular timing through a learned latent trajectory representation that summarizes accumulated health history and produces probabilistically coherent transition distributions across Healthy, Mild Disability, Severe Disability, and Death states. Using longitudinal data from the Health and Retirement Study, we evaluate performance on actuarially relevant outcomes derived from transition probabilities under substantial class imbalance, including severe disability and mortality. LANTERN achieves statistically significant improvements in discrimination for severe disability and improved calibration relative to logistic regression and gradient-boosted tree benchmarks, with gains confirmed via paired patient-level bootstrap confidence intervals. Multiclass transition predictions remain well-calibrated, demonstrating reliable probabilistic accuracy across all health states. The resulting transition estimates are directly suitable for discrete-time cohort projection, illustrating the potential of structured machine learning models to enhance endpoint risk stratification and valuation in LTCI applications.

Survival Heterogeneity in U.S. Hospice Patients: a Retrospective Cohort Study

Ian Duncan, University of California Santa Barbara

Hospice in the United States delivers comfort-focused, goal-concordant care to individuals with a physician-certified prognosis of six months or less under the Medicare Hospice Benefit. Utilization has expanded over the past two decades, yet late referral remains common and lengths of stay are often short: national reports show a median hospice stay of only a few weeks, with substantial heterogeneity across settings and diagnoses. Because end-of-life care accounts for a sizable share of Medicare expenditures, short hospice survival time makes prognosis and timely referral important policy and clinical issues. CMS guidance emphasizes four key palliative drug classes—analgesics, antiemetics, laxatives/ anticholinergics, and anxiolytics—as essential for symptom control. To summarize clinical complexity and comorbidity, diagnoses are mapped to the CMS Hierarchical Condition Categories (HCC) model, which aggregates ICD codes into clinically coherent, risk-relevant groups. This study uses a large patient cohort from Enclara Pharmacia Inc., a national hospice pharmacy benefit manager (PBM), linking survival outcomes to longitudinal prescribing across the four core drug classes. We characterize U.S. national hospice length-of-stay patterns across admission settings and patient subgroups using Kaplan–Meier methods and logistic regression for six-month survival. Additionally we apply Cox proportional hazards models to determine whether measurable covariates—demographics, level of care, clinical severity, and medication exposure—can jointly explain the survival heterogeneity observed in the prior descriptive analysis. We formally test the proportional hazards assumption by extending the model to allow time-dependent effects.

Evaluating Representativeness in Healthcare Claims Data

Rob Lieberthal, Lieberthal & Associates, LLC

Health AI models increasingly drive risk adjustment and care management decisions. However, claims data reflect utilization patterns rather than population health, creating systematic biases that affect model outputs. This bias reduces model reliability and makes compliance with actuarial standards of practice more challenging. This SOA-sponsored project created a framework to identify and quantify bias in claims data and AI models. "Model cards" for machine learning were used for documentation of potential sources of bias, and an assessment tool is used to determine the effectiveness of statistical correction mechanisms for disparate model results. We present findings from three scenarios designed to mimic real-world modling bias. We assess the impact of geographical representation bias in a model used to predict sleep apnea rates in urban and rural populations. We examine documentation bias in the diagnosis of type 2 diabetes when clinically important comorbidities are undercoded. We also assess an intersectional bias scenario where the combination of disparities based on age and income in combination lead to underutilization of colorectal cancer screening, a key preventative test. In each scenario, we deploy methods such as propensity score matching, entropy balancing, and related statistical techniques to mitigate bias. We use synthetic data in order to produce a ground truth (known underlying) rate that can be compared with raw and corrected models. The results demonstrate the lack of a "one-size fits all" solution - instead, bias correction methods must be tailored to the bias scenario. Finally, we show how these results can be documented through an Excel based decision tool. This tool gives an indicator of the expected extent of bias, as well as recommendations in terms of model acceptance, revision, or rejection. These tools in combination are expected to lead to more equitable, fair approaches to modeling access and disparities in health insurance and beyond.

Continuous Time Optimal Insurance With Prevention Efforts and Price Incentives

Evan Cribbie (s, r), York University

Inspired by recent technological advancements such as telematics and wearable devices, we develop a novel insurance framework featuring real-time monitoring of policyholders' loss-preventive effort and a reward-based reimbursement mechanism that incentivizes such effort. Unlike existing literature that typically examines self-protection and self-insurance as separate mechanisms, our framework provides a unified treatment, allowing effort to mitigate both frequency and severity of losses, either individually or in combination. Within this framework, we derive the optimal effort level and optimal insurance demand in closed form. Subsequently, through extensive comparative statics, we unveil a series of rich economic implications that characterize this emerging insurance paradigm. These findings offer key insights for the design of next-generation insurance products that leverage real-time behavioural data.

Reducing Uncertainty in Linear Regression via a Minimum Variance Risk Functional: Applications to Actuarial Problems

Zinoviy Landsman, Actuarial Recearch Center, University of Haifa

Uncertainty is inherent in statistical, actuarial, and economic models, making its accurate quantification essential for risk management and solvency capital assessment. Building on the Location of Minimum Variance Squared Distance (LVS) risk functional introduced recently by Landsman and Shushi, we extend this variance-based framework to linear regression models commonly used in actuarial practice. This leads to regression-type predictors defined via the Minimum Variance Squared Deviation (MVS) criterion, providing a risk-sensitive alternative to classical least squares methods. We show that under symmetric response distributions, MVS coincides with the traditional Minimum Expected Squared Deviation (MES) estimator, while for non-symmetric (typically skewed) distributions the two approaches differ, with the gap driven by higher-order dependence structures influenced by the joint third-moment matrix of distribution P and the covariance matrix of predicted vector Y We derive an explicit analytical form of the MVS estimator and propose a hybrid approach combining MVS and MES criteria. To illustrate the applicability of our approach, we present two numerical examples: (i) predicting three components of fire losses---buildings, contents, and profits---and (ii) forecasting returns for six market indices based on the returns of their dominant stocks.

Enhancing Insurance Pricing Stability: The Robust Quadratic Credibility

Qian Zhao, Robert Morris University

While credibility theory remains a cornerstone of actuarial pricing, classical linear models—such as the Bühlmann and Bühlmann–Straub estimators—often compromise stability when faced with heavy-tailed data or outliers. To address these limitations, this study introduces the Robust Quadratic Credibility (RQC) framework, a refined methodology designed to enhance both estimation accuracy and robustness. The RQC model synthesizes second-order polynomial adjustments with winsorized ground-up loss data, allowing it to capture complex non-linear dependencies while capping the distorting influence of extreme losses. We provide a rigorous mathematical foundation for the RQC framework, establishing its asymptotic properties, and deriving closed-form expressions for the premium calculation. Theoretical results demonstrate that the RQC estimator consistently reduces Mean Square Error (MSE) compared to classical linear, semi-linear, and standard quadratic models. And real data analysis of a Swiss property fund validates the practical advantages of the model, revealing superior stability against data contamination compared to traditional methods. This research advances credibility theory by offering a methodology that effectively balances mathematical efficiency, robustness, and practical applicability across diverse insurance settings.

Structured Dispersion Modeling for Mortality Data Using a Conway-Maxwell-Poisson Specification

Emiliano Valdez, University of Connecticut

Mortality models that attempt to capture dispersion typically assume a fixed dispersion structure, an assumption that is rarely satisfied in practice, and can lead to miscalibrated uncertainty and poor predictive performance. In this paper, we introduce a flexible framework for explicitly modeling dispersion in mortality data using the Conway-Maxwell-Poisson distribution, which accommodates underdispersion, equidispersion, and overdispersion within a unified specification. Rather than imposing a global dispersion parameter, the framework allows both the type and degree of dispersion to vary by age and over time, thus capturing structural heterogeneity that simpler models may overlook. A Bayesian formulation treats dispersion as unknown, with prior structures that coherently propagate parameter, process, and distributional uncertainty. Estimation is carried out via Markov chain Monte Carlo (MCMC) methods. Using empirical death data for males in England and Wales, we show that variability in mortality counts differs substantially across ages and across time periods. This has meaningful implications for the calibration of longevity risk and the pricing of annuity products. This is a collaborative work with Jackie Siaw Tze Wong of the University of Essex.

A Tale of Two Pathways to Gompertz Mortality: Reliability and Vitality From an Actuarial Perspective

Kenneth Zhou, University of Waterloo

This paper studies two mechanistic explanations for human mortality by examining reliability theory and vitality modelling through a unified actuarial perspective. While the two approaches arise from different ageing mechanisms, we show that both can naturally generate the Gompertz law under suitable assumptions and can be extended to produce the Makeham law and late-life mortality plateaus. Using Canadian mortality data, we investigate the empirical behaviour of each approach and highlight the roles of heterogeneity, extrinsic risk, and stochastic randomness. Furthermore, we develop parallel definitions of biological age under both approaches and analyse how subjective survival beliefs emerge from misspecified parameters. Our comparison of these two approaches provides actuarial insights into the natural foundations of Gompertz mortality and the interpretation of ageing, frailty and death.

Structural Changes in Persistence of Mortality

Wanying Fu, Lebanon Valley College; with Barry Smith, Lebanon Valley College

Recent researchers have observed that long-memory is prevalent in mortality data. Related to a quantifiable measure of persistence, it is an important characteristic of mortality dynamics. However, prior researchers did not consider potential change in the persistence degree and assumed it is constant. Our research for the first time considers change in the persistence of mortality and demonstrates that mortality data displays obvious and substantial such changes. We apply a test of Martins and Rodrigues, a tool that has already been demonstrated to be effective in macroeconomics research, to detect the change in persistence in mortality time series for the first time. Our approach considers changes both in persistence and also in trend, separately, for each single-age mortality time series. Our results show that these two types of structural changes are very different in the aspects of age clustering and the time points of breaks. In experiments on simulated data, our model presents the best accuracy in the estimation of persistence degree compared to two control models.

Risk and Premium Sharing in the Distributed Insurance

Jiajie Yang, Bowling Green State University

Decentralized insurance has been rapidly evolving in the insurance market. It reduces the centralized role of insurers by distributing core functions among multiple participants, such as capital provision, underwriting, risk allocation, and claims processing. This presentation focuses on distributed insurance, one of the two leading models in decentralized insurance markets. To support its sustainable development, we establish a set of key principles governing the risk and premium allocation in this setting. These principles provide a rigorous foundation for designing allocation with feasibility and incentivization. The proposed allocation generalizes allocation rules observed in practice, which can be observed as a unifying framework for several practical allocations. The resulting models demonstrate strong potential for enhancing participation incentives and facilitating market growth. We also discuss partial axiomatic characterizations of these allocation rules.

Intertemporal Risk Sharing in Distributed Insurance

Youxi Zhang (s, r), Tsinghua University

We study intertemporal risk sharing in distributed insurance markets. we develop a multi-period model in which investors provide capital to absorb insurance losses while an internal loan mechanism reallocates shocks across both investors and time. In the benchmark two-investor, two-period environment, we characterize the optimal internal loan as the solution to a tradeoff between contemporaneous variance reduction and future repayment risk, and we show how individual rationality constraints endogenously scale down the first-best transfer. We then extend the analysis to a general setting with N investors and T periods and derive closed-form optimal loan rules for different smoothing schemes. Across these environments, the optimal loan redistributes capital toward investors with relatively high current exposure while spreading repayment over future periods in a way that minimizes aggregate discounted variance. The model delivers sharp conditions under which intertemporal smoothing is welfare improving, identifies how participation constraints limit feasible risk sharing, and shows that longer repayment horizons can strictly improve efficiency by lowering the variance cost of smoothing. Our results provide a tractable theoretical foundation for the design of decentralized insurance mechanisms and more broadly for dynamic risk-sharing arrangements in markets with rotating capital providers.

An Empirical Analysis of Medical Malpractice Payment Severity and Tail Risk Using the National Practitioner Data Bank

David Dussey (s), Middle Tennessee State University; with Kelvin Ansah, Middle Tennessee State University

Medical malpractice is one of the most volatile liability lines in the United States because a relatively small number of very large claims can drive a disproportionate share of aggregate loss. This study develops an actuarial severity modeling framework for the National Practitioner Data Bank (NPDB) public-use payment data, the principal federal repository of malpractice settlements and judgments involving licensed health care practitioners. This study analyzed inflation-adjusted, grouped payment data using specialized statistical estimators to establish an empirical benchmark. Testing revealed that the Burr XII model best fit the overall data, while extreme value methods were necessary for analyzing high-severity losses. Ultimately, a spliced model combining Burr XII for typical claims and a generalized Pareto distribution for extreme tails provided the most accurate risk estimates. Subgroup analysis reveals significant heterogeneity across allegation type, clinical outcome, practitioner age, settlement lag, and state jurisdiction, with obstetrics-related claims and quadriplegic/brain-damage outcomes showing greatest tail exposure. This severity modeling framework improves insurance risk management by aiding in policy pricing, reinsurance structuring, and reserve establishment. By accurately capturing both typical and extreme loss scenarios, it enables more reliable tail-risk quantification and informed capital allocation.

Functional Decline and the Dynamics of Informal Care: Evidence From Nhats

Carol Troy, Tunghai University International College

This paper examines how changes in functional status are associated with subsequent changes in informal caregiving among older adults. Using panel data from Rounds 11–14 of the National Health and Aging Trends Study (NHATS), the analysis focuses on within-person transitions in activities of daily living (ADL) limitations and corresponding changes in caregiving receipt and intensity. By exploiting longitudinal variation, the study characterizes how individuals adjust to functional decline through increased reliance on informal care. The empirical approach emphasizes a transition-based framework, allowing for the identification of entry into caregiving and changes in the number of helpers and caregiving intensity. This design highlights the timing and sequencing of adjustments to health deterioration, rather than relying on static cross-sectional relationships. The analysis also considers heterogeneity across living arrangements and baseline functional status, providing insight into how contextual factors shape caregiving responses. By focusing on dynamic adjustment, the paper contributes to the literature on aging and caregiving by documenting patterns in how informal care responds to changes in need over time. These findings have implications for policies aimed at supporting informal caregivers and managing long-term care demands in aging populations, particularly in contexts where formal care provision is limited or uneven.

Pricing Climate Risk in Health Insurance: a Dynamic Actuarial Model for an Environmentally Driven Infectious Disease (Valley Fever)

Trevor Reckell (s, r), Arizona State University

Climate change will likely be driving the expansion of environmentally sensitive infectious diseases, with transmission patterns mediated by complex environmental factors that already create and are bound to create more financial risks for health insurers. Coccidioidomycosis (Valley fever), especially in the U.S. Southwest, where progressive cases may require lifelong antifungal therapy, prolonged ICU stays, and neurosurgical interventions, exemplifies this challenge, yet no actuarial models currently exist that directly incorporate environmental drivers of transmission into insurance risk assessment. To our knowledge, this study presents the first actuarial model in the literature to link environmentally driven transmission dynamics with insurance risk by adapting a fully identifiable novel ten-compartment mechanistic Ordinary Differential Equation (ODE) model. The model utilizes mechanistic functions tied to measurable environmental parameters, accurately capturing the nonlinear dynamics of the pathogen's underground saprobic lifecycle and high rates of subclinical infections that complicate disease burden estimation. We map epidemiological compartments to insurance states and demonstrate net level premium calculations using parameters fitted to Maricopa County, Arizona, data. Results reveal that standard static premiums fail to account for environmental volatility, leading to periods where premiums are insufficient during seasonal outbreak peaks. Using MATLAB simulations, we quantify climate risk by projecting tail-risk payout surges under sustained daily temperature increases of 1°F, 2°F, and 5°F. Our iterative premium adjustment algorithm yields dynamic, solvency-adjusted rates that respond to changing environmental conditions and increasing Valley fever incidence. This research pioneers direct incorporation of climate projections into medical actuarial modeling for environmentally dependent pathogens, establishing a methodology adaptable to other climate-sensitive diseases as environmental risks evolve.

Loss Reserving With Generalized Linear Models and Textual Description of Claims

Nii Okine, Appalachian State University

This paper presents a novel loss reserving approach for property-casualty insurance using an event-level generalized linear model (GLM), which can be extended to incorporate textual claim descriptions and pre-trained word embeddings as predictors. The proposed method is a simplified micro-level reserving approach based on a regression model that bins claim transactions by development years. The reserving process is divided into two parts: predicting the expected number of non-zero payments, and estimating the amount for each non-zero payment. Reserves are calculated by multiplying the expected frequency by the payment amount severity. Using Bayesian methods with horseshoe priors, the model's predictive distribution improves with textual data, leading to better out-of-sample predictions and lower deviation. The results of the Gini index show an improved ability to differentiate high and low-severity claims, indicating that word embeddings help identify patterns and produce more accurate reserve estimates. Recent advances in natural language processing (NLP) have transformed how unstructured text data are used in insurance and actuarial science. Word embeddings, like those from transformer-based models such as word2vec, GloVe (Global Vectors for Word Representation), and BERT (Bidirectional Encoder Representations from Transformers) help insurers analyze policy texts, claims, and underwriting notes. However, until now, NLP's use in loss reserving has remained limited in the literature. In this paper, we demonstrate how word embeddings can be used to enhance loss reserving when used with the proposed generalized linear model framework. This presentation is based on the work coauthered with Dr. Gee Y. Lee (Michigan State University).

Predictive Modeling Frameworks for P&C Personal Lines Insurance Pricing and Reserving

David Han, UT San Antonio

P&C insurers use statistical models for pricing and loss reserving, both of which rely on historical claims, exposure, and policyholder behavior. While these functions are traditionally separate, modern granular data and predictive modeling allow for more integrated approaches. This research introduces predictive modeling frameworks to address three key actuarial challenges: integrating policyholder demand into rate balancing, evaluating multi-period profitability dynamics, and estimating policy-level incurred but not reported (IBNR) losses. First, the research addresses rate adequacy by integrating predictive demand models - using logistic regression and tree-based algorithms for acquisition and retention - with expected loss cost models. This demand-weighted off-balancing framework accounts for how price changes affect portfolio composition, correcting premium and loss distortions caused by relying solely on unadjusted in-force data. Second, the framework is extended to a multi-period setting to manage profit drift, which is the divergence between expected and realized profitability over time due to shifts in business mix, claim patterns, or model limitations. Finally, the research replaces traditional, aggregated triangle-based reserving with a policy-level IBNR framework. By modeling report lag through a discrete-time hazard formulation and predicting claim severity based on lag and specific covariates, this approach estimates expected ultimate losses using granular policy- and claim-level features.

The Optimal Combination of Reinsurance and Index Insurance

Jiandong Ren, Western University

Controlling insurance companies' risk levels is essential to insurance operations. This is especially important due to the increasing catastrophic (CAT) risks. Reinsurance is the primary tool for insurance companies to manage their risk level and underwriting capacity. However, as noted in literature, most insurers purchase relatively little CAT reinsurance against large events because CAT reinsurance premiums are high relative to expected losses. Index-based insurance contracts are financing devices that enable insurance risk to be sold in capital markets. Thus, they potentially offer a viable mechanism for financing CAT losses than conventional insurance and reinsurance. However, since the payout is based on the index rather than the loss itself, basis risk exists. Results for optimal reinsurance and index insurance policies are abundant in the economics/insurance literature. However, studies on how to combine the two types of risk-transfer mechanisms are scarce. Therefore, in this paper, we explore the optimal combination of reinsurance and index insurance to hedge an insurer's risk. By assuming that the payout functions of reinsurance and index insurance policies are piecewise linear, we provide numerical solutions to the optimal combinations. Our methodology is easy to interpret and can be applied to other optimal insurance problems where analytical solutions are not available.

Optimal Investment, Consumption, and Insurance Strategies Under Claim Habit: Claim Habit Accounts for Deductible

Shansong Huang (s), University of Connecticut

We study an optimal consumption, investment, and insurance problem in which financial decisions are made continuously while insurance choices are adjusted discretely over time. Standard premium principles typically depend only on contract indemnity, which contrasts with real-world insurance practice where claim history plays a central role. To address this discrepancy, we incorporate claim history through a claim-habit process, allowing past claims to dynamically affect future premiums and coverage decisions. The model features a stochastic wealth process subject to investment returns, consumption, and random losses driven by a Poisson process. Insurance contracts include deductibles, and a claim is triggered only when losses exceed the deductible threshold. We derive the associated HJB equations and characterize optimal controls for consumption, investment, and insurance decisions. The discrete nature of insurance introduces a hybrid control structure, leading to regime-dependent dynamics. We obtain semi-explicit solutions for key components and numerical experiments illustrate how claim habit affects optimal insurance demand, wealth dynamics, and consumption paths. Our results contribute to bridging the gap between theoretical insurance pricing and industry practice, offering a framework for studying dynamic insurance decisions under path-dependent pricing rules.

Log-Optimal Portfolio Construction for Binary Options With Combinatorial Constraints

Bin Zou, University of Connecticut

We study the problem of optimal wealth allocation across independent binary options with known payouts, aiming to maximize log utility under practical constraints. This general framework arises in settings such as prediction markets (e.g., Kalshi and Polymarket), financial event contracts (e.g., Nadex), and sports betting (e.g., Draftkings and FanDuel). The Kelly Criterion provides a classical solution for the bet sizing of a single binary option, and numerous papers have explored extensions to multiple binary options. Our work expands on this body of research by investigating how to incorporate combinatorial constraints into the model, including limits on the number of binary options to select in a portfolio, a requirement that arises in many settings. These constraints considerably increase the computational complexity of the problem, thereby necessitating advanced solution methodologies. To address this challenge, we develop a logic-based Benders decomposition algorithm that provides a scalable and computationally efficient solution framework. Although broadly applicable, we focus on sports betting due to its market scale and unique inclusion of parlay options.

Multi-Output Extreme Spatial Model for Complex Production Systems

Xing Wang, Chinese Academy of Sciences

Data-driven spatial models in machine learning have enabled efficient control of production systems. However, most machine learning models are devoted to modeling the mean response, so they are inappropriate to analyze abnormal extreme events that are often the main interests. Since extreme events from tail distribution give rise to prohibitive expenditures in system management, extreme spatial models should be utilized to analyze extreme risks. Recent engineering applications of extreme modeling are limited to simple cases such as univariate modeling, and it is insufficient for complex systems. Moreover, existing extreme spatial models in other domains cannot be directly applied to controllable systems. In this paper, we propose an extreme spatial model that enables the modeling of multi-output response control systems. Robust parameter estimation is proposed for marginal extreme distributions, and efficient composite likelihood estimation is devised to cope with high dimensional problems. The proposed model is applied to the modeling of maximum residual stress in composite aircraft production and the application of the spatial model to extreme climate risks.

An Age Grouping Framework for Multi-Population Mortality Modeling

Cezar Campeanu (s), University of Prince Edward Island

This study extends existing mortality prediction frameworks by incorporating information borrowed from population–gender–age subgroups that exhibit similar mortality patterns. The borrowed information is integrated into classical mortality models to improve the accuracy of future mortality rate forecasts. To capture structural similarities among mortality trajectories, several distance measures are evaluated in combination with four linkage methods, particularly when each subgroup comprises multiple age-specific mortality trajectories. Extensive empirical analyses using data from the Human Mortality Database demonstrate the superior predictive performance of the proposed approach.

Modeling Spatially Compounding Events With Graph Neural Network

Shimeng Huang, Purdue University

Natural disasters generate spatially correlated losses through interconnected environmental and hydrological systems, yet existing catastrophe loss models struggle to capture such spatial dependencies at the property level. We propose a hierarchical graph neural network (GNN) framework that models multi-level spatial structure in flood insurance losses. The framework captures inter-region dependencies along two dimensions---geographic proximity and directed hydrological connectivity along river networks---and aggregates property-level information within each region through a permutation-equivariant architecture that respects the exchangeability of properties. A recurrent neural network encodes temporal weather dynamics, and the fused representations are passed through a feedforward network to produce property-level predictive distributions based on the generalized gamma family. We apply the framework to claims from named storms in Florida (1978--2023) under the National Flood Insurance Program. The proposed model significantly outperforms both a non-graph baseline and a proximity-only GNN in point and probabilistic forecasts of individual claim severity and in aggregate event loss predictions on held-out storm events. The improvements persist under a temporal split evaluating forward-looking generalization. These results demonstrate that incorporating spatial structure substantially improves the modeling of losses from spatially compounding weather events, and that explicitly accounting for directed hydrological dependencies provides significant additional predictive value beyond proximity-based spatial relationships.

Interest: a Library for Formalized Financial Math and Actuarial Science

Bjørn Kjos-Hanssen, University of Hawaii at Manoa

Standard actuarial education includes an exam on financial mathematics, specifically the mathematical theory of interest rates. In this talk we describe a project taking the first steps toward formalizing this theory in the proof assistant Lean. As Lean’s Mathlib library already has a thorough coverage of calculus, we are able to develop the theory of interest directly. We start with the Annuity Equation, a staple of actuarial science and financial mathematics, relating a payment, present value, future value, interest rate, and maturity date. Using the Lean proof assistant, we verify the unique solvability of the Annuity Equation for each variable under reasonable assumptions. We next do the same for a Macaulay duration equation, with some help from Harmonic’s mathematical superintelligence tool Aristotle. Finally, using Radisic’s verified numerical computation tool LeanCert, we are able to formally prove the correctness of solutions to actuarial exam questions having numerical answers.

Rethinking Actuarial Education in a Global World: the Role of Actuarial Education Companies

Gabriel Necoechea, ACTEX Learning; with Bill Marella, ACTEX Learning

The actuarial profession is increasingly central to the global dialogue on creating a fairer and more sustainable world. The United Nations Development Program (UNDP), which works globally to eradicate poverty and reduce inequality, has identified the insurance sector as a key factor in achieving their Sustainable Development Goals (SDGs). Insurance and risk protection mechanisms directly support six SDGs and are crucial to the successful realization of five others. At the heart of this dialogue is actuarial education. At ACTEX Learning, a leading global provider of actuarial education, we believe that Actuarial Education Companies (AECs) play a pivotal role in shaping a better future. In this presentation, we will discuss our approach to actuarial education within this global context, with a particular emphasis on the importance of partnerships. We will share case studies of successful programs that illustrate our commitment to this mission, expanding access to affordability, and highlight the positive impact of our initiatives. Outline 1. Actuarial Education: A global perspective a. Actuarial Education: A Core need in the World Today b. Who are the Stakeholders in Actuarial Education? c. Global World, Global Challenges, Global Solutions 2. The power of Partnership a. 1+1=3 Mindset -- Corporate/ AEC synergies -- AEC/AEC synergies -- Universities/ AEC synergies -- Professional Bodies/AEC Synergies b. Communities of Practice: Connecting people & ideas 3. Creating Lasting Impact: Case Studies a. Case Study 1: Strengthening University Actuarial Faculty Teaching in Low to Middle Income Countries: Actuarial Faculty Development Program in partnership with the United Nations Development Program-Milliman GAIN program b. Case Study 2: Ghana Initiatives: • Actuarial Society of Ghana (ASG): Curriculum support for the newly created ASG pathway • Enabling Exam access: ACTEX partnership with Ghana Diaspora Initiative in 3 Ghana Universities c. Case Study 3: Foreign Language Instruction Support • Insurance Payment Guarantee Fund of Kazakhstan: partnering to increase accessibility of SOA exams to Russian speaking candidates in Central Asia, • ACA: development of an SRM Spanish course with the Colombian Actuarial Association, 4. What the Future Holds a. Sustainability in Education b. A Better, More Equitable World!

From Calculus I to Credentialed Actuary: Where We Lose Students and How to Fix It

Kevin Doran, University of Alabama

The actuarial pathway is known for its rigor, yet many students who begin in actuarial science do not persist through graduation or into professional credentialing. This presentation explores where and why students tend to exit the pathway, from early coursework in Calculus I and II through initial exam attempts and the search for internships. Drawing on advising experience, student trends, and existing research, this presentation identifies several key exit points and exit events along the actuarial journey. These include early challenges in foundational math courses, the transition to more abstract probability-based material, the impact of first actuarial exam outcomes, and difficulty securing internships. Although many students enter the major and/ or minor with strong mathematical backgrounds, they often encounter a level of rigor that exceeds expectations, which can undermine confidence and prompt reconsideration of career goals. In addition, limited understanding of the structure and demands of professional exams contributes to misaligned expectations. These academic and professional pressures frequently converge, increasing the likelihood of attrition. This presentation also highlights practical strategies to support student persistence, including earlier career exposure, structured exam preparation, intentional advising practices, and improved internship readiness. By approaching actuarial education as a developmental pathway, institutions can better support students through critical transition points and improve long-term outcomes for aspiring actuaries.

Dynamic Optimal Staking in Decentralized Insurance

Xiaochen Jing, University of Illinois Urbana-Champaign

Losses in decentralized finance (DeFi) are often driven by discrete, event-based shocks, such as smart contract vulnerabilities, oracle manipulation, and exploitative trading strategies such as sandwich attacks. These risks are characterized by low frequency but high severity, or high frequency with smaller impacts, which together generate heavy-tailed and clustered loss patterns. We develop a stochastic control framework to model decentralized insurance mechanisms, where a large population of investors dynamically allocates capital (staking) to provide coverage against protocol-specific risks. The aggregate claims process is linked to a stochastic cryptocurrency price process, allowing for interactions between market dynamics and insurance liabilities. We combine empirical evidence on major exploit events and sandwich attack intensity to construct a stylized representation of aggregate losses. The key insight is to treat DeFi losses in a unified framework that reflects both routine market fluctuations and the impact of extreme cyber events. Our results highlight the importance of capturing these risk features in DeFi insurance design, with implications for pricing, risk assessment, and capital allocation.

Optimal Risk Sharing in Multi-Period Peer-To-Peer Insurance

Dung Pham (s), Bowling Green State University

In this paper, we study optimal risk-sharing strategies in a peer-to-peer insurance market across multiple periods. Building on established results that optimal risk-sharing allocations take a linear form, we develop a framework to fully characterize the optimal participation coefficients under individual risk capacity constraints. Beginning with the two-period baseline, we extend the analysis to a multiple-period setting in which investors enter the market sequentially and each faces a personal risk capacity constraint. A key finding is that the ratio of risk shares between any two investors remains constant across all periods they are jointly active. This invariance property simplifies the problem, allowing us to identify and solve all possible cases depending on which investors' capacity constraints are binding. For each case, we derive the closed-form optimal coefficients and the conditions under which that case holds.

Incorporating Heart Rate Variability Into Insurance Pricing: Evidence From Simulation and Wearable-Derived Data

Adrian O Hagan, University College Dublin

Heart rate variability (HRV), which can be measured using wearable devices such as smart watches or smart rings, is widely recognised as being associated with mortality and morbidity risk. However, the implications of incorporating HRV into life-insurance and health-insurance pricing, particularly in the possible presence of information asymmetry between individuals and insurers, remain unclear. This research examines how HRV-based risk information may affect insurer performance under alternative pricing strategies using a controlled simulation framework. We first generate a realistic synthetic population of individuals calibrated to age- and sex-specific baseline mortality rates using census and published life tables data. We then introduce an HRV-related multiplicative hazard component, which adjusts the baseline hazard of each individual (based on their simulated age, gender and behavioural and health-related covariates) with effect sizes varied across a plausible range informed by the clinical literature. Two notional insurers are considered in the simulation study: one that prices policies using traditional rating factors only; and another that incorporates HRV into premium calculations in additional to traditional rating factors. The product underpinning the simulation study is a term life insurance policy. Individuals are assumed to purchase insurance based on premium price under varying degrees of price elasticity. We additionally simulate the proportion of the population that is informed about their HRV-adjusted risk and how this affects their purchasing decisions. Both the strength of the HRV–mortality/morbidity association and the proportion of informed individuals are varied, with each scenario repeated multiple times to account for stochastic variability. This allows us to understand the uncertainty in the outcomes observed and the implications for the financial outcomes for each of the companies. Results are presented in terms of premiums earned, losses paid, loss ratios, profit ratios, and deaths in each portfolio of policyholders, and are compared across the two companies.

Robust Optimal Portfolio in a Mixture Setting With Partial Ambiguity

Tianrun Wang (s), University of Iowa

Managing insurance and financial risk when data is limited is a key task in the insurance industry. In this paper, we focus on cases where the risk distribution is modeled as a mixture with some components estimable to high precision or known, and others, along with their weights, are not. Our paper addresses two robust portfolio optimization problems with partial ambiguity, where the loss function involves either variance or conditional value-at-risk (CVaR). We use a projected subgradient descent algorithm to solve the optimization problems. The problem reduces to a convex-nonconcave minimax problem. We show that, while the general problem converges at an $O(1/\sqrt{k})$ rate, where k denotes the number of iterations, exponential convergence is possible in some cases. Lastly, we provide numerical examples to show the effectiveness of our approach and the attainment of a geometric convergence rate. This work aims to provide more effective solutions for actuarial decision-making under model uncertainty.

Pricing Forward Start Options Under an Additive-Multiplicative Stochastic Volatility Model

Ibukun Amusan, Austin Peay State University

Forward start options are exotic options that become active on a specified future date. While the option is priced and paid for at inception, its strike price is not fully set until the activation date. Pricing these options is important because they have practical uses, including the valuation of employee stock options that vest in the future, hedging guaranteed benefits, and serving as building blocks for cliquet options. Forward start options have been studied under several frameworks, ranging from the foundational Black-Scholes model to stochastic volatility models such as the Heston model. This presentation examines their pricing under a coupled additive and multiplicative stochastic volatility model, which is an extension of the Ornstein-Uhlenbeck stochastic volatility model, and compares the resulting valuation with those obtained from other models.

Optimal Loss Reporting Under Bonus-Malus Systems

Yi Wu (s, r), University of Connecticut

Bonus-malus systems (BMS) are widely used in insurance to adjust premiums based on individual claim history. While such systems are intended to incentivize safer behavior, they also create incentives for policyholders to underreport small losses in order to avoid future premium increases. This talk studies how such incentives affect optimal reporting and insurance decisions over time. We consider a finite-horizon model in which a policyholder faces random losses and chooses both a deductible and a reporting strategy. The BMS is modeled as a finite-state Markov chain, where transitions between premium classes depend on reported claims. Under exponential utility, the policyholder's problem is analyzed in two steps: determining the optimal reporting strategy for a given deductible, and then choosing an optimal deductible while accounting for induced reporting behavior. The main result characterizes the optimal reporting strategy as a time- and state-dependent barrier rule. The reporting threshold decomposes into three components: the deductible level, the difference in future premiums capturing class transitions, and a risk adjustment term given by the difference in certainty-equivalent costs. This structure provides a clear interpretation of the trade-off between immediate indemnity payments and future premium costs, accounting for risk. We also discuss the existence, uniqueness, and monotonicity of the optimal deductible. The analysis provides a tractable framework for understanding loss reporting behavior under experience rating mechanisms.

Statistical Characteristics of Declines and Rises in the U.S. Stock Market

Min Shu, Central Michigan University

A novel upward and downward methodology is developed to systematically investigate the statistical characteristics of declines and rises in different total market capitalization segments of U.S. stocks Market. The study includes four major U.S. stock market indices: the Wilshire 5000 Total Market Index, the S&P 500 Index, the S&P MidCap 400 Index, and the Russell 2000 Index, representing the overall market, large-cap stocks, mid-cap stocks, and small-cap stocks, respectively. At each point in time, the activity level of the current upward (downward) phase is checked by comparing the maximum deviation value with a preset tolerance value. This tolerance value is used to quantify the level of price fluctuation allowed relative to the upward (downward) trend. Furthermore, we apply the log-periodic power law singularity (LPPLS) method to categorize the causes of bubbles and crashes into two types: endogenous and exogenous. This study creates a paradigm for future studies in declines and rises in not only the stock market, but also other financial markets and economic indices.

Queuing Systems in Actuarial Science: Theory and Applications

Natalia Humphreys, University of Texas at Dallas

In this presentation we explore Queuing Systems (QS) as mathematical models used to describe and analyze the behavior of waiting lines or queues. QS are commonly applied in various fields, including telecommunications, insurance industry, computer networks, customer service, manufacturing, and traffic systems. They serve as important instruments to understand and optimize processes where resources (such as servers or service facilities) are limited and customers require service. After defining QS as a classical birth-and-death stochastic process, we explore its fundamental identity, the main result regarding its limiting behavior and several of its main characteristics. After exploring various types of QS, we introduce the thinning process, a powerful tool in the theory of Poisson processes that allows us to selectively count certain types of events from an underlying Poisson process, based on an arbitrary probability. We conclude our presentation with a few general examples that play significant role in actuarial science and beyond.

Business Interruption Risk Modeling Framework for Polymetallic Nodule Deep Sea Mining

Mobasshira Zaman (s), School of Computing and Augmented Intelligence, Arizona State University, USA

Deep-sea polymetallic nodule (PMN) mining presents an emerging industry, and the operational pipelines and technology for this are still under development. Operating under extreme environmental uncertainty and with negligible loss history, PMN projects expose insurers to substantial business interruption (BI) exposures that resist conventional actuarial treatment. To bridge the gap, this paper utilizes a probabilistic framework for modeling aggregate BI loss distributions under data-scarce conditions. The proposed approach integrates a Bayesian Belief Network (BBN) with expert-elicited conditional probabilities to model causal dependencies across operational subsystems. The system-level BI loss probability is then employed to determine restoration dynamics and economic valuation. To our knowledge, this is the first system-level actuarial loss estimation framework that estimates insurance pricing ranges based on operational BI loss for burgeoning sectors. The result shows annual interruption probability ranges from 19.3% under favorable operational regimes to 77% under adverse conditions. From the sensitivity analysis, the dominant operational and managerial subsystems are noted. However, incorporating cost-based reveals most of these dominant subsystems, causing minor BI loss, making the aggregated losses innocuous for insurers. Expected restoration times for single interruptions range from 17.5 ± 3.8 to 52.7 ± 20.4 days. Annual BI insurance premiums for multiple interruptions range from $1.1M to $10.9M. The insurers, mining companies, and other stakeholders can utilize this framework to make informed decisions and reduce business risk.

Injury Risk Management in the National Basketball Association: an Actuarial Approach

Jackson Lautier, Bentley University

Major professional sports leagues have become large-scale financial institutions. This presents an increasing financial risk to an injury sustained by its athletes and, therefore, a growing need for injury risk management studies. We present a study of injuries in the National Basketball Association (NBA) from the perspective of insurable risks. Specifically, we employ a three-part actuarial compound risk model to identify drivers of injury occurrence frequency and a two-part injury severity through missed games given an injury and a financial loss per game missed. We fit this model using a novel dataset from the 22-23' NBA regular season that includes player injury, tracking, box score, salary, demographic, television, and travel information and economic estimates of game values. We predict higher losses for players with higher salaries, 32+ minutes played per game, and in larger markets. We estimate the top ten players account for $453M in at-risk injury losses per season, which is over 25% of all estimated at-risk injury losses. The actuarial approach also suggests risk mitigation strategies. We estimate that a uniform 10% cut in average minutes played per game reduces the expected compound loss for the highest risk players by 30-35% or $9-25M per player. Leaguewide, we estimate that shortening the length of an NBA game from 48 to 40 minutes would reduce total expected claims by $493M. We discuss how these results fit within related literature, salary cap accounting, and the tanking discourse, including suggested areas of further work. Data and replication code are made available. This is a joint work with Hashan Peiris and Himchan Jeong, Simon Fraser University.

Robust Quantile Least Squares for Learning Loss Severity Models With Incomplete Data

Mohammed Adjieteh, Appalachian State University

Building on the quantile least squares (QLS) methodology originally proposed for fully observed location-scale families, this paper develops a QLS approach for robust estimation of actuarial loss severity models under incomplete data. The method extends the QLS framework for location-scale families to insurance payment data affected by deductibles, policy limits, and coinsurance. Both payment-per-payment and payment-per-loss settings are considered for lognormal severity models. The proposed estimators are constructed by linking empirical and theoretical quantiles under the transformed data structures and by using the covariance structure of sample quantiles to improve efficiency. The resulting estimators have explicit regression forms and are easy to compute. Large sample properties such as consistency and asymptotic normality are established, and the influence functions are bounded, which ensures robustness. The proposed approach provides a balance between efficiency and robustness when compared with maximum likelihood and trimmed moment based methods. Simulation studies show that the estimators perform well under contamination and model misspecification. An application to real insurance loss data illustrates the usefulness of the method for practical severity modeling under common coverage modifications.

Semi-Supervised Machine Learning Algorithms for Fraud Detection Using Imperfect Fraud Labels From Claims Analytics

Michelle Xia, Department of Statistics and Actuarial Science, Northern Illinois University

Fraud detection is a critical task in claims analytics due to the high cost of fraud investigations. In this talk, we present novel semi-supervised algorithms for predicting insurance fraud using imperfect fraud labels that exhibit a unique unidirectional misclassification property, as studied in our previous work (Xia et al., 2023; Chen et al., 2021; Akakpo et al., 2019). For fraud detection, we treat the misclassified variable as the response and extend the Bayesian model of Xia and Gustafson (2018) to likelihood-based inference, incorporating predictors for the prevalence of misclassification. Through simulation studies, we demonstrate that the proposed method helps eliminate bias in parameter estimates while improving out-of-sample prediction of claims fraud. Case studies are conducted for both Property and Casualty (P&C) and health insurance data, using the proposed approach as well as existing semi-supervised learning algorithms from the machine learning literature that combines supervised learning with unsupervised learning (e.g., Van Engelen et al., 2020).

Valuing and Managing Value-Based-Care Contracts: A Latent-State Decision Framework under Treatment Heterogeneity and Uncertainty

Ramzi Abujamra, ActuariAI LLC

Value-based care asks payers and risk-bearing providers to allocate a fixed budget across interventions to improve outcomes and reduce cost. This is an allocation problem, not a prediction problem — yet the standard instrument, risk adjustment, estimates who is likely to incur cost, not who would benefit from intervention, nor whether the benefit exceeds its cost. We present a latent-state decision framework that treats risk, responsiveness, and net value as distinct decision dimensions, and links two phases of the problem — valuing a contract at signing and managing it through the year — through a single economic quantity, the marginal value of capital (λ). In the valuation phase, the framework estimates a state-dependent treatment-response operator, values each patient–intervention pair as the discounted displacement of a latent severity trajectory net of cost, allocates the budget by a shadow-price hurdle, and attributes portfolio value by a Shapley decomposition. A prior identifiability analysis characterizes when the response operator is recoverable at all — an overlap/positivity-style requirement — and shows that administrative claims structurally lack the discretionary-intervention variation needed, so operator recovery is demonstrated as a positive control. In the management phase, the same λ prices the in-year choice to gather information versus act: gather only when the value of information exceeds its λ-priced opportunity cost, extended to a sequential policy (Hamilton–Jacobi–Bellman) on the belief state. All mechanisms are exhibited on a real CMS population with authored treatment operators; the contributions are structural — the distinctness of the decision axes and the shadow-price bridge linking valuation to management — while dollar magnitudes are illustrative. We frame value-based-care targeting as decision-making under heterogeneity and uncertainty, spanning contract valuation and in-year management within one architecture.

Funding Relief and Pension Behavior: Evidence From the American Rescue Plan

Xuan Tang (s), Temple University

In this study, we investigate how single-employer pension plans change their funding and investment behavior in response to the American Rescue Plan Act (ARP) of 2021. To facilitate the recovery from the impact of COVID-19 pandemic, the funding requirements for single-employer pension plans were substantially relaxed under ARP 2021, primarily through extended funding amortization and enhanced interest rate smoothing. Using a difference-in-differences design with simulated instrumental variable, we establish a causal link between plan investment behavior and pension relief policies. We find that plans adopting ARP relief have implemented more aggressive investment strategies, shifting weights from bonds and cash toward equity and pooled funds. In particular, deeply underfunded plans decreased their corporate and government debts by approximately 5.7 and 3.7 percentage points, respectively. We also find that plans with larger asset sizes, lower funding ratios, and union-bargained benefits contribution rates tend to adopt the ARP relief earlier. Actuarial consulting firms play an important role in adoption timing. While ARP 2021 reduces the pension contribution pressure, our findings suggest that the relief actions also introduce unintended risk-taking behavior, amplifying moral hazard concerns among pension plans.

Efficient and Interpretable Transformer for Counterfactual Fairness

Panyi Dong (s, r), University of Illinois Urbana-Champaign

The growing reliance of machine learning models in high-stakes, highly regulated domains such as insurance has created a growing tension between predictive performance, interpretability, and regulatory fairness requirements. In these settings, models are expected not only to deliver reliable predictions but also to provide transparent decision rationales and comply with strict fairness requirements. Existing fairness-aware learning methods for tabular data, however, often focus primarily on group-level fairness metrics or depend on explicit and structural causal model assumptions that are challenging to validate in practice. Meanwhile, attention-based transformers offer powerful mechanisms for modeling complex data relationships as demonstrated in various language tasks, yet their attention mechanisms alone do not ensure counterfactually fair predictions, even when combined with fairness-aware techniques. To address these limitations, we propose the Feature Correlation Transformer (FCorrTransformer), an attention-light architecture tailored for tabular data. In this design, the attention matrix admits a direct statistical interpretation as pairwise feature dependencies, enhancing both interpretability and efficiency. Leveraging this structure, we introduce Counterfactual Attention Regularization (CAR), a framework that enforces group-invariant fair representations of sensitive features at the attention level, promoting counterfactually fair predictions without relying on explicit causal assumptions. Empirical evaluations on imbalanced classification and regression benchmarks demonstrate that FCorrTransformer combined with CAR achieves strong counterfactual fairness while maintaining competitive predictive performance and substantially reducing model complexity compared with standard transformer-based baselines. Overall, this work bridges a critical gap between fairness theory and machine learning models, offering a practical framework for responsible AI in regulatory-sensitive domains.

Geometric Power-Distance Tilted Kernel Density Estimation for Heavy-Tailed Distributions

Jackie Siaw Tze Wong, University of Essex

Kernel density estimation for heavy-tailed distributions remains challenging due to severe data sparsity in the tails and the resulting instability of classical smoothing methods. Standard kernel density estimators tend to systematically underestimate tail mass, while existing remedies based on data perturbation or tilting often rely on likelihood-based criteria that perform poorly in heavy-tailed regimes. In this paper, we propose a distance-weighted tilted kernel density estimator designed to enhance tail sensitivity while preserving global smoothness. The method assigns observation-specific weights proportional to a power of the distance from the sample center, controlled by a tuning parameter that regulates tail emphasis. Unlike likelihood-based tilting, the proposed weighting scheme directly targets tail regions through geometric information and acts as a non-asymptotic regularization mechanism for heavy-tailed density estimation. We establish pointwise consistency and asymptotic normality of the proposed estimator under mild regular variation conditions. Although the asymptotic distribution coincides with that of the classical kernel density estimator, the finite-sample behavior is substantially improved in the tails. Extensive simulation studies demonstrate marked gains in tail probability estimation and tail-weighted error measures across a range of heavy-tailed distributions. An application to real data illustrates the practical relevance of the method.

CTE Induced Premium Principles and Properties

Linjiao Wu, Appalachian State University

The traditional pricing approach in the insurance industry assumes independence among insureds, yet overlooks the complexities of interdependent risk profiles. This dissertation addresses this limitation by proposing a premium pricing model tailored for managing dependent risks, drawing inspiration from conditional tail expectation (CTE) theory. In our model, each individual insured's premium is contingent upon the collective loss surpassing a predefined threshold. To validate the efficacy of our model, we introduce several key properties to ensure fairness and stability in premium determination among insured individuals, including diversification and monotonicity. Diversification ensures that adding one policyholder to the insured group does not unjustly increase the premiums of others, while monotonicity ensures that others’ premiums do not increase due to the increased riskiness of individual policyholders. We analyze these properties under various distributional assumptions, such as normal, exponential, and Pareto distributions. By establishing the explicit CTE-induced premium and conducting comprehensive parameter analyses and simulations, we investigate the pricing dynamics under different scenarios, demonstrating the robustness and efficacy of our model. In conclusion, this study emphasizes the importance of integrating nuanced risk dependencies into insurance pricing models. Our proposed model, rooted in conditional tail expectation theory, not only enhances risk management capabilities but also facilitates more equitable premium determination, thereby enhancing the resilience and stability of the insurance sector. This research lays the groundwork for broader adoption in various real-world applications.

From Steps to Smooth: the Optimal Shape of Catastrophe Bond Payouts

Wei Wei, University of Illinois Urbana-Champaign

CAT bonds are a well-established mechanism for transferring catastrophic risk from insurers to capital markets, contributing to the financial resilience of the insurance sector. Despite their widespread use, indemnity scheme of CAT bonds are typically structured in layers, which may lead to moral hazard, legal disputes, and other frictions. This study explores the optimal design of indemnity schemes to minimize a selection of risk measures. In contrast to the stepwise payouts of traditional layer structures, we find that the optimal indemnity should adjust continuously: starting at zero for small losses and increasing steadily to full coverage as losses mount increases. Additionally, we determine the optimal attachment point across different model specifications and perform a comparative analysis to assess how changes in external parameters affect the optimal contract.

Hedging Geopolitical Risk: a Stochastic Regime and Optimization Framework

Hossam Mohamed (s), Cairo University

This study proposes a dynamic stochastic framework to analyze how insurers can effectively manage geopolitical risk using multiple risk-mitigation instruments. While existing literature has examined the general impact of geopolitical risk on insurance markets, a significant gap remains regarding how insurers optimally combine core insurance-based hedging instruments to mitigate extreme tail losses. To address this, we develop a regime-dependent stochastic control model that classifies geopolitical conditions into normal, stress, and crisis states utilizing a Hidden Markov Model (HMM). Our empirical analysis leverages comprehensive insurer-level panel data, encompassing premiums, claims, and combined ratios across specialty lines. This is integrated with firm-level indicators of reinsurance utilization, diversification, and capital adequacy, with geopolitical exposure quantified via the Geopolitical Risk (GPR) Index. Underwriting losses are modeled through a regime-dependent loss-generation process, capturing both the frequency and severity dynamics inherent in specialty insurance portfolios. The hedging instruments are subsequently jointly modeled within a constrained optimization framework that minimizes tail risk, measured by Conditional Value-at-Risk (CVaR), subject to capital, capacity, and operational constraints. The expected results suggest that geopolitical risk cannot be managed effectively through a single hedging instrument. The model is expected to show that integrated hedging strategies can reduce extreme losses under normal and stress conditions, but their effectiveness may decline during systemic crisis periods.

Temporal Hierarchical Forecasting of U.S. Billion-Dollar Disaster Costs and Frequencies: an Actuarial Application

Simon Atoyire, Department of Statistics, Miami University, Oxford, Ohio; with Tatjana Miljkovic, Department of Statistics, Miami University, Oxford, Ohio

Accurate long-range projections of flood and severe storm losses are foundational to insurance premium pricing, loss reserving, and federal disaster program solvency, yet no existing actuarial study has applied temporal hierarchical forecasting to the U.S. billion-dollar disaster dataset. This paper addresses that gap. Using 44 years of NOAA quarterly data (1980–2024), we apply temporal hierarchical forecasting (THF) with Minimum Trace (MinT) reconciliation to jointly model the cost and frequency of billion-dollar severe storms and floods. The framework constructs coherent forecasts simultaneously at quarterly, semi-annual, and annual scales, directly matching the multi-horizon planning cycles of insurance reserving and federal budget appropriations while addressing a fundamental challenge of this data: approximately 45% of quarters record zero or below-threshold events, a level of sparsity that renders standard actuarial time series models unstable. Three base models, ARIMA, ETS, and TSLM, are evaluated within the reconciliation framework. Reconciled ARIMA under THF achieves the lowest forecast error across every aggregation level for both cost and frequency series, reducing RMSE by up to 32% relative to benchmark methods at the quarterly level and providing reliable 99% prediction interval coverage that standalone annual models cannot guarantee. A comprehensive simulation study confirms that accuracy gains are largest precisely where conventional models are weakest: in high-sparsity, fine-scale settings. These results have direct implications for actuarial practice. The NFIP, which carries $22.5 billion in Treasury debt attributable in part to premium rates that underreflect true flood risk, and private insurers modeling multi-year catastrophe exposure both require forward-looking, multi-scale loss projections of the type this framework produces. We discuss pathways for integrating THF into actuarial rate-setting workflows and present ongoing deep learning extensions (LSTM, N-HiTS) designed to capture the non-linear regime shifts increasingly characteristic of U.S. natural hazard data.

An Economic Scenario Generator for Retirement Modeling

Brian Hartman, Brigham Young University

Effective retirement and financial planning requires tools to model and simulate future financial markets. We build an economic scenario generator (ESG) to simulate these potential future markets. Components of the ESG include inflation, interest rates, equity returns, and bond returns. This ESG provides the tools needed to analyze longevity risk for specific financial situations and, in turn, helps answer questions such as “how much should be annuitized?” and “what level of spending is sustainable?” Joint work with Evan Miller and Jean-Francois Begin.

Collar Stabilization Buffers and Basis Risk in Group Self-Annuitization Schemes

Jean-François Bégin, Simon Fraser University

Group self-annuitization schemes efficiently pool longevity risk but expose participants to significant benefit volatility. We propose a benefit-stabilization mechanism based on a zero-cost collar (ZCC) implemented through option-based hedging, relaxing the perfect replication assumption commonly adopted in the literature by explicitly incorporating basis risk. Optimal cross-hedging strategies are derived within a quadratic risk-minimization framework under stochastic volatility. We show that the ZCC strategy stabilizes income and extends the period over which benefit payouts remain steady. Put option-based hedging strategies provide stronger downside protection and improve the sustainability of long-term benefits by aligning with the convexity and volatility sensitivity of the downside liability. We further show that optimal rebalancing frequency depends critically on the hedge's gamma exposure: long-gamma strategies benefit from more frequent rebalancing to reduce hedging errors, whereas short-gamma strategies require lower rebalancing frequencies to limit trading losses. Sensitivity analyses confirm the robustness of the stabilization mechanism across alternative market environments and hedging instruments.

Buying Time: Optimal Service Purchase and Retirement Timing in Defined Benefit Plans

Kristen Moore, University of Michigan

We study retirement timing decisions in a defined benefit (DB) pension plan with a service-purchase option. An employee who would otherwise retire at a fixed time T may elect to purchase L additional years of service and retire early. Earlier retirement provides additional leisure but requires an upfront payment and typically results in a reduced post-retirement income stream. We model this trade-off in a continuous-time retirement framework by allowing the employee to choose L to maximize the value of wealth and leisure at retirement in both deterministic and life-contingent settings. Our model captures a common feature of public pension systems: early retirement is often accompanied by both an upfront cost and a permanent reduction in benefits. We show that this structure yields tractable and intuitive results in several benchmark cases, including settings without mortality risk and settings with mortality risk under simplifying assumptions. In more general cases, we characterize optimal behavior through comparative statics and numerical examples. A key insight is that the interaction between the finite-horizon value of leisure and the lifetime cost embedded in pension pricing can generate a range of behaviors, including monotone strategies and interior optima. While many results align with economic intuition, others require more careful interpretation. We also extend the model to allow for dynamic decision-making via a multi-period service-purchase option, solved by backward induction. The results provide insight into optimal retirement timing and the role of plan design in shaping participant behavior. This is joint work with David Kausch and Virginia Young.

Pricing Parametric Hydropower Insurance Under Spatial Drought Correlation: a Vine Copula Approach for the Southwestern United States

Mohak Dwarkadhish Sharma (s, r), Arizona State University

Prolonged drought has made hydropower revenues in the southwestern United States highly volatile, with shared water sources causing losses to move together and heightening risk for operators and insurers. Differences in plant design further shape exposure. Facilities with large reservoirs can buffer short or moderate droughts, while run-of-river and low-storage plants pass hydrological shocks directly into revenues, creating uneven portfolio risk. To address this, we develop a vine copula framework to model revenue risk and price parametric insurance contracts under spatial correlation, with validation through out-of-sample performance, estimation uncertainty, regime-dependent stability, and tests for temporal non-stationarity. We analyze several hundred hydropower facilities across six southwestern states over recent years, constructing a plant-day panel via Chow-Lin GLS temporal disaggregation, and use vine copulas to capture joint dependence among inflow, generation, and revenue, enabling Monte Carlo simulation under alternative contract designs. Results reveal substantial tail risk at the pooled regional level, and while parametric insurance materially reduces extreme downside exposure at a moderate premium ratio, basis risk remains high, with frequent under-coverage of loss events and limited payout correlation; spatial dependence dominates portfolio pricing, amplifying premiums several-fold relative to the independence benchmark due to synchronized drought impacts. The framework offers guidance for operators evaluating tail protection and for insurers pricing concentrated portfolios, where spatial correlation erodes diversification benefits and elevates capital requirements.

Pricing of Temperature Derivative Under Stochastic Volatility Jump Model

Yasintorn Wongwoottisaroch (s, r), University of Illinois at Urbana-Champaign

Recent climate variability has increased the frequency and magnitude of weather-related shocks, creating significant financial uncertainty for firms whose revenues or liabilities depend on temperature conditions. Weather derivatives have emerged as a financial instrument to hedge such exposure by linking payoffs to observable weather indices. However, the limited liquidity and customization of weather derivative markets constrain the use of market prices and motivate the development of model-based valuation approaches. This study proposes a stochastic volatility–jump (SVJ) framework for modeling temperature indices and applies the Fast Fourier Transform (FFT) method to efficiently evaluate option-type weather derivative payoffs. The numerical results show that, under appropriate calibration and numerical settings, FFT and Monte Carlo approaches yield broadly consistent pricing outcomes. As a result, by capturing both continuous fluctuations and abrupt weather shocks, the model provides a flexible benchmark for pricing and risk assessment and offers a foundation for further extensions to broader market and risk-management applications.

Financed Emissions, Internal Carbon Charges, and Market Equilibrium

Zhongyi Yuan, Penn State

Financed emissions have become the largest component of financial institutions' carbon footprint. We investigate how investors' use of internal carbon charges to reduce financed emissions impacts market equilibrium. We develop a portfolio selection model, based on which we examine asset prices, investor behavior, investment performance, and investor surplus in equilibrium. We then endogenously determine the investors’ internal carbon prices, which are inversely related to emission-averse investors’ target level of (adjusted) carbon intensities. While the literature documents that investors' preferences, such as environmental, social, and governance taste, are a channel that generates carbon risk premium, our results indicate that carbon charges on financed emissions are another channel. Interestingly, we find that a firm’s carbon risk premium is driven by its excess emission intensity relative to the (scaled) market level. Moreover, emission-averse investors' certainty-equivalent investment returns are reduced nonlinearly with respect to their internal carbon charges.

Risk-Neutral Valuation with a Non-Traded Fractional Brownian Underlying

Jayen Tan (s, r), Cornell University

Classical no-arbitrage pricing models rely exclusively on semimartingale price processes to preclude arbitrage opportunities and ensure compatibility with Itô calculus. This restriction, however, excludes a wide array of empirically relevant dynamics, including long-range dependency, rough paths, and anomalous diffusion, thereby limiting its applicability to some real-world complexities. We develop the risk-neutral valuation framework for derivatives whose payoffs are driven by fractional Brownian motion, a non-semimartingale generalization of classical Brownian motion that captures these complexities. Motivated by the empirical evidence of persistent temperature dynamics, we apply the framework to the weather derivatives market. Joint work with Robert Jarrow.

Regime Changes and Bubble Status in Global Stock Markets Post-2020 Crash

Min Shu, Central Michigan University

Following the global stock market crash of 2020, international equity markets entered a period of rapid, sustained growth. Using the Log-Periodic Power Law Singularity (LPPLS) method, we systematically investigate the bubble status of ten major global indices across both developed and emerging markets: the S&P 500, DJIA, and NASDAQ (USA), FTSE 100 (UK), DAX (Germany), NIKKEI 225 (Japan), CSI 300 (China), HSI (Hong Kong), BSESN (India), and BOVESPA (Brazil). Our findings reveal that the peak confidence indicator for some indices exceeds 20%. This suggests that their price trajectories exhibit distinct LPPLS bubble patterns, characterized by faster-than-exponential growth qualified by accelerating log-periodic oscillations. These indices are currently situated within a positive bubble regime. Because these accelerating growth trends are likely unsustainable, the current regime is expected to conclude either through a sharp market crash or a transition into volatile sideway plateaus. This study establishes a paradigm for analyzing regime changes not only in equity markets but across broader financial markets and economic indicators.

Investments in Municipal Bonds and Asset-Liability Management by Property/casualty Insurance Companies in Illinois

Krzysztof Ostaszewski, Illinois State University; with Tice Sirmans, Illinois State University

Insurers are influential investors in bond markets, including as investors in municipal securities. Life insurers have long utilized asset-liability management, and we evaluate whether property/casualty insurers may also invest in municipal bonds for the additional benefit of risk mitigation for the property they insure. We investigate the relationship between municipal bond holdings and insurer losses and loss ratios in a sample of property/casualty insurers writing business in Illinois initially invested in municipal bonds in the state of Illinois in 2009. We study the potential effects between municipal bond holdings and improved losses in 2014, 2019, and 2024 based on investments in 2009. We do not find a statistically significant relationship between investments in municipal bonds and losses. We provide limitations that may have impeded the finding of statistical significance. Nonetheless, the use of insurer investments to improve American infrastructure is a question worthy of additional pursuit.

Special & Invited Session Abstracts

Actuarial Sins: Discussion of Items All Actuaries Need to Be Aware of… and Need to Avoid

Kathy Olcese, Retired; Josh Taub, The Infinite Actuary; with Bethany Coffey, Nationwide

What are the ‘sins’ that an actuary needs to be aware of and how can we avoid these? This presentation will recap the foundations of actuarial professionalism and invite discussion on the topic of ‘actuarial sins’, while referencing relevant precepts from the Code of Professional Conduct and ASOPs.

A Modular Framework for Casualty Catastrophe Modeling

Rob Lieberthal, Lieberthal & Associates, LLC; with Jeffrey Zheng, Temple University

This presentation demonstrates a modular framework for casualty catastrophe modeling implemented as an open-source R package with an Excel equivalent. The framework addresses key challenges common to casualty catastrophe work: sparse historical data, activity-based correlation, policy triggering logic, and transparency for reinsurance pricing and portfolio assessment. Five core modules process policy bordereaux, exposure matrices, and parameter inputs to generate claims outputs, ground-up losses by activity, and portfolio risk metrics. We demonstrate the parameter derivation workflow using cyber catastrophe data (24 events, 1998–2024) as a worked application for handling sparse casualty cat data: zero-inflated Poisson frequency, LogNormal-Pareto severity, and sector-specific activation probabilities derived from NAICS activation patterns. The modular design supports alternative parameterizations for product liability, mass tort, or emerging risks. The complete implementation will be released under MPL2.0 on the Casulaty Actuarial Society (CAS) GitHub repository.

Entity-Specific Cyber Risk Assessment Using Insurtech Empowered Risk Factors

Jiayi Guo (s, r), University of Illinois Urbana-Champaign

The lack of high-quality public cyber incident data limits empirical research and predictive modeling for cyber risk assessment. This challenge persists due to the reluctance of companies to disclose incidents that could damage their reputation or investor confidence. Therefore, from an actuarial perspective, potential resolutions conclude two aspects: the enhancement of existing cyber incident datasets and the implementation of advanced modeling techniques to optimize the use of the available data. A review of existing data-driven methods highlights a significant lack of entity-specific organizational features in publicly available datasets. To address this gap, we propose a novel InsurTech framework that enriches cyber incident data with entity-specific attributes. We develop various machine learning (ML) models: a multilabel classification model to predict the occurrence of cyber incident types (e.g., Privacy Violation, Data Breach, Fraud and Extortion, IT Error, and Others) and a multioutput regression model to estimate their annual frequencies. While classifier and regressor chains are implemented to explore dependencies among cyber incident types as well, no significant correlations are observed in our datasets. Besides, we apply multiple interpretable ML techniques to identify and cross-validate potential risk factors developed by InsurTech across ML models. We find that InsurTech empowered features enhance prediction occurrence and frequency estimation robustness compared to only using conventional risk factors. The framework generates transparent, entity-specific cyber risk profiles, supporting customized underwriting and proactive cyber risk mitigation. It provides insurers and organizations with data-driven insights to support decision-making and compliance planning.

Quantifying Social Inflation in Liability Insurance With Advanced Statistical Methods

Fang Yang, Georgia State University

Social inflation, which is the rising liability claim costs beyond general economic inflation, has become a major concern for insurers and reinsurers, yet it is difficult to quantify because litigation outcomes are heavy-tailed and the mix of cases reaching verdict versus settlement changes over time. Using a large database of U.S. jury verdicts and settlements, we develop case-mix-adjusted social inflation measures through multiple channels that matter to reinsurers: plaintiff win rates (a frequency-type channel), settlement propensity (a frequency-type channel), and verdict/settlement severity. The approach combines rolling-window logistic regression for probabilities and quantile (Value-at-Risk) regression for severities, with uncertainty quantified via a random-weighted bootstrap. We find statistically significant relative increases in plaintiff win probability of approximately 20–30% from 2009 to 2024, alongside a statistically significant relative decline in settlement probability of more than 10% over the same period. The dominant channel is verdict severity: even after controlling for explanatory variables, verdict awards rise sharply after 2020, increasing by more than 100% from 2020 to 2024, whereas settlement amounts show limited and often statistically insignificant inflation. Therefore, inflation in total amounts payable to plaintiffs closely tracks verdict severity. Social inflation is more pronounced for corporate-defendant and uninsured-defendant cases and in states without tort caps or third-party litigation funding (TPLF) regulation. Also, we find that social inflation has impacts not only on “nuclear verdicts”, but also on moderate losses in a similar manner.

Practical Digital Accessibility for Actuarial Science Instructors

Dan Poole, The Ohio State University

New digital accessibility requirements are changing how we design and deliver course materials, and many actuarial science instructors are wondering how to adapt their courses. This workshop will focus on practical strategies for creating accessible course content while maintaining the technical rigor of actuarial education. Through demonstrations and examples, participants will explore approaches for making slides, documents, equations, tables and graphs more accessible. The workshop will also introduce templates and other resources that can simplify the process and support ongoing course development. Participants will leave with practical techniques, ready-to-use resources and greater confidence in implementing accessibility best practices in their own courses.

Update on Society of Actuaries Education

Stuart Klugman, Society of Actuaries

This annual update will provide a review of SOA education and examination over the past year and provide a preview of upcoming changes.

Pathway to P/C Success: Exploring 2026 CAS Opportunities

Maggie Lyons, Casualty Actuarial Society; with Margaret Gaddy, Casualty Actuarial Society

Join us for an engaging and informative session on the 2026-2027 CAS Credentialing Pathway. Learn about the key steps and emerging opportunities for students pursuing success in the property and casualty actuarial field. The session will spotlight the innovative Property & Casualty Predictive Analytics (PCPA) exam/project and the latest updates to CAS credentialing requirements. Additional highlights will include CAS resources tailored for students and professors, tools designed to support academic success and launch the next generation of P/C actuaries.

Leveraging LLMs for Unstructured Claims Data Analysis

Rob Lieberthal, Lieberthal & Associates, LLC

Actuaries traditionally rely on structured numerical and categorical data for reserving and ratemaking. The purpose of this project was to develop a proof-of-concept approach to using large language models (LLMs) to extract structured predictors from unstructured claims data. The goal is to address the gap between rich narrative information and quantitative modeling requirements. Medical records processing served as the primary use case. We implement a two-stage LLM processing architecture, separating document-level extraction (Stage 1) from claim-level synthesis (Stage 2). Each claim maintains its identifier, and documents are time stamped to enable augmentation of existing datasets with LLM-derived insights. The framework uses LLM-generated synthetic documents to create complete claim ecosystems for testing. This ecosystem includes synthetic medical notes, phone calls, and adjuster assessments. Synthetic data allow for controlled testing with known ground truth characteristics and shareable, open-source datasets. The prototype extracts 36 actuarial variables that are used in reserving, ratemaking, and claims management functions. We validate the results of the LLM extraction with a review by two independent clinician experts. We extract 14 core variables, including medical complexity, litigation risk, and claim development pattern. Validation against synthetic data demonstrated overall extraction accuracy of at least 4 out of 5 across all variable categories, with strong confidence score calibration and a moderate degree of interrater reliability. Finally, integration with chain ladder reserving shows the practical value of this approach. Severity-segmented analysis using LLM-extracted classifications shows the applicability of the approach to actuarial estimates of overall claims. The integration also shows the interoperability of the LLM extraction with a wider set of actuarial methods. Future priorities include extension to additional insurance lines, integration with existing actuarial software platforms, and ongoing validation protocols to ensure that the deployment of LLMs results in accurate insights.

What Do We Know About Cyber Risk Reserving? First Insights from Bayesian Nowcasting of Data Breach IBNR

Maochao Xu,

Traditional actuarial reserving methods, including Chain-Ladder-type approaches, are built on relatively stable historical development patterns and sufficiently mature claims experience. Cyber insurance challenges these assumptions. Data breach incidents often involve long discovery, containment, and reporting delays, creating substantial uncertainty about incurred but not reported (IBNR) events. As a result, the observed data available at a valuation date may provide only a partial view of the underlying cyber incident process. This talk provides a first look at cyber risk reserving through the lens of Bayesian nowcasting. Using data breach incidents as a case study, we develop a Bayesian framework to estimate the posterior distribution of hidden IBNR incident counts. The model incorporates calendar-time effects to reflect evolving cyber threat environments, reporting-delay effects to capture delayed emergence, and heterogeneity across sectors or incident groups. Posterior inference is obtained through Markov chain Monte Carlo methods, allowing the reserving uncertainty to be quantified directly rather than through deterministic development factors. Empirical results show that the Bayesian nowcasting approach provides more accurate and informative estimates than several classical reserving benchmarks. Beyond the specific model, the talk discusses broader challenges and opportunities in cyber reserving, including frequency-severity integration, reporting-delay uncertainty, and the development of dynamic reserving frameworks that update IBNR estimates and uncertainty measures as new breach reports become available.

Presenting

Society of Actuaries®

Nationwide®

American Academy of Actuaries

Platinum

Casualty Actuarial Society

Silver

Canadian Institute of Actuaries

Institut canadien des actuaires

Bronze

ACTEX Learning®

The Cincinnati Insurance Companies

TheInfiniteActuary