ACTUARIAL RESEARCH CONFERENCE 2024

PROGRAM

July 18–20, 2024

MTSU®

Student Union Building on the Middle Tennessee State University campus

ACTUARIAL RESEARCH CONFERENCE 2024

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ACTUARIAL SCIENCE
at Middle Tennessee State University

Middle Tennessee State University offers an outstanding and comprehensive program in Actuarial Science. It was established in 1987 under Dr. J.C. Hankins as the founding director. Today, MTSU's Actuarial Science program is nationally and internationally recognized as one of the best in the southeastern region of the U.S. It is the only program in Tennessee to receive the highly selective and prestigious Center of Actuarial Excellence (CAE) designation in 2024 from the Society of Actuaries (SOA). It achieved the Gold Level in the Casualty Actuarial Society (CAS) 2023 University Recognition Program, one of only 15 Gold Level schools worldwide.

We offer a range of programs for undergraduate and graduate studies in Actuarial Science. Our students receive cutting-edge training and learning experience to become qualified actuaries. MTSU offers:

- B.S. in Actuarial Science
- Undergraduate minor in Actuarial Science
- M.S. in Mathematics
  with concentration in Actuarial and Financial Mathematics
- M.S. in Professional Science
  with concentration in Actuarial Science
- Ph.D. in Computational and Data Science

CAE
CENTER OF ACTUARIAL EXCELLENCE
SOCIETY OF ACTUARIES®

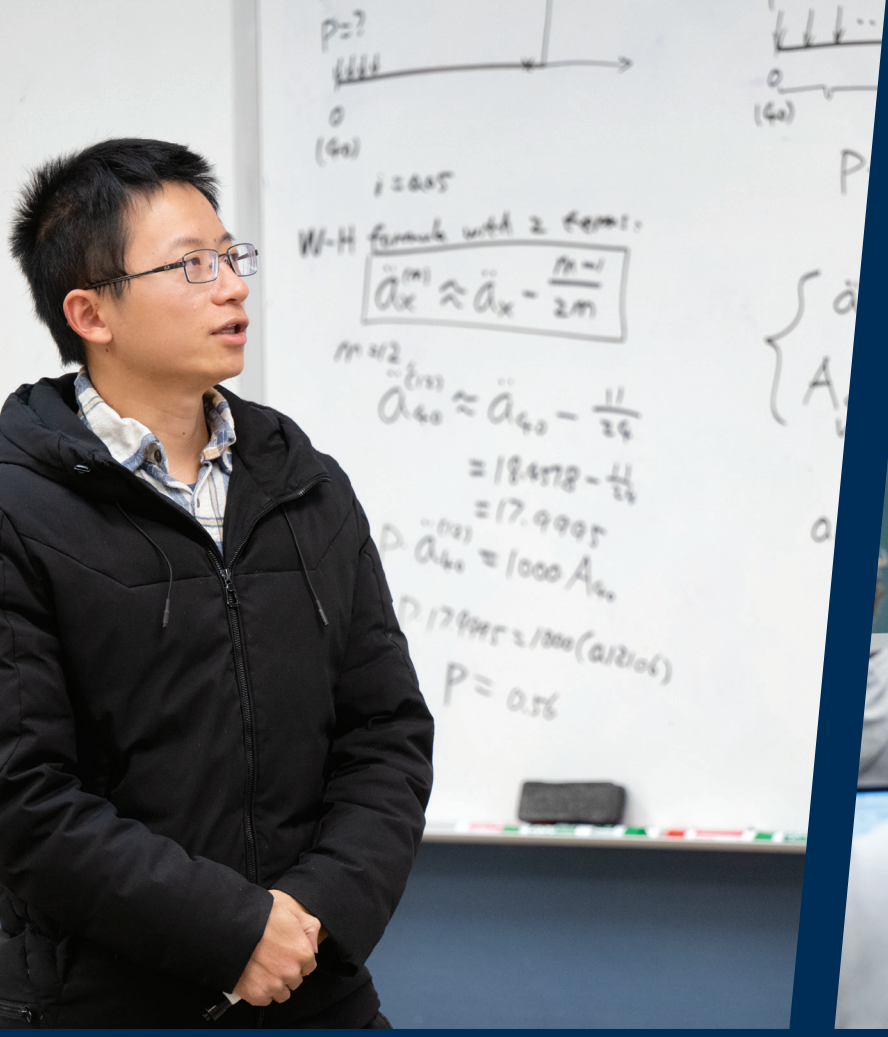
While majoring in Actuarial Science, many of our undergraduate students earn:

- Minor in Data Science
- Minor in Risk Management and Insurance

As of 2022, over 50 Actuarial Science alumni have achieved Associate or Fellow of the SOA or the CAS designations. Two students achieved Associate of the SOA before graduation from MTSU with M.S. degrees. More than 50% of our students pass at least two exams before graduation, and many receive multiple jobs offers before finishing the program. Our program has international academic partnerships with several universities, including Ningbo University, Guangxi University, and the China University of Technology in China.

MTSU Actuarial Science has received several grants, including State of Tennessee Health Rate Review Project for 2011–2013; Casualty Actuaries of the Southeast (CASE) 2012, 2015, and 2017 grants to promote the actuarial profession in MTSU; and CAS/SOA individual grant for research in 2021.

CAS
CAS University Recognition Program Gold Level



Middle Tennessee State University

Middle Tennessee State University (MTSU), located in Murfreesboro and near Nashville, the capital of Tennessee, is a public university with an enrollment of more than 20,000 students. It is the No. 1 producer of graduates for the Greater Nashville economy, has been named to The Princeton Review list of Best Colleges in the U.S. five years in a row, and is also the top destination for transfer students in Tennessee. Opened September 11, 1911, as a two-year program for training teachers, today it is one of the largest universities in the state.

MTSU, designated a high research doctoral university, comprises eight undergraduate colleges and a College of Graduate Studies. Its curricular breadth ranges from traditional programs on which the school was founded to new, innovative ones designed for a rapidly changing society. MTSU is a regional university that provides services and continuing education to the central Tennessee area. One in six college graduates in greater Nashville holds an MTSU degree, with more than 70,000 alumni working in the region. While many MTSU students are from Tennessee, the University draws from almost every state and from more than 70 countries. MTSU offers more than 300 undergraduate and graduate degrees in diverse disciplines that prepare students for high-demand careers.

The University is equipped with state-of-the-art buildings and top-notch classrooms, laboratories, and gathering spaces suitable for a large conference. MTSU is also located close to several other universities: Vanderbilt, Tennessee State, Belmont, Fisk, and Tennessee Tech.

PLENARY SPEAKERS

Bridging Theory and Practice: Collaborative Research for Real-World Impact

Lisa Schilling, FSA, EA, FCA, MAAA
Director of Practice Research, SOA

Abstract: The Society of Actuaries Research Institute is eager to partner with academic researchers on significant grant applications. The SOA's role would be to bring to the academic research project a direct link to practical applications for actuaries in industry to use. Funders are interested in elevating their research beyond the theoretical realm, and the SOA is interested in helping you achieve that. Join us to explore how we can collaborate to advance actuarial practice in the real world.

Bio: In the role of director of practice research at the Society of Actuaries Research Institute, Schilling leads the actuarial practice research activities of the Society of Actuaries to benefit the global actuarial profession. She oversees the development, creation, and production of research projects that provide valuable research insights to members, stakeholders, and the public, and assists in raising awareness of the global actuarial profession. She brings nearly 40 years of experience to this role, having previously served in various actuarial research functions at the SOA, as chief actuary for a large pension fund, and as a retirement actuarial consultant at a large consulting firm.

The Role of Financial Economics in Actuarial Practice

Hal Pedersen, PhD, ASA
Director, Actuarial Program at University of California, Santa Barbara

Abstract: Financial economics plays an important role in actuarial practice. In the 1990s, financial economics was the "new new thing" for actuarial practice. Financial economics was integrated into the actuarial syllabus and figured prominently in the preliminary actuarial exams. This prominence has faded, and the last change in the preliminary actuarial exam content removed many of these topics. What happened? The discussion will review the history of financial economics in actuarial practice and take note of some of the important contributions that actuaries have made to this area. We will then discuss the current state of the art of financial economics in actuarial practice and offer a perspective on why this remains important and exciting. The last part of the session will discuss the NAIC's move to a new economic scenario generator and the financial economics involved in this important part of actuarial practice.

Bio: Hal W. Pedersen, ASA, MAAA, PhD is a leading expert on economic scenario generation and insurance risk, with more than 25 years of industry experience. He is senior lecturer at the University of California, Santa Barbara (UCSB) and director of the UCSB Actuarial program. Previously, he was managing director at

Conning, where he led the development of Conning's economic scenario generator and its application to investment risk management. He served as L.A.H. Warren professor of actuarial science at the University of Manitoba (2003–2011) and was a member of the actuarial faculty at Georgia State University (1996 – 2001). He is past vice-chair of the Education and Research Section Council of the Society of Actuaries, current vice-chair of the Investment Section Council of the Society of Actuaries, and current chair of the American Academy of Actuaries Economic Scenario Generator Subcommittee.

Reserving Innovation in Property-Casualty Insurance

Chandu Patel, FCAS, MAAA
Vice President at AmTrust Financial Services Inc.

Abstract: Technology is ushering in new methods for analyzing property casualty reserve estimates for solvency and balance sheet purposes. From Bayesian models and machine learning to CAT reserving and claim life cycle development, attendees will be introduced to fresh thinking and techniques for reserving developed by professors and actuarial practitioners. In addition, attendees will learn why the CAS is the organization of choice for publishing property-casualty actuarial research and hear about the wide array of opportunities for professors and graduate students to partner with the CAS on funded research projects.

Bio: Patel is a Fellow of the Casualty Actuarial Society and a member of the American Academy of Actuaries. Prior to joining AmTrust, he was a consultant with Huggins Actuarial Services Inc. Previously, he served at the senior vice president level at Tower Insurance Company, Endurance Services Limited, and ACE/Chubb Limited. Patel has over 35 years of experience being the lead reserving actuary for several large firms as well being a senior manager at KPMG LLP.

Patel has a Master of Science in Chemical Engineering from Stevens Institute of Technology, New Jersey. He also has his bachelor's in Chemical Engineering from the Indian Institute of Technology, Bombay, India. He won the 1998 Reserves Paper Prize from the Casualty Actuarial Society and was the assistant editor of a book titled *Catastrophe Modeling: A New Approach to Managing Risk* (published by staff at The Wharton School, University of Pennsylvania). Patel is also a frequent speaker on the topic of reserving and linkages between pricing and reserving at industrywide actuarial conferences.

Annmarie Geddes Baribeau, Research Manager, Casualty Actuarial Society

Bio: Baribeau has nearly 35 years of experience working with actuaries in various capacities ranging from research manager and investigative journalist to marketing and communications consultant. Publishing more than 650 articles, Baribeau's list of insurance publications includes the Casualty Actuarial Society's Actuarial Review, the American Academy of Actuaries' Contingencies, and the Insurance Agents and Brokers' Leader's Edge. Baribeau has also spoken at several actuarial conferences and webinars on topics including personal auto trends, cyber insurance, and marijuana legalization.

INVITED SESSIONS

Professionalism Session: You are the fulcrum of Self-Regulation!

Brian Jackson
Director of Professionalism, American Academy of Actuaries

The actuarial profession in the United States substantially self-regulates its members' ethical and practice standards in the development and delivery of work products and actuarial opinions. Self-regulation is both a privilege and a burden shared by all credentialed actuaries and must be supported by all members of the profession. The Code of Professional Conduct (Code) is the foundation of this effort and serves as the primary tool for measuring professional responsibility and assuring the public and regulatory authorities that the actuarial profession can be depended upon to act effectively consistent with the public interest. This presentation will utilize the profession's "Web of Professionalism" to explore what it means to be a professional actuary and fulfill the profession's responsibility to the public.

Insights from Behavioral Economics

Moderator: Steve Jackson,
Director of Research, American Academy of Research

The 2024 American Academy of Actuaries Award for Research centered on the theme of Insights from Behavioral Economics/Behavioral Finance for Insurance, Retirement, and Risk Management. The Academy received several excellent submissions. On this panel, we will hear presentations from three of the authors who submitted their work for consideration, each one applying insights in a distinct way.

Doron Samuell, Ph.D., Behaviour (Sydney, Australia): Counteracting dishonesty strategies: A field experiment in life insurance underwriting (with Demetris Christodoulou, Robert Slonim and Franziska Tausch)

Taylor Graciano, Ph.D. candidate, University of Georgia: Till Death Do Us Part: Widowhood and Healthcare Utilization

Jackson Lautier, Ph.D., Bentley University: Credit Risk Convergence

CAS Research Paper Series on Race and Insurance Pricing

Annmarie Geddes Baribeau, CAS Research Manager
Peng Shi, Professor at Wisconsin School of Business
Richard Moncher, FCAS, MAAA, CAS Vice President-Administration

Actuaries have a responsibility to scrutinize the processes, systems and models we build to understand if the inputs and outcomes truly reflect fair and equitable practices. Building on the foundation of Phase 1 of the CAS's 2022 Research Paper Series on Race and Insurance Pricing, the CAS has launched five new research projects in 2024, addressing topics such as Practical Application of Bias Measurement and Mitigation Techniques in Insurance Rating, Impacts of Usage-Based Insurance on Racial Bias in Insurance Pricing, and Potential Unintended Impacts of Bias Mitigation on Other Protected Class Dimensions. The CAS is also sponsoring research into regulations related to algorithmic bias, along with actuarial approaches in response to such regulations. This session will present findings from these research projects and spark a dialogue among attendees on these important industry challenges.

WELCOME RECEPTION

Wednesday, July 17, 6:00 p.m.

Student Union Ballroom

Welcome to the Actuarial Research Conference 2024! We are delighted to invite you to our Welcome Reception on July 17, 2024, at 6:00 p.m. in the Student Union Ballroom at Middle Tennessee State University. This reception offers an excellent opportunity for attendees to socialize and network with fellow professionals, researchers, and students in the field of actuarial science. Enjoy an evening of engaging conversations, light refreshments, and valuable information about the upcoming conference sessions and events scheduled for the next day. We look forward to a vibrant and enriching conference experience with all of you.

DAY 1: THURSDAY, JULY 18

Schedule

July 18, 2024 (Morning)

8:45–9:00 a.m.
Opening Remarks, Ballroom C

9:00–10:00 a.m.
Plenary Talk, Ballroom C

Chair: Don Hong

Bridging Theory and Practice: Collaborative Research for Real-World Impact

Lisa Schilling, FSA, EA, FCA, MAAA, Director of Practice Research, SOA

10:00–10:30 a.m. Coffee Break

10:30 a.m.–12:00 p.m.
Parallel Session 1

PS 1A: Ballroom C
Chair: Annmarie Geddes Baribeau

CAS Research Paper Series on Race and Insurance Pricing

Annmarie Geddes Baribeau, CAS

Peng Shi, University of Wisconsin-Madison

Richard Moncher, FCAS, CAS Vice President of Administration

PS 1B: Ballroom D
Chair: Hong Keung Tony Ng

- *Zero-Inflated Tweedie Boosted Trees with CatBoost for Insurance Loss Analytics*, Emiliano Valdez, University of Connecticut
- *Causality-based feature selection and application to insurance analytics*, Nii Okine, Appalachian State University
- *Comparative Analysis of Recent Implementations of Gradient Boosting for Decision Trees in Insurance Applications*, Dominik Chevalier, Université Laval (S)

PS 1C Room 224
Chair: Brian Hartman

- *Modeling County-Level Spatio-Temporal Mortality Rates Using Dynamic Linear Models*, Zoe Gibbs McBride, University of Connecticut (S)
- *A Multivariate Spatiotemporal Model for County Level Mortality Data in the Contiguous United States*, Robert Richardson, Brigham Young University
- *Cluster Analysis of County-Level Mortality in the Continental U.S.*, Chris Groendyke, Robert Morris University

12:00–1:30 p.m.
Lunch Break

July 18, 2024 (Afternoon)

1:30–3:30 p.m.
Parallel Session 2

PS 2A: Ballroom C
Chair: Qiang Wu

- *Update on Society of Actuaries Education*, Stuart Klugman, SOA
- *Pathway to P/C Success: Exploring 2024 CAS Opportunities*, Maggie Lyons and Tamar Gertner, CAS
- *A Metric For Improved Teaching Of Hard Parts Of Courses*, Russell Hendel, Towson University
- *The Flipped Actuarial Classroom*, Diana Skrzydlo, University of Waterloo

PS 2B: Ballroom D
Chair: Kenneth Q. Zhou

- *A new paradigm of mortality modeling via individual vitality dynamics*, Kenneth Zhou, Arizona State University
- *Mortality Prediction: A Parameter Transfer Approach*, Yechao Meng, University of Prince Edward Island
- *A Least Squares Framework for Fitting the Cairns-Blake-Dowd Models and Its Cohort Extensions*, Yiping Guo, University of Waterloo (S)

PS 2C: Room 224
Chair: Qiuqi Wang

- *Standard and comparative e-backtests based on elicitability*, Qiuqi Wang, Georgia State University
- *Value-at-Risk- and Expectile-based Systemic Risk Measures and Second-order Asymptotics: With Applications to Diversification*, Yimiao Zhao, University of Waterloo (S)
- *Including Expert Knowledge in Tarification: a Bayesian Approach*, Anne Paquet, Université du Québec à Montréal (S)
- *Pricing Credit Default Swaps under Shocks, Regime Shifts and Recovery Uncertainties*, Yuhao Liu, UNSW (S)

3:30–4:00 p.m. Coffee Break

4:00–9:00 p.m.
Nashville Experience Tour

Buses leave from parking lot near Student Union Ballroom

Nashville Tour

An exciting and free Nashville tour is available for all Actuarial Research Conference participants! This optional excursion offers a chance to experience the vibrant sights and sounds of Music City. The tour departs July 18 at 4:00 p.m. from Middle Tennessee State University and returns at 9:00 p.m., allowing ample time to soak in the city's rich culture and attractions. Don't miss this opportunity to explore Nashville, all while networking and socializing with fellow conference attendees.

Time	Location/Event
4:00 p.m.	**Leave from MTSU**
5:00 p.m.	**Gaylord Opryland/Opry Mills Drop-Off** We will drop off participants at Opryland and Opry Mills, where you can indulge in a variety of activities. Spend your time shopping at the numerous stores and boutiques, offering everything from high-end fashion to unique local goods. Savor delicious meals at the diverse range of dining options available, from casual eateries to fine dining restaurants. Don't miss the opportunity to visit the Gaylord Opryland Garden Conservatory, a stunning indoor garden featuring lush greenery, beautiful flowers, and serene water features. Whether you're looking to shop, dine, or simply relax in the tranquil conservatory, Gaylord Opryland and Opry Mills offer a delightful experience for everyone. **We will pick you up at 8:30 p.m. to go back to Murfreesboro, giving you ample time to enjoy.**
5:30–6:45 p.m.	**Parthenon (stay)** Take this opportunity to enjoy the beautiful Centennial Park and the stunning Parthenon. This park is an urban oasis, offering serene walking trails, lush green spaces, and picturesque gardens perfect for relaxation and exploration. At the heart of the park, you'll find the Parthenon, an exact replica of the ancient temple in Athens, Greece. Marvel at its majestic architecture and explore the art museum inside, which houses an impressive collection of American art and a full-scale replica of the statue of Athena. We leave at 6:45 p.m. to downtown.
7:00 p.m.	**Lower Broadway/Downtown Drop-Off** We encourage you to immerse yourself in the vibrant atmosphere of Lower Broadway downtown. Explore the bustling streets filled with live music, dine at a variety of local restaurants, and soak in the unique culture of Nashville. Whether you're visiting iconic honky-tonk bars, browsing eclectic shops, or simply enjoying the lively ambiance, there's something for everyone to enjoy. Take your time to experience all that this legendary district has to offer before rejoining the group for the ride back. **We will pick you up at 8:45 p.m. to go back to Murfreesboro.**
8:30 p.m.	**Pick up Opryland participants**
8:45 p.m.	**Pick up Downtown participants**
9:30–10:00 p.m.	**Drop-off near hotels in Murfreesboro, with final stop at MTSU**

Any participant **who misses the bus** will need to use local transportation options such as taxi, Uber, Lyft, or other rideshare services to return to their hotel/MTSU. The distance from Nashville to MTSU is approximately 38 miles, and the cost of a rideshare is estimated to be between $40 and $60, depending on availability and demand. Please note that this is just an estimate, and actual prices may vary.

DAY 2: FRIDAY, JULY 19

Schedule

July 19, 2024 (Morning)

9:00–10:00 a.m.
Plenary Talk, Ballroom C

Chair: Steve Jackson

The Role Of Financial Economics In Actuarial Practice

Hal Pedersen, PhD, ASA, Director, Actuarial Program at University of California, Santa Barbara

10:00–10:30 a.m. Coffee Break

10:30 a.m.–12:00 p.m.
Parallel Session 3

PS 3A: Ballroom C
Moderator: Steve Jackson

Insights from Behavioral Economics

Doron Samuell, Behaviour (Sydney, Australia)

Taylor Graciano, University of Georgia

Jackson Lautier, Bentley University

PS 3B: Ballroom D
Chair: Peng Shi

- *Dynamic Prediction of Insurance Claims,* Peng Shi, University of Wisconsin-Madison
- *Strategic underreporting and optimal deductible insurance,* Dongchen Li, York University
- *Privacy-Preserving Collaborative Information Sharing through Federated Learning,* Zhiyu Quan, University of Illinois Urbana-Champaign

PS 3C: Room 224
Chair: Stuart Klugman

- *Basis Risk in Variable Annuity Separate Accounts,* Wenchu Li, St. John's University
- *Variable Annuity Portfolio Valuation with Shapley Additive Explanations,* Gayani Thalagoda, University of New South Wales (S)

12:00–1:30 p.m.
Lunch Break

July 19, 2024 (Afternoon)

1:30–2:30 p.m.
Plenary Talk, Ballroom C

Chair: Annmarie Geddes Baribeau

Reserving Innovation in Property-Casualty Insurance

Annmarie Geddes Baribeau, CAS Research Manager, and Chandu Patel, FCAS, MAAA, Vice President at AmTrust Financial Services Inc. and chair of the CAS reserves working group

2:30–3:00 p.m. Coffee Break and Group Photo

3:00–5:00 p.m.
Parallel Session 4

PS 4A: Ballroom C (3:00–4:15 p.m.)
Chair: TBA

Professionalism: You are the fulcrum of Self-Regulation!

Brian Jackson,
Director of Professionalism,
American Academy of Actuaries

PS 4B: Ballroom D
Chair: Andrés Villegas

- *Pooling functional disability and mortality in long-term care insurance and care annuities: A matrix approach for multi-state pools,*
  Andrés Villegas, UNSW Sydney
- *Maximizing outcomes with cost constraints in assigning treatments to patients in ROI driven analysis in healthcare,*
  Ramzi Abujamra,
  Highmark Health
- *Neural-Network Models for Long-term Care Insurance Supply: An Enterprise Risk Management,*
  Sebastain Awondo,
  The University of Alabama

PS 4C: Room 224
Chair: Ning Wang

- *Investment-consumption Optimization with Transaction Cost and Learning about Return Predictability,*
  Ning Wang, Australian National University
- *Application of deep reinforcement learning in asset liability management,*
  Takura Asael Wekwete, Actuarial Society of South Africa (ASSA)
- *Gaining Insights into ESG Index Volatility with Deep Learning,*
  Ramchandra Rimal, Middle Tennessee State University
- *Optimal Consumption and Investment under Uncertain Lifetime and Lifetime Income,*
  Xiaoyu (Univa) Song,
  University of Wisconsin-Madison (S)

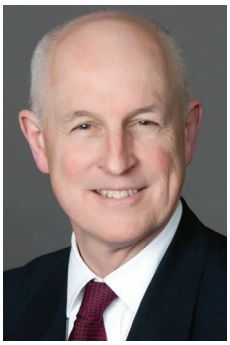
5:30–6:30 p.m.
Poster Session

Utilizing Recurrent Neural Networks for Real-Time Cryptocurrency Price Prediction and Trading Strategy Optimization, SHAMIMA NASRIN TUMPA, Tennessee Tech University (S)

7:00–9:30 p.m.
Banquet at Student Union Ballroom

BANQUET SPEAKERS

Ian Duncan, PhD, FSA, FIA, FCIA, FCA, CSPA, MAAA



Ian Duncan is adjunct professor of Actuarial Statistics at the University of California, Santa Barbara, and chief actuary of Arbital Health. He has founded or co-founded five healthcare analytics companies, including Santa Barbara Actuaries Inc., which merged with Arbital Health in December 2023. Duncan holds a graduate degree in economics from Balliol College, Oxford, and a PhD in Statistics from Heriot-Watt University, Edinburgh, Scotland. He is a fellow of a number of actuarial societies. He is active in public policy and healthcare reform and served on the board of directors of the Commonwealth of Massachusetts Health Insurance Authority from 2007-2014. He currently serves on the boards of Arbital Health, Clover Insurance (a New Jersey-based Medicare Advantage plan), and the Society of Actuaries. He is the author of over 80 peer-reviewed papers on healthcare outcomes and predictive modeling, and several books. His books include a second edition of *Healthcare Risk Adjustment and Predictive Modeling* (Actex Publications), published in May 2018.

Lisa Slotznick, FCAS, MAAA

Lisa Slotznick is the president of the American Academy of Actuaries. She has served in many volunteer roles at the Academy, including as vice president of casualty, as chairperson of the Climate Change Joint Committee and of the Committee on Property and Liability Financial Reporting, and as vice chairperson of the Committee on Qualifications.

Slotznick retired after 42 years as a practicing actuary, with over 33 years as an auditing and consulting actuary within the Property Casualty Actuarial Practice of PricewaterhouseCoopers (PwC). As a practicing actuary, she provided advisory and audit services for various types of entities—insurers and self-insurers—specializing in many property and casualty insurance exposures. These exposures included core coverages such as automobile liability and workers compensation, as well as warranties, asbestos exposures, and both old and new environmental exposures, such as remediation costs and insurance products. Her areas of expertise include financial reporting, loss reserving, and actuarial opinions. Slotznick graduated from Bryn Mawr College with a Bachelor of Arts in Greek.

Richard B. Moncher, FCAS, MAAA

Richard B. Moncher, FCAS, MAAA, is the CAS Vice President-Administration, which oversees CAS research publications. In his role as a vice president, he serves on the CAS Executive Council. He earned his Fellowship in 1992, and is a longtime volunteer for the CAS, including in the areas of finance and investments, professionalism, leadership development, publications, and professional education. He is currently working as a consultant for Sigma Actuarial Consulting Group, with a focus on reserve analyses, captive feasibility studies, and allocation of risk.

Announcement of the winner of the Academy Award for Research

The American Academy of Actuaries Award for Research recognizes an early-career scholar whose work contributes significantly to an actuarial perspective on a public policy issue of interest to U.S. actuaries and public policymakers.

The award will include a monetary prize of $7,500 and presentations of the work—either in person or virtually—at the Academy's Annual Meeting in October in Washington, D.C., and/or at the Actuarial Research Conference in July at Middle Tennessee State University in Murfreesboro, Tenn.

Each year, the award is devoted to research on a particular theme with broad applicability across different policymaking and regulatory environments and across actuarial practice areas. For 2024, the award theme is: "Insights from Behavioral Economics/Behavioral Finance for Insurance, Retirement, and Risk Management."

DAY 3: SATURDAY, JULY 20

Schedule

July 20, 2024 (Morning)

9:00–10:30 a.m.
Parallel Session 5

PS 5A: Ballroom C
Chair: Emiliano Valdez

- *Climate and Market Risk Stress Testing: Application to Property and Casualty Insurers,* Sebastain Awondo, The University of Alabama
- *Climate Extremes and Financial Crises: Similarities, Differences, and Interplay,* Eugenia Fang, University of New South Wales (S)
- *Bridging the Disaster Protection Gap with Index Insurance,* Shimeng Huang, University of Wisconsin-Madison (S)

PS 5B: Ballroom D
Chair: Lu Xiong

- *Unraveling the Complexities of Urban Housing Market Trends: A Predictive Analytics Approach,* Lu Xiong, Jiyao Luo, Middle Tennessee State University
- *Predicting Car Insurance Claims using Machine-Learning Methods,* Moon Nguyen, Youngstown State University
- *Statistical Learning of Trade Credit Insurance Network Data with Applications to Risk Classification,* Woongchae Yoo, Georgia State University (S)

PS 5C: Room 224
Chair: Stuart Klugman

- *Update to "Tools for Counting Actuaries,"* Mike Smith, SOA International Section Council
- *Model Misspecification and Data-Driven Model Ranking Approach for Insurance Loss And Claims Data,* Hon Keung Tony Ng, Bentley University
- *Q-Credibility for Compound Losses Under Dependent Risk Profiles for Frequency and Severity,* Kelvin Tang, University of New South Wales (S)

10:30–11:00 a.m. Coffee Break

11:00 a.m.–12:30 p.m.
Parallel Session 6

PS 6A: Ballroom C
Chair: Lu Xiong

- *Predicting Insurance Reserve using Varying-Coefficients Model with Machine Learning and Statistical Technique,* Danlei Zhu, Middle Tennessee State University (S)
- *Recurrent Neural Networks for Multivariate Loss Reserving and Risk Capital Analysis,* Pengfei Cai, McMaster University (S)

PS 6B: Ballroom D
Chair: Ramchandra Rimal

- *Assessing Fire-Induced Losses through Markovian Random Fields on Trees, CHUISSEU TCHUISSEU* André Orelien, Université Laval (S)
- *Actuarial Perspectives on Fire Losses for Heavy Timber Construction,* Jérémie Barde, Laval University (S)
- *Memory in Temperature and its Impacts on Weather Insurance and Derivatives under a Fractional Ornstein-Uhlenbeck process,* Jayen Tan, Cornell University (S)

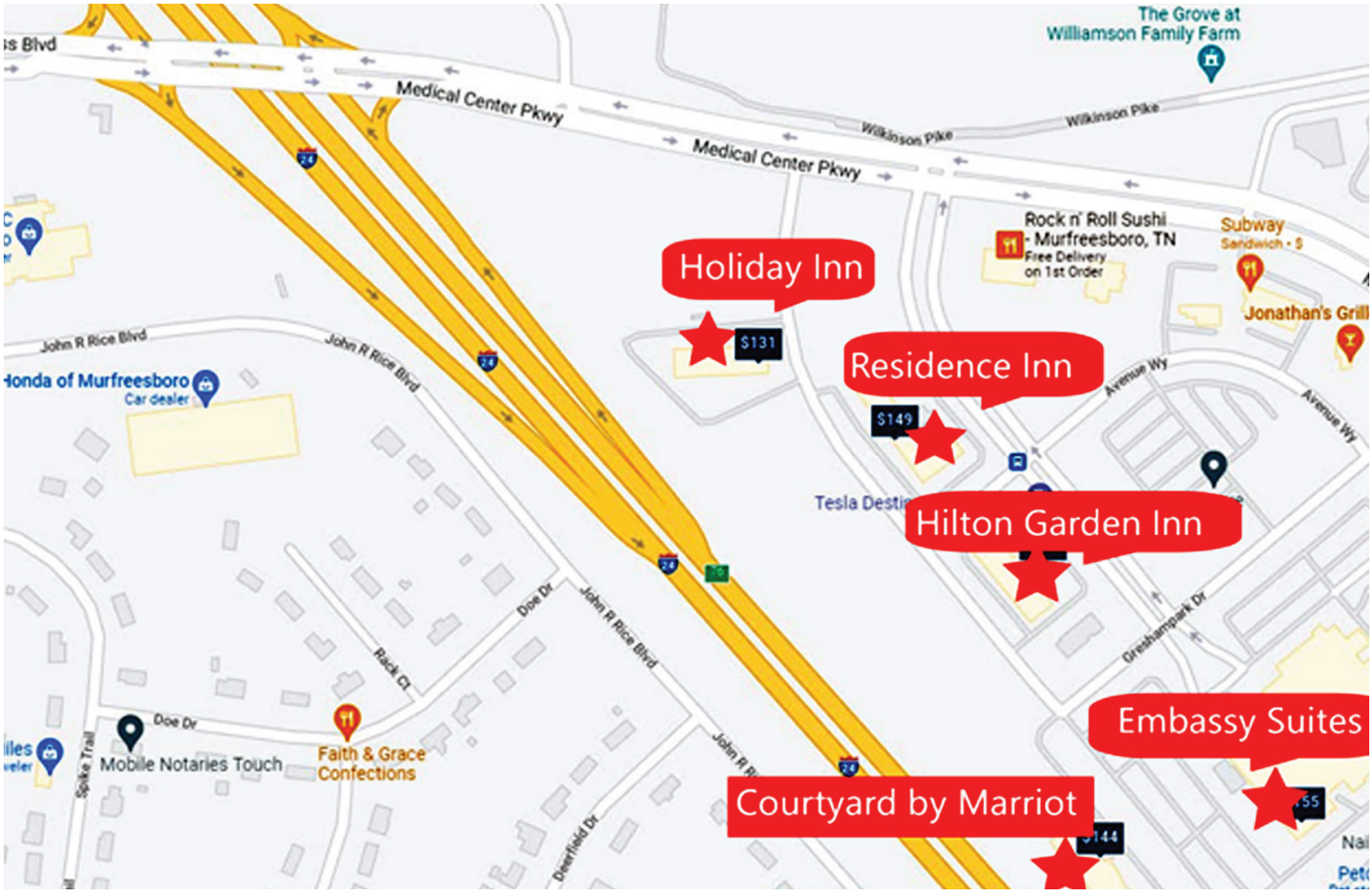
PS 6C: Room 224
Chair: Qiang Wu

- *Optimization of Actuarial Neural Networks with Response Surface Methodology,* Belguutei Ariuntugs, Tennessee Technological University (S)
- *Data Mining of Telematics Data: Unveiling the Hidden Patterns in Driving Behaviour,* Ian Weng (Sophia) Chan (S)

12:30 p.m. Adjourn / Boxed Lunches to Go

HOTEL INFORMATION

We will provide shuttle services to the following hotels.



Hotel Name	Distance to MTSU	Location
Courtyard by Marriott Nashville SE/ Murfreesboro	6 miles	1306 Greshampark Drive, Murfreesboro
Embassy Suites by Hilton Nashville SE/ Murfreesboro	6 miles	1200 Conference Center Boulevard, Murfreesboro
Hilton Garden Inn Murfreesboro	6 miles	1335 Conference Center Boulevard, Murfreesboro
Holiday Inn Murfreesboro, an IHG Hotel	7 miles	1453 Silohill Lane, Murfreesboro
Residence Inn by Marriott Nashville SE/ Murfreesboro	6 miles	1409 Conference Center Boulevard, Murfreesboro

ARC 2024 SHUTTLE SCHEDULE

Date	Time	Location
July 17, 2024	7:00 p.m.	Pickup at the MTSU Student Union Building (STU) and drop off at various hotels mentioned above.
July 18, 2024	7:45 a.m.	The first shuttle starts hotel pickup and takes to STU.
	8:15 a.m.	The second shuttle starts hotel pickup and takes to STU.
	4:00 p.m.	Pickup at the MTSU Student Union Building (STU) and drop off at various hotels mentioned above. This is for participants who do not go on the Nashville tour.
July 19, 2024	8:00 a.m.	The first shuttle starts hotel pickup and takes to STU.
	8:30 a.m.	The second shuttle starts hotel pickup and takes to STU.
	5:00 p.m.	Pickup at the MTSU Student Union Building (STU) and drop-off at various hotels mentioned above.
	6:30 p.m.	Pickup from hotels and drop-off at STU. This is for banquet participants.
	9:00 p.m.	The first shuttle pickup at STU, takes to various hotels.
	9:30 p.m.	The second shuttle pickup at STU, takes to various hotels.
July 20, 2024	8:00 a.m.	The first shuttle starts hotel pickup, takes to STU.
	8:30 a.m.	The second shuttle starts hotel pickup, takes to STU.

CAMPUS MAP AND PARKING

Parking

Parking will be located in the Academic Lot.

Conference

Conference will be held in the Student Union Building (STU).

Interactive Campus Map

Scan QR code to find an interactive MTSU campus map.

LOCAL ATTRACTIONS

Murfreesboro Area

Stones River National Battlefield (NPS)

The Battle of Stones River began on the last day of 1862 and was one of the bloodiest conflicts of the Civil War. The battle produced important military and political gains for the Union, and it changed forever the people who lived and fought here.

Discovery Center at Murfree Spring

Engaging Curious Minds to Fuel the Future. Chartered in 1986 as Children's Museum Corporation of Rutherford County, the Discovery Center provides hands-on educational opportunities for the community.

Oaklands Mansion

The history of Oaklands, an elegant mansion caught in the crossfire of the Civil War. This nationally registered, historic landmark reflects a time of prosperity in the Old South, the hardships suffered during the Civil War, and the pride of the Murfreesboro community.

Bradley Academy Museum and Cultural Center

Bradley Academy Museum and Cultural Center is a historic school building that now serves as a museum and community center. Tours are also available.

Boro Beach

Boro Beach is an outdoor swimming pool at Sports*Com recreational facility.

Greenways and Wetlands Home

Explore the greenways and wetlands of Murfreesboro through Friends of the Greenway, Murfree Springs Wetlands, and trailheads and maps.

Cannonsburgh Village

Historic Cannonsburgh Village is located on 6 acres in Murfreesboro, and represents approximately 100 years of rural Tennessee life from the 1830s to the 1930s.

Wat Lao Buddhist Temple

The temple grounds are gorgeous with beautiful examples of Southeast Asian architecture and art. Located at 5214 Old Nashville Hwy, Murfreesboro.

Stones River Town Center

Stones River Town Centre is a partially enclosed shopping and dining destination in Murfreesboro.

The Avenue Murfreesboro

The Avenue Murfreesboro offers an outdoor shopping experience with a mix of specialty shops, local boutiques, big-box retailers, and unique restaurants.

Nashville Area

Grand Ole Opry

The Grand Ole Opry, an American icon and Nashville's No. 1 attraction, is known for creating one-of-a-kind entertainment experiences for audiences of all ages.

Country Music Hall of Fame and Museum

This the home of contry music, safeguarding over 2.5 million artifacts, with two expansive floors of gallery space featuring permanent and limited-engagement exhibits.

Belle Meade Historic Site and Winery

In the 1800s, Belle Meade was one of the largest and wealthiest private estates in Nashville, raising the nation's finest thoroughbred race horses. Having hosted celebrities, presidents, generals, and a wealth of revered turfmen, Belle Meade is one of Nashville's top attractions.

The Johnny Cash Museum

The Johnny Cash Museum features the world's largest collection of Johnny Cash artifacts and memorabilia in the world.

Gaylord Opryland Resort Gardens

Nashville's Gaylord Opryland Resort and Convention Center has nine acres of lavish indoor gardens. Meticulously selected and lovingly maintained by a staff of 20 full-time interior horticulturists, the landscaping is a colorful, year-round paradise tucked inside this amazing resort. Each of the gardens is housed under one of the hotel's soaring atriums, creating a series of breathtaking horticultural wonderlands.

Nashville Parthenon/Centennial Park

Standing as the centerpiece in Nashville's Centennial Park, the Parthenon is a full scale replica of the Parthenon in Athens, Greece. Come inside to see the 42-foot gilded sculpture of Athena.

Andrew Jackson's Hermitage

The Hermitage, home of President Andrew Jackson, is one of the largest and most visited presidential homes in the United States, and recently named the No. 1 historic house in Tennessee. Today, The Hermitage is a 1,120-acre National Historic Landmark with over 30 historic buildings and welcomes some 200,000 annual visitors, including 30,000 schoolchildren, from all 50 states

Ryman Auditorium

When you walk through the doors of historic Ryman Auditorium, one thing becomes clear right away: This isn't just another nightly music venue, and it's so much more than a daytime tourist stop. This place is hallowed ground. This is the exact spot where bluegrass was born—where Johnny Cash met June Carter, where souls were saved and a slice of history was nearly lost. It was right here that country music found an audience beyond its own back porch, and countless careers took off as deals were signed on napkins and paper scraps backstage.

Belmont Mansion

Belmont Mansion is the largest house museum in Tennessee and one of only a few whose history revolves around the life of a woman: Adelicia Acklen. The historic house is open to visitors for tours.

Lane Motor Museum

Lane Motor Museum in Nashville features the largest European collection of cars and motorcycles in the United States.

Madame Tussauds Nashville

Madame Tussauds Nashville, the world's greatest wax museum, celebrates legendary music icons in Music City. This attraction focused solely on the lyrical legends that have shaped the musical landscape of America.

ABSTRACTS

Bridging Theory and Practice: Collaborative Research for Real-World Impact

Lisa A. Schilling, FSA, EA, FCA, MAAA, Director of Practice Research, Society of Actuaries Research Institute

The Society of Actuaries Research Institute is eager to partner with academic researchers on significant grant applications. The SOA's role would be to bring to the academic research project a direct link to practical applications for actuaries in industry to use. Funders are interested in elevating their research beyond the theoretical realm, and the SOA is interested in helping you achieve that. Join us to explore how we can collaborate to advance actuarial practice in the real world.

The Role of Financial Economics in Actuarial Practice

Hal Pedersen, PhD, ASA, Director, Actuarial Program at University of California, Santa Barbara

Financial economics plays an important role in actuarial practice. In the 1990s, financial economics was the "new new thing" for actuarial practice. Financial economics was integrated into the actuarial syllabus and figured prominently in the preliminary actuarial exams. This prominence has faded, and the last change in the preliminary actuarial exam content removed many of these topics. What happened?

The discussion will review the history of financial economics in actuarial practice and take note of some of the important contributions that actuaries have made to this area. We will then discuss the current state of the art of financial economics in actuarial practice and offer a perspective on why this remains important and exciting. The last part of the session will discuss the NAIC's move to a new economic scenario generator and the financial economics involved in this important part of actuarial practice.

Professionalism Session: You are the fulcrum of Self-Regulation!

Brian Jackson, Director of Professionalism, American Academy of Actuaries

The actuarial profession in the United States substantially self-regulates its members' ethical and practice standards in the development and delivery of work products and actuarial opinions. Self-regulation is both a privilege and a burden shared by all credentialed actuaries and must be supported by all members of the profession. The Code of Professional Conduct (Code) is the foundation of this effort and serves as the primary tool for measuring professional responsibility and assuring the public and regulatory authorities that the actuarial profession can be depended upon to act effectively consistent with the public interest. This presentation will utilize the profession's "Web of Professionalism" to explore what it means to be professional actuary and fulfill the profession's responsibility to the public.

Insights from Behavioral Economics

Moderator: Steve Jackson, Director of Research, American Academy of Research

The 2024 American Academy of Actuaries Award for Research centered on the theme of Insights from Behavioral Economics/Behavioral Finance for Insurance, Retirement, and Risk Management. The Academy received several excellent submissions. On this panel, we will hear presentations from three of the authors who submitted their work for consideration, each one applying insights in a distinct way.

- **Doron Samuell**, Ph.D., Behaviour (Sydney, Australia): **Counteracting dishonesty strategies: A field experiment in life insurance underwriting** (with Demetris Christodoulou, Robert Slonim and Franziska Tausch)
- **Taylor Graciano**, Ph.D. candidate, University of Georgia: **Till Death Do Us Part: Widowhood and Healthcare Utilization**
- **Jackson Lautier**, Ph.D., Bentley University: **Credit Risk Convergence**

CAS Research Paper Series on Race and Insurance Pricing

Annmarie Geddes Baribeau, CAS Research Manager

Peng Shi, Professor at Wisconsin School of Business

Richard Moncher, CAS Vice President of Administration

Actuaries have a responsibility to scrutinize the processes, systems and models we build to understand if the inputs and outcomes truly reflect fair and equitable practices. Building on the foundation of Phase 1 of the CAS's 2022 Research Paper Series on Race and Insurance Pricing, the CAS has launched five new research projects in 2024, addressing topics such as Practical Application of Bias Measurement and Mitigation Techniques in Insurance Rating, Impacts of Usage-Based Insurance on Racial Bias in Insurance Pricing, and Potential Unintended Impacts of Bias Mitigation on Other Protected Class Dimensions. The CAS is also sponsoring research into regulations related to algorithmic bias, along with actuarial approaches in response to such regulations. This session will present findings from these research projects and spark a dialogue among attendees on these important industry challenges.

Pathway to P/C Success: Exploring 2024 CAS Opportunities

Maggie Lyons, CAS Director of Certification Development

Tamar Gertner, CAS Director of Engagement

Join us for an exciting and informative session with Maggie Lyons, CAS Director of Certification Development, as she unveils the 2024-25 CAS Educational Journey. Discover the essential steps and exciting opportunities for students aiming to excel in the property and casualty actuarial field. Dive into the innovative Property & Casualty Predictive Analytics (PCPA) exam/project and the comprehensive Data and Insurance Series Courses, and get the latest updates on all CAS credentialing requirements. This session will also include Tamar Gertner, CAS Director of Engagement, highlighting invaluable CAS resources available to students and professors that will set you and your students on the path to P/C actuarial excellence.

Reserving Innovation in Property-Casualty Insurance

Annmarie Geddes Baribeau, CAS Research Manager, and

Chandu Patel, FCAS, MAAA, Vice President at AmTrust Financial Services Inc. and chair of the CAS reserves working group

Technology is ushering in new methods for analyzing property casualty reserve estimates for solvency and balance sheet purposes. From Bayesian models and machine learning to CAT reserving and claim life cycle development, attendees will be introduced to fresh thinking and techniques for reserving developed by professors and actuarial practitioners.

Update on Society of Actuaries Education

Stuart Klugman, Senior Staff Fellow, Society of Actuaries, sklugman@soa.org

This annual update will provide a review of SOA education and examination over the past year and provide a preview of upcoming changes. There will be time for attendees to ask questions. Note for organizers: At most ARCs this is part of a joint session with similar presentations from the CIA and CAS.

Application of deep reinforcement learning in asset liability management

Takura Asael Wekwete, Fellow of the Actuarial Society of South Africa (FASSA); Special Projects Actuary, Actuarial Society of South Africa (ASSA), takurawekwete@gmail.com

Asset Liability Management (ALM) is an essential risk management technique in Quantitative Finance and Actuarial Science. It aims to maximise a risk-taker's ability to fulfil future liabilities. ALM is especially critical in environments of elevated interest rate changes, as has been experienced globally between 2021 and 2023. Traditional ALM implementation is still heavily dependent on the judgement of professionals such as Quants, Actuaries or Investment Managers. This over-reliance on human input critically limits ALM performance due to restricted automation, human irrationality and restricted scope for multi-objective optimisation. This paper addressed these limitations by applying Deep Reinforcement Learning (DRL), which optimises through trial, and error and continuous feedback from the environment. We defined the Reinforcement Learning (RL) components for the ALM application: the RL decision-making Agent, Environment, Actions, States and Reward Functions. The results demonstrated that DRL ALM can achieve duration-matching outcomes within 1% of the theoretical ALM at a 95% confidence level. Furthermore, compared to a benchmark weekly rebalancing traditional ALM regime, DRL ALM achieved superior outcomes of net portfolios which are, on average, 3 times less sensitive to interest rate changes. DRL also allows for increased automation, flexibility, and multi-objective optimisation in ALM, reducing the negative impact of human limitations and improving risk management outcomes. The findings and principles presented in this study apply to various institutional risk-takers, including insurers, banks, pension funds, and asset managers. Overall, DRL ALM provides a promising Artificial Intelligence (AI) avenue for improving risk management outcomes compared to the traditional approaches.

Climate and Market Risk Stress Testing: Application to Property and Casualty Insurers

Sebastain Awondo, Associate Researcher, The University of Alabama, snawondo@ua.edu

The impact of climate-related risks on emerging and developing economies has become a significant concern for financial and insurance regulators. Insurance regulators are concerned with the increased vulnerability of (re)insurers and state-funded risk pools, known to be directly impacted by climate change risks. These entities are constantly exposed to multiple sources of risks, including climate-related risks, market risks, and operational risks. However, multi-risk stress testing models that simultaneously test a firm's likelihood to survive climate-related risks and other forms of risk are scarce or limited.

In addition, existing stress testing models fail to properly account for feedback mechanisms stemming from the adoption of climate risk mitigation and adaptation strategies, making the models practically unreliable. Whereas, there exists strong interdependence between human actions, the environment, and climate-related risks. Therefore, mitigation or adaptation policies implemented would in turn affect the state of the environment, risks, and human responses, creating a dynamic feedback process and state of nature. Therefore, modeling such interdependence and accounting for mitigation and adaptation pathways with feedback into the multi-risk model is critical for developing reliable stress testing models.

In this study, I develop and apply climate-related multi-risk stress testing models with feedback mechanisms to evaluate the likelihood of major property and casualty insurers in the Southeastern coastal states to payout claims and remain solvent following specific scenarios of catastrophic hurricanes and market risks. Our analysis provides a deeper understanding of the extent to which companies and sectors can survive multiple sources of risks with policy implications on regulation and promoting resilience with "green" mitigations, adaptations, and capital requirements.

Neural-Network Models for Long-term Care Insurance Supply: An Enterprise Risk Management

Sebastain Awondo, Associate Researcher, The University of Alabama, snawondo@ua.edu

Despite the growing need for private insurers to increase their market shares of Long-term Care (LTC), the number of insurers offering LTC insurance (LTCI) coverage has decreased from its peak of over 100 in 2004 to about a dozen in 2020 due to high claim exposure and insolvency.

This paper employs neural networks and an enterprise risk management framework to predict insolvency risk using firm-level accounting and financial time-series data, allowing for early interventions by regulators to prevent further deterioration and the demise of LTCIs.

An enterprise risk management (ERM) framework seeks to identify, assess, monitor, and proactively manage a portfolio of risks associated with their business operations. To this end, our empirical approach dwells on a holistic risk management approach to LTCI by incorporating determinants of risk profiles associated with underwriting, investing, credit, and the financial business operations of LTCI to train and validate the predictive model of LTCI insolvency. More specifically, our time-to-event neural network models include as predictors earned premium, incurred claims, loss ratio, number of new policies issued, policyholder persistency rate, policy reserves, population over 65 years, GDP per capita, inflation, interest rate on the 5- and 30-year Treasury, and 63 policy variations over two decades to train, validate, and predict the supply of discontinuation of LTCI.

Investment-consumption Optimization with Transaction Cost and Learning about Return Predictability

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In this paper, we investigate an investment-consumption optimization problem in continuous-time settings, where the expected rate of return from a risky asset is predictable with an observable factor and an unobservable factor. Based on observable information, a decision-maker learns about the unobservable factor while making investment-consumption decisions. Both factors are supposed to follow a mean-reverting process. Also, we relax the assumption of perfect liquidity of the risky asset through incorporating proportional transaction costs incurred in trading the risky asset. In such way, a form of friction posing liquidity risk to the investor is examined. Dynamic programming principle coupled with an Hamilton–Jacobi–Bellman (HJB) equation are adopted to discuss the problem. Applying an asymptotic method with small transaction costs being taken as a perturbation parameter, we determine the frictional value function by solving the first and second corrector equations. For the numerical implementation of the proposed approach, a Monte-Carlo-simulation-based approximation algorithm is adopted to solve the second corrector equation. Finally, numerical examples and their economic interpretations are discussed.

Gaining Insights into ESG Index Volatility with Deep Learning

Ramchandra Rimal, Assistant Professor, MTSU, ramchandra.rimal@mtsu.edu

Integrating environmental, social, and governance (ESG) factors into investment decisions has become integral for individual and institutional investors. Recognizing the importance of ESG frameworks, corporate leaders increasingly emphasize their value in fulfilling environmental and social responsibilities. However, predicting stock market behavior, particularly within ESG portfolios, presents unique challenges due to increased complexity and volatility compared to broader market indices. To tackle this, we propose an integrated computational framework utilizing deep learning models such as Long Short-term Memory (LSTM), Gated Recurrent Unit (GRU), and Convolutional Neural Network (CNN) to forecast ESG index volatility. Our approach involves a comprehensive analysis to select input features from fundamental data, technical indicators, and macroeconomic factors, aiming to reduce uncertainty in volatility prediction. Model performance is evaluated using standard assessment metrics, with rigorous hyperparameter tuning and model selection techniques employed to identify the most effective model. Statistical analyses confirm the robustness and reliability of our approach.

Causality-based feature selection and application to insurance analytics

Nii Okine, Assistant Professor, Appalachian State University, okinean@appstate.edu

In insurance analytics, insurers use data from policies, claims, and transactions for insurance pricing, reserve estimation, and other insurance processes. With the rise of telematics, usage-based insurance, and smart homes, more detailed datasets are being collected and used. Hence, feature selection techniques are becoming more important to improve the quality of the data for estimation and prediction exercises. Traditional feature selection algorithms focus on selecting features based on their correlations with the response variable without considering causal relationships. Therefore, the paper aims to establish a causality-based feature selection in the insurance literature. We employ the Hill-Climbing algorithm, a global structure learning approach, and incorporate expert knowledge to determine the causal structure of our model. To estimate the causal effect, we used Pearl's causal inference framework. Our empirical analysis using data from a Professional Liability claims-made coverage suggests that causality-based models have potential benefits for building interpretable and robust prediction models.

Model misspecification and data-driven model ranking approach for insurance loss and claims data

Hon Keung Tony Ng, Professor, Bentley University, tng@bentley.edu

Statistical models are crucial in analyzing insurance loss and claims data, offering insights into various risk elements. The prevailing statistical notion that "all models are wrong" can wield significant influence, particularly when multiple competing statistical models are considered. This becomes particularly pertinent when all models portray similar characteristics within certain subsets of the support of the random variable under scrutiny. Since the true model is unknown in practical scenarios, the challenge of model selection becomes daunting, complicating the study of associated characteristics of the true data generation process. To address these challenges, the concept of model averaging is embraced. Often, averaging over multiple models helps alleviate the risk of model misspecification, as different models may capture distinct aspects of the data or modeling assumptions. This enhances the robustness of the model selection process and yields a more acceptable and reasonable estimate compared to relying solely on a single model. This paper introduces two novel data-based model selection methods—one based on the likelihood function and the other on the density power divergence measure. The focus is on estimating the Value-at-Risk (VaR) of non-life insurance claim size data, providing comprehensive insights into potential insurer losses. The performance of the proposed procedures is compared through Monte Carlo simulations, both in uncontaminated data scenarios and in the presence of contamination. Additionally, the applicability of the methods is demonstrated using two real non-life insurance datasets, estimating VaRs at different confidence levels.

Privacy-Preserving Collaborative Information Sharing through Federated Learning

Zhiyu Quan, Assistant Professor, University of Illinois Urbana-Champaign, zquan@illinois.edu

This research explores the critical balance between leveraging proprietary data for collaborative gains and protecting business-sensitive information and client privacy. Taking advantage of unique and comprehensive proprietary data from multiple insurance and InsurTech firms, we present the first comprehensive examination of the real economic benefits of the federated learning framework as a privacy-enhancing business solution for data collaboration. We explore a complete variety of dimensions that span the boundaries of multiple business entities within the business context. The proposed business solution could foster access to the collective intelligence of industry peers in scenarios where physical data aggregation is infeasible, thereby yielding a more comprehensive assessment of user-related features across entities and providing industry-level insights, enhancing standards, preventing fraud, improving efficiency, and driving innovation.

A Least Squares Framework for Fitting the Cairns-Blake-Dowd Models and Its Cohort Extensions

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The Cairns-Blake-Dowd (CBD) models are widely used in stochastic mortality analysis. Typically, these models depend on distributional assumptions for death counts and employ maximum likelihood estimation (MLE) for parameter estimation within a generalized linear model (GLM) framework for parameter estimation. In this paper, we first conduct multiple numerical analyses, revealing that the GLM assumptions are often not met, leading to suboptimal forecasting accuracy. Subsequently, we explore an alternative approach: applying the least squares principle for parameter estimation in the family of CBD models, particularly those incorporating cohort effects. This approach is motivated by the need for a more adaptable and straightforward method in handling diverse datasets, a challenge often encountered with MLE due to its reliance on specific distributional assumptions.

A Cluster Analysis of County-Level Mortality in the Continental U.S.

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This project considers clusters of mortality curves for counties in the continental United States for the years 2000-2021. County-level mortality curves (for both males and females) are built using cubic splines, and we then obtain regression coefficients on these splines. These coefficients are used as the basis to form clusters of counties having similar mortality patterns; we found that in general, three clusters are optimal. Clustering is done for each individual year, as well as for all years combined.

We find that the cluster-level mortality curves have broadly similar shapes but differ most notably at ages 5–35. We examine the differences between these clusters in terms of several covariates collected on the constituent counties and find that the counties are characterized by widely divergent values of covariates such as population, race, home value, household size, and education. Broadly, we find that the clusters largely represent an urban / rural divide. We also consider how the county composition of clusters changes over time. Finally, we compare the performance of the cluster-level mortality curves to those formed at the state level.

Dynamic Prediction of Insurance Claims

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Accurate prediction of an insurer's outstanding liabilities is crucial for maintaining the financial health of the insurance sector. This study is driven by the imperative for insurers to dynamically forecast unpaid losses using the granular transaction data on individual claims. We introduce a copula-based point process framework to model the recurrent events of payment transactions from an insurance claim, where the longitudinal payment amounts and the time-to-settlement outcome are formulated as the marks and the terminal event of the counting process, respectively. The dependencies among the three components are characterized using the method of pair copula constructions. We further develop a stage-wise strategy for parameter estimation and illustrate its desirable properties with numerical experiments. Real data applications further illustrate that our proposed joint model enhances the insurer's decision making in claims management and risk financing operations.

Maximizing outcomes with cost constraints in assigning treatments to patients in ROI driven analysis in healthcare

Ramzi Abujamra, Senior Analyst, Highmark Health, rabujamra1@gmail.com

A popular approach in healthcare is to assign treatment interventions to patients that maximize outcomes. Such treatments typically lead to improved patient status, especially beneficial when the right treatment is assigned to the right patient (at the right time). However, many of the current approaches have focused on health outcomes without considering cost in the formulation. Here we propose an approach that optimizes for both health outcomes and costs. The approach presented here develops on the outcome weighted learning (OWL) work in dynamic treatment regimes. The main idea is to generate treatment recommendation for a given patient cohort, that synthesizes both outcomes and cost considerations of the proposed treatment. This ultimately enables an ROI driven approach for treatment recommendations that actuaries could use in their work offering a more comprehensive framework for decision-making.

Predicting Insurance Reserve using Varying-Coefficients Model with Machine Learning and Statistical Technique

Danlei Zhu, Ph.D. Student, Middle Tennessee State University, dz2t@mtmail.mtsu.edu

Since 1980s, actuaries always choose Generalized Linear Models (GLM) serve as a foundation for analysis projects to help insurance companies predict reserves or unearned premium risk at a particular time spot, since industry regulation requires models should be transparent enough to be interpretable. However, classical linear models often fall short in capturing complex relationships present in real-world scenarios, and actuaries do not often apply machine learning techniques as the first choice due to "Black box" performance which causes less interpretability. To improve it, this research introduce decision tree boosted varying-coefficients model (VCM) and spline VCM to actuarial data for analysis. They try to achieve greater realism by allowing constant coefficients in classical linear models to be dependent on a set of covariates. Through models training and predicting, it has been shown that VCM is worthy to be used, it performs well while keeping a level of interpretability and allowing more complexity of linear form.

Climate Extremes and Financial Crises: Similarities, Differences, and Interplay

Eugenia Fang, PhD Student, University of New South Wales, eugenia.fang@unsw.edu.au

Despite differences between the two concepts at first glance, extremes of climate and financial systems (that is, climate extremes and financial crises) actually share strong similarities. We name some of the most important ones including regime shifts, feedback loops, tipping and non-linearity, and systemic impact. We summarize that these similarities stem from their fundamental nature of stochasticity, deep uncertainty, and complex systems. Furthermore, we establish a connection between the two systems by discussing their interplay, especially the channels that link climate extremes to financial crises, and the mechanisms by which financial distress exacerbates losses from climate extremes. In light of the parallel and interplay, we highlight that some well-established actuarial and financial models, techniques, and ideas behind them may be potentially useful in modeling climate extremes and managing catastrophe risks.

Assessing Fire-Induced Losses through Markovian Random Fields on Trees

CHUISSEU TCHUISSEU André Orelien, Phd Student, Université Laval, aocht@ulaval.ca

Understanding the aftermath of fire incidents is crucial for effective risk assessment and mitigation strategies. This study presents an approach to modeling fire-induced losses using Markovian random fields on trees. Unlike predictive models, our approach focuses on characterizing the spatial patterns of losses rather than predicting their exact magnitude. By employing Markovian random fields, we capture the spatial distribution of losses inherent in fire spread, providing valuable insights into the extent of damages to properties. Through specific case studies, we demonstrate the capabilities of our methodology. This research contributes to the broader discourse on fire risk assessment and management, which may offer valuable insights for stakeholders and decision-makers involved in mitigating the impact of fire incidents on ecosystems and communities.

Strategic Underreporting and Optimal Deductible Insurance

Dongchen Li, Assistant Professor, York University, dcli@yorku.edu

Experience-rating systems, such as bonus-malus systems, offer discounts on future premiums to insureds who maintain a claim-free record, thereby generating incentives for insureds to not report certain losses. This paper formulates an optimal loss-reporting problem in a continuous-time framework for an insured with full insurance. The insured follows a barrier strategy for reporting losses and aims to maximize the expected exponential utility of her terminal wealth over a random horizon τ. In the special case when τ has a constant hazard rate, we obtain the optimal barrier strategy in closed form, which is a strictly positive constant. In the general case of a time-varying hazard rate for τ we obtain the optimal barrier strategy in semi-closed form, subject to solving a system of ordinary differential equations. Additionally, we uncover several noteworthy qualitative insights into both the optimal barrier strategy and the associated value functions.

A new paradigm of mortality modeling via individual vitality dynamics

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The significance of mortality modeling extends across multiple research areas, including life insurance valuation, longevity risk management, life-cycle hypothesis, and retirement income planning. Despite the variety of existing approaches, such as mortality laws, intensity processes, and factor-based models, they often lack compatibility or fail to meet specific research needs. To address these shortcomings, our study introduces a novel approach centered on modeling the dynamics of individual vitality and defining mortality as the depletion of vitality level to zero. More specifically, we develop a four-component modeling framework to analyze the initial value, trend, diffusion, and sudden changes in vitality level over an individual's lifetime. Our vitality-based mortality model stands out for its modularity, broad applicability, and enhanced interpretability, offering an alternative paradigm for mortality modeling. We demonstrate the model's estimation and analytical capabilities through a numerical example, followed by a detailed discussion on its practical implementation and significance in various research directions.

Statistical Learning of Trade Credit Insurance Network Data with Applications to Risk Classification

Woongchae Yoo, PhD Student, Georgia State University, wyoo2@gsu.edu

Trade Credit Insurance (TCI) has received little attention in the literature, especially in the context of risk classification and ratemaking. In this paper, with a full 4-year individual business- and policy-level TCI data from an Asian TCI insurer, we present a preliminary analysis of binary risk classification for TCI data using logistic Generalized Linear Models (GLM) augmented with node features derived from network graphs to capture inter-node dependencies existing in the data. The results show that the augmented GLM outperforms the basic GLM in terms of fitting. We also introduce a more comprehensive approach for future research, an augmented Generalized Linear Mixed Model (GLMM) and the stochastic variational Expectation-Conditional Maximization (ECM) algorithm to better account for the claim histories of sellers and buyers, network relationships, as well as reporting delays, to align more closely with the characteristics of TCI data.

q-credibility for compound losses under dependent risk profiles for frequency and severity

Kelvin Tang, Student, UNSW, kelvin.tang@student.unsw.edu.au

We generalise the credibility estimator to incorporate the full claim information regarding frequency and severity by expressing the premium in terms of the observed claim numbers and individual loss amounts. Policyholders are characterised by separate risk factors for frequency and severity, assumed to be drawn from a bivariate prior distribution, thus allowing these components to be dependent. This is advantageous over traditional approaches, which model the aggregate loss over a period, as we differentiate between cases of frequent small claims and fewer large claims. Given that credibility is inherently determined by the frequency of claims, our methodology can properly account for this factor. Additionally, we incorporate up to quadratic terms in claim number and size to capture nonlinearities in the premium and this includes an interaction between frequency and severity. Our method involves extending the classical structural parameters, and we derive the credibility factors for frequency and severity that minimise the mean squared error to the pure premium. Like classical credibility, the resulting estimator can be expressed as a weighted average of the collective and individual claim history, and solutions are found for parametric and non-parametric cases. Numerical examples confirm the improved performance over aggregate modelling methods, even when the distributions of frequency and severity are independent.

Variable annuity portfolio valuation with Shapley additive explanations

Gayani Thalagoda, PhD Candidate, University of New South Wales, g.thalagoda@student.unsw.edu.au

This study proposes a metamodeling method that utilizes Shapley additive explanations in selecting the representative sample in an explainable manner for valuing variable annuity portfolios. Selecting a representative sample with clear and explainable criteria is necessary when applying metamodeling techniques to principle-based calculations. The proposed method involves (i) training a surrogate neural network with existing valuations for the same portfolio across multiple market conditions and (ii) decomposing the overall risk of a policy into clearly separated contributions from each risk driver using Shapley additive explanations. This decomposition results in an informative and explainable representation of the insurance policy data, which can later be used to select the representative sample under a new market condition. Furthermore, by fine-tuning the surrogate neural network with the carefully chosen representative sample, the proposed method offers a systematic way to improve the neural network's estimation with limited data in the new market condition. The proposed method can assist users in explaining the reasoning behind selecting a policy as representative. Furthermore, the proposed method aligns with the U.S. National Association of Insurance Commissioners (NAIC)'s requirements for principle-based reserves for variable annuities, which necessitate representative policies to be selected in a manner that sufficiently reflects the impact of policy characteristics on the calculated risk measure. Our numerical analyses show that the proposed method outperforms conventional methods in the existing literature in prediction accuracy and goodness of fit.

Modeling County-Level Spatio-Temporal Mortality Rates Using Dynamic Linear Models

Zoe Gibbs McBride, Student, University of Connecticut, zgibbs8@gmail.com

The lifestyles and backgrounds of individuals across the United States differ widely. Some of these differences are easily measurable (ethnicity, age, income, etc.) while others are not (stress levels, empathy, diet, exercise, etc.). Though every person is unique, individuals living closer together likely have more similar lifestyles than individuals living hundreds of miles apart. Because lifestyle and environmental factors contribute to mortality, spatial correlation may be an important feature in mortality modeling. However, many of the current mortality models fail to account for spatial relationships. This paper introduces spatio-temporal trends into traditional mortality modeling using Bayesian hierarchical models with conditional auto-regressive (CAR) priors. We show that these priors, commonly used for areal data, are appropriate for modeling county-level spatial trends in mortality data covering the contiguous United States. We find that mortality rates of neighboring counties are highly correlated. Additionally, we find that mortality improvement or deterioration trends between neighboring counties are also highly correlated.

Pricing Credit Default Swaps under Shocks, Regime Shifts and Recovery Uncertainties

Yuhao Liu, PhD Candidate, UNSW, yuhao.liu@unsw.edu.au

Consider a credit default swap (CDS) written on some defaultable underlying asset. The likelihood of default depends on the occurrence of shocks and the market regime. Moreover, in the event of default its recovery payment comprises both an endogenous component contingent on the market performance until default and an exogenous component to account for its unpredictability. Building upon the pricing framework developed by Liu and Tang (2024), this study undertakes a numerical analysis to assess the impacts of the shock risk, the regime-shift risk, and the recovery risk on CDS valuation. The default intensity and the interest rate are assumed to jointly follow an affine jump-diffusion process, which allows the development of a recursive algorithm that significantly enhances the efficiency of computation tasks through Monte Carlo simulations.

Value-at-Risk- and Expectile-based Systemic Risk Measures and Second-order Asymptotics: With Applications to Diversification

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The systemic risk measure plays a crucial role in analyzing individual losses conditioned on extreme system-wide disasters. In this paper, we provide a unified asymptotic treatment for systemic risk measures. First, we classify them into two families of Value-at-Risk- (VaR-) and expectile-based systemic risk measures. While VaR has been extensively studied, in the latter family, we propose two new systemic risk measures named the Individual Conditional Expectile (ICE) and the Systemic Individual Conditional Expectile (SICE), as alternatives to Marginal Expected Shortfall (MES) and Systemic Expected Shortfall (SES). Second, to characterize general mutually dependent and heavy-tailed risks, we adopt a modeling framework where the system, represented by a vector of random loss variables, follows a multivariate Sarmanov distribution with a common marginal exhibiting second-order regular variation. Third, we provide second-order asymptotic results for both families of systemic risk measures. This analytical framework offers a more accurate estimate compared to traditional first-order asymptotics. Through numerical and analytical examples, we demonstrate the superiority of second-order asymptotics in accurately assessing systemic risk. Further, we conduct a comprehensive comparison between VaR-based and expectile-based systemic risk measures. We find that expectile-based measures output higher risk evaluation than VaR-based ones, emphasizing the former's potential advantages in reporting extreme events and tail risk. As a financial application, we use the asymptotic treatment to discuss the diversification benefits associated with systemic risk measures. The financial insight is that the expectile-based diversification benefits consistently deduce an underestimation and suggest a conservative approximation, while the VaR-based diversification benefits consistently deduce an overestimation and suggest behaving optimistically.

Comparative Analysis of Recent Implementations of Gradient Boosting for Decision Trees in Insurance Applications

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Generalized linear models (GLM) are the most popular option for general insurance ratemaking. However, boosted decision trees have been shown to improve predictive performance over GLMs. Since the first gradient boosting algorithm based on decision trees was proposed by Friedman in 2001, many improvements and sophistications have been proposed. We present the differences between XGBoost, LightGBM, CatBoost, NGBoost, XGBoostLSS and Probabilistic Gradient Boosting Machines and we criticize their advantages and disadvantages in the context of actuarial data. Comparison topics include contributions to the stochastic gradient boosting algorithm, means of preventing overfitting and hyperparameters to tune. While the first three yield point estimates, the last three are designed for probabilistic regression. These two frameworks are compared from an actuarial standpoint. The results obtained for many actuarial datasets on claim frequency and severity show that none of the algorithm clearly stands out for point prediction accuracy, but that there are winners in terms of computational efficiency. Point prediction accuracy is measured with the deviance of the assumed probability distributions and the root mean squared error (RMSE) on a test sample. The training time is the measure used to assess computational efficiency of the implementations. We also discuss model adequacy for probabilistic regression with the use of proper scoring rules.

A Metric for Improved Teaching of Hard Parts of Courses

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An illustrative example facilitates understanding. Consider the problem from the Financial Mathematics (FM) preliminary exam syllabus of pricing (finding the present value in a 4% interest environment) of a 30-year retirement annuity paying $2000 monthly in the first year, with level monthly payments in future years increasing by 2% annually. Notice that the following four questions each have two answers (indicated in parenthesis): (a) What is the interest rate (4% annually, 0.3274% monthly (there is also a modified rate)); (b) how many periods are involved (12 months for the level payments, 30 years for the increasing payments; (c) what are the period lengths (months for the level payments; years for the increasing payments); (d) what types of annuities are involved (level for the monthly payments, geometrically increasing for the annual payments). This motivates the idea of the interference metric, the number of questions needed for the solution of a problem that has 2 or more answers; the problem posed above has an interference metric of 4. The word interference, comes from the psychological literature, and was introduced by Stroop in 1931, who observed that even a simple recognition task, like recognizing the font color of a printed word increases in difficulty if there is interference; it takes more time to recognize words like green written in blue font, then say chair written in blue. The author has noticed that high interference of typical problems in a course component precisely indicates areas where weaker students fail. The simple technique of juggling course time, allocating more time for high-interference course components and less time for low-interference components drastically reduces the failure rate. The presentation applies this easily learned technique to several preliminary-exam courses and shows connection with other teaching techniques.

Basis Risk in Variable Annuity Separate Accounts

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Variable annuities (VAs) are hybrid long-term financial products that combine both the insurance and investment functions. Many VA policies have complex long-term financial guarantees attached that expose insurers to a large amount of systematic equity risk. Hedging this risk is paramount, but the effort is complicated by basis risk, i.e., the discrepancy between changes to the value of VA guarantees in response to financial market movements and the returns of potential hedging instruments. There is an expanding strand of literature examining the dynamic hedging algorithm for VA portfolios, though, in the majority of these studies, the mapping on VA-underlying mutual funds is still conducted at the individual fund level with a single index or futures contract as the hedging instruments. In this study, we develop a novel portfolio fund mapping strategy that simultaneously addresses the three primary challenges insurers face in practice when hedging the VA liabilities: (i) reduce basis risk by producing a high-quality fund mapping; (ii) limit transaction costs incurred from rebalancing the fund mapping strategy; and (iii) keep the fund mapping tractable by using few instruments. We combine the sure independence screening (SIS) procedure with revised LASSO regression to reduce transaction costs while aiming to maximize the mapping efficiency of VA portfolios. To document the real-world effectiveness of our proposed approach, we conduct an empirical study of two U.S. VA providers: a market leader and a minor player, respectively. We use historical monthly returns of the companies' VA-underlying mutual funds from October 2008 to December 2022, with 645 ETFs serving as potential mapping instruments. For the market leader with its 390 unique VA funds, we find that our approach can lower basis risk to around 8.8% while requiring investment in only 10 ETFs on average across our sample period, with a monthly turnover ratio of 1.1%. The smaller firm with 80 unique VA funds requires 14 ETFs on average, with a 5.0% turnover ratio, in order to achieve an 11.6% basis risk level. We conclude that basis risk can be much less of a concern to VA providers than previously suggested by presenting a practically feasible algorithm that helps insurers mitigate basis risk effectively and improve the quality of their VA hedging.

The Flipped Actuarial Classroom

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Like many instructors, during the pandemic I discovered many advantages with online teaching, although I missed the classroom interactions. Since returning in person, I wanted to keep the best of both worlds and so I used a "flipped classroom" approach in my courses in both Fall 2022 and Spring 2023. Lecture material was delivered asynchronously via videos and the reduced in-class time prioritized active learning and formative assessment. Now that I've done it twice, I will share ideas (from my own course and others') about ensuring student accountability to the material, getting buy-in from students, and pitfalls to avoid when teaching in this modality. Interactive activities during the session will help you decide if flipping is right for your course context, and develop some ideas for how you might design it.

Standard and comparative e-backtests based on elicitability

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Backtesting risk measures is important for financial regulators to evaluate risk forecasts reported by financial institutions. As a natural extension to standard/traditional backtests, comparative backtests are introduced to compare different forecasting methods. Based on recently developed concepts of e-values and e-processes, we design a model-free method for standard backtests of identifiable risk measures. In addition, we develop model-free comparative backtests for elicitable risk measures by constructing e-processes. As an important example, we discuss standard and comparative backtests for expectiles, one of the most popular risk measures besides Value-at-Risk and Expected Shortfall, based on e-processes. Simulation studies will be presented as good illustration.

Optimal Consumption and Investment under Uncertain Lifetime and Lifetime Income

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We develop a life-cycle framework to study optimal asset allocation strategies for retirees under lifetime income such as pension income or social security. More precisely, we extend the analysis from Yaari (1965) and Leung (1994) by allowing for optimal investments in risky and riskless assets. Leveraging results from Leung (1994), we show that the consumer fully depletes wealth (if she does not die before that) and solely relies in the survival contingent income from some point forward. Relying on the maximum principle for stochastic control (Yong and Zhu, 2012), we characterize the optimal depletion time, optimal consumption, and optimal investment via a system of Forward-Backward Stochastic Differential Equations (FBSDEs). In numerical illustrations, we compare our results to situations where individuals ignore or can borrow against future income.

Actuarial Perspectives on Fire Losses for Heavy Timber Construction

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Fire losses represent a significant risk in property insurance. To comprehend and quantify this risk, we use two Canadian databases containing numerous fire incidents: one from the city of Toronto and another named the National Fire Information Database (NFID). We model the losses employing various parametric families and use risk measures to quantify the risk of the model. Once the losses are modeled, we explore different scenarios using a fictional pool to analyze the fund's evolution. In the pursuit of developing a peer-to-peer insurance model for the heavy timber construction sector, we are interested in risk-sharing rules. Our aim is to comprehend the dynamics of risk sharing by examining a portfolio of buildings with diverse structural types.

Optimization of Actuarial Neural Networks with Response Surface Methodology

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In the current data-driven landscape, machine learning is pivotal, especially in actuarial science where precision is paramount. Neural networks are powerful tools for predictive modeling, enhancing risk assessment, pricing strategies, and decision-making within the insurance and financial sectors. These algorithms require optimization of user-defined hyperparameters, such as learning rates, number of layers, and activation functions, to ensure efficient use of resources as the complexity and scale of machine learning algorithms increase.

This approach focuses on the Combined Actuarial Neural Networks (CANN), selected for its relevance in actuarial applications and built-in safety features for tasks such as mortality forecasting and pricing. We employ a Factorial Arrangement Design of Experiments for sampling hyperparameters, followed by leveraging Response Surface Methodology (RSM) to fit a quadratic surface over the hyperparameter space to identify optimal or near-optimal settings. Our proposed method is particularly well-suited for optimizing performance when resources are constrained.

Unlike traditional methods such as grid search, which tests multiple hyperparameter combinations sequentially and can require a large number of runs, RSM offers a structured approach to experiment design that effectively explores the response surface and captures potential curvature.

Preliminary results indicate that our method not only predicts the performance of the CANN algorithm accurately but also identifies critical hyperparameters. In initial experiments focusing on batch size and the number of epochs, we discovered that some hyperparameters could be omitted after the first trial due to their statistically insignificant effect on overall performance. Our approach achieved a near-optimal point with only 29 runs, compared to 460 runs needed by the grid search method, resulting in a 94% reduction in runs and significantly enhanced efficiency.

Keywords: Hyperparameter Optimization, Response Surface Methodology, Actuarial Science, CANN

Including Expert Knowledge in Tarification: A Bayesian Approach

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Commercial insurance covers a wide range of risks, making usual pricing algorithms less effective for calculating premiums. Experienced experts understand these risks, and integrating their insights into our algorithms could improve policyholder segmentation. This presentation aims to propose a new model for rating fire risks in commercial insurance by incorporating expert opinion using Bayesian statistics and generalized linear mixed models. Also, due to the imbalanced nature of the insurance database, with very low claim frequency, various methods to rebalance the data will be explored to enhance claim predictions.

Utilizing Recurrent Neural Networks for Real-Time Cryptocurrency Price Prediction and Trading Strategy Optimization

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This research explores the application of Recurrent Neural Networks (RNN) to develop a real-time predictive model for cryptocurrency prices, specifically aiming to optimize trading strategies within this highly volatile market. Traditional forecasting methods often struggle to capture the complex dynamics of cryptocurrency prices due to their nonlinear behavior and market sensitivity.

Our approach involves the innovative use of Long Short-Term Memory (LSTM) networks, Gated Recurrent Units (GRU), and Bidirectional LSTM (Bi-LSTM) models to handle the time-series data of cryptocurrency prices effectively. The study spans an intensive ten-week period involving phases of data collection, model design, and iterative testing, focusing on the cryptocurrencies Bitcoin (BTC), Ethereum (ETH), and Litecoin (LTC).

We utilize a combination of historical price data, trading volumes, and market sentiment analysis derived from social media to train our models. The performance of these models is rigorously tested through backtesting against historical data, assessing their profitability and risk with metrics such as RMSE (Root Mean Square Error) and MAPE (Mean Absolute Percentage Error).

Preliminary results indicate that our RNN-based models significantly outperform traditional methods, providing more accurate predictions and robust trading strategies that are responsive to real-time market changes. This research not only enhances academic understanding of financial prediction using deep learning techniques but also delivers practical tools for traders navigating the complexities of the cryptocurrency markets.

Bridging the Disaster Protection Gap with Index Insurance

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With rising frequency, natural disasters are leading to dramatically increasing financial costs in recent decades. Yet, the insurance protection gap for natural disasters is large, with over 60% of global economic losses uninsured from 2012 to 2021. In contrast to traditional indemnity insurance with high adjustment costs and long delays in claims settlement, index-based contracts can greatly reduce the cost and time of claims settlement while offering much needed protection against catastrophic events. The question arises: can index insurance be utilized to bridge the protection gap, as an alternative to indemnity insurance? While promising, index insurance faces basis risk due to the mismatch between the chosen index and actual losses. By leveraging comprehensive weather data and deep learning models, we intend to construct a modeled index capable of forecasting the ultimate losses from flood events for a given claim with reduced basis risk. Moreover, we will explore the potential of the proposed index insurance to improve the coverage of disaster insurance under a utility framework. We aim to show that a high-quality index with low basis risk is crucial for improving insurance coverage. This offers valuable insights for policymakers, insurers, and policyholders on leveraging insurance innovations for greater disaster resilience.

Update to “Tools for Counting Actuaries"

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At the 2023 ARC researchers Mano and Smith presented “Tools for Counting Actuaries.” For 2024 Smith and Bank would like to update the research with more data and more discussion of the data quality. The update will preview a September paper/presentation scheduled for JoCo 2024.

Recurrent Neural Networks for Multivariate Loss Reserving and Risk Capital Analysis

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In the property and casualty (P&C) insurance industry, reserves comprise most of a company’s liabilities. These reserves are the best estimates made by actuaries for future unpaid claims. It’s important to note that reserves for different business lines (LOBs) are related due to dependencies between LOBs. While the actuarial industry has developed both parametric and non-parametric methods for loss reserving, only few tools have been created to capture both the pairwise dependence between loss triangles and the development year dependence. This paper explores the use of RNN methods to model the pairwise dependence and development year dependence and develop predictive distributions for reserves using machine learning techniques. We construct an RNN model to capture the complex dependencies between two LOBs by expanding on the Deep Triangle (DT) model from Kuo (2019). For the DT model, we use the incremental paid loss from two LOBs as input and the symmetric squared loss as the loss function. We then use block bootstrap and generative adversarial network (GAN) to generate synthetic loss triangles to derive the predictive distribution for reserves. To demonstrate our method, we apply and calibrate these methods using data from 30 companies from the National Association of Insurance Commissioners database (Meyers and Shi, 2011) and compare the results with copula regression models. When using 30 companies data, in copula regression and DT, we account for the heterogeneity across companies. The findings indicate that the DT model outperforms the copula regression models in predicting total loss reserve. Furthermore, the predictive distribution for reserves shows that risk capitals calculated from the DT model combined with GANs are smaller than those from the copula regression models, suggesting a more significant diversification benefit. Finally, these findings are also confirmed in a simulation study.

Pooling functional disability and mortality in long-term care insurance and care annuities: A matrix approach for multi-state pools

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Mortality risk sharing pools including group self-annuitisation, pooled annuity funds and tontines have been developed as an effective solution for managing longevity risk. Although they have been widely studied in the literature, these mortality risk sharing pools do not consider individual health or functional disability status nor the need for long-term care (LTC) insurance at older ages. We extend these pools to include functional disability and chronic illness and present a matrix-based methodology for pooling mortality risk across heterogeneous individuals classified by functional disability states and chronic illness statuses. We demonstrate how individuals with different health risks can more equitably share mortality risk in a pooled annuity design. A multi-state pool is formed by pooling annuitants considering both longevity and LTC risks and determining the actuarially fair benefits based on individuals' health states. Our methodology provides a general structure for a pooled annuity product that can be applied for general multi-state models. We present an extensive analysis with numerical examples using the US Health and Retirement Study (HRS) data. Our results compare expected annuity benefits for individuals in poor health to those in good health, show the effects of incorporating systematic trends and uncertainty, assess how the valuation of the expected annuity payments interacts with the assumptions used for the multi-state model and assess the impact of pool size.

A Multivariate Spatiotemporal Model for County Level Mortality Data in the Contiguous United States

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We seek to understand the factors that drive mortality in the contiguous United States using data that is indexed by county and year and grouped into 18 different age bins. We propose a model that adds two important contributions to existing mortality studies. First, we treat age as a random effect. This is an improvement over previous models because it allows the model in one age group to borrow information from other age groups. Second, we utilize Gaussian Processes to create nonlinear covariate effects for predictors such as unemployment rate, race, and education level. This allows for a more flexible relationship to be modeled between mortality and these predictors. Understanding that the United States is expansive and diverse, we allow for many of these effects to vary by location. The flexibility in how predictors relate to mortality has not been used in previous mortality studies and will result in a more accurate model and a more complete understanding of the factors that drive mortality. Both the multivariate nature of the model as well as the spatially-varying non-linear predictors will advance the study of mortality and will allow us to better examine the relationships between the predictors and mortality.

Zero-Inflated Tweedie Boosted Trees with CatBoost for Insurance Loss Analytics

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In this paper, we explore advanced modifications to the Tweedie regression model in order to address its limitations in modeling aggregate claims for various types of insurance such as automobile, health, and liability. Traditional Tweedie models, while effective in capturing the probability and magnitude of claims, usually fall short in accurately representing the large incidence of zero claims. Our recommended approach involves a refined modeling of the zero-claim process, together with the integration of boosting methods in order to help leverage an iterative process to enhance predictive accuracy. We focus on challenging cases identified by previous models without causing significant overfitting. Despite the inherent slowdown in learning algorithms due to this iteration, several efficient implementation techniques that also helps precise tuning of parameter like XGBoost, LightGBM, and CatBoost have emerged; however, we chose to utilize CatBoost, a boosting approach that effectively handles categorical and other special types of data. The core contribution of our paper is the assembly of separate modeling for zero claims and the application of tree-based boosting ensemble methods within a CatBoost framework, assuming inflated probability of zero is a function of the mean parameter. The efficacy of our enhanced Tweedie model is demonstrated through its application to an insurance telematics dataset, which presents the additional complexity of compositional feature variables. Our modeling results reveal a marked improvement in model performance, showcasing its potential to deliver more accurate predictions suitable for insurance claim analytics.

Mortality Prediction: A Parameter Transfer Approach

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Borrowing information from populations with similar mortality patterns is a recognized strategy for the mortality prediction of a target population. This mirrors the concept of Transfer Learning, a popular and promising area in modern data mining and machine learning, which aims at improving the performance of target learners on target domains by transferring the knowledge contained in different but related source domains. This project focuses on applying transfer learning to actuarial applications of mortality predictions. We explore how data from other mortality datasets can be effectively integrated into the parameter transfer learning framework to improve mortality predictions for a target population. Our approach includes incorporating existing mortality prediction models into a regularization framework with closed-form solutions. Additionally, we develop an iterative updating algorithm for classic mortality models and penalty forms.

Unraveling the Complexities of Urban Housing Market Trends: A Predictive Analytics Approach

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Predictive analytics is a crucial tool in urban development and real estate planning. This presentation explores data science methodologies for forecasting urban housing market trends, integrating historical data, current market dynamics, and machine learning models to estimate supply and demand. A case study of a high-rise development project demonstrates the use of predictive models to assess the competitive landscape and potential market impact, utilizing variables such as vacancy rates and unit numbers to develop robust forecasting models. The findings emphasize the value of data-driven decision-making in urban planning and real estate, addressing complex market challenges.

Predicting Car Insurance Claims using Machine-Learning Methods

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In this talk, we will present a comparative study on car insurance claim predictions using different machine-learning methods, namely Generalized Linear Model, Artificial Neural Network, and Gradient Boosting. We use each of the methods and the combination of them to build predictive models for car insurance claims. We will also explain the process of cleaning and organizing data for each of the model and how to deal with unbalanced data such as insurance claims. Our results show that the Gradient Boosting method outperform the others with the accuracy of prediction exceed 95%.

Data Mining of Telematics Data: Unveiling the Hidden Patterns in Driving Behaviour

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With the advancement in technology, telematics data which capture vehicle movements information are becoming available to more insurers. As these data capture the actual driving behaviour, they are expected to improve our understanding of driving risk and facilitate more accurate auto-insurance ratemaking. In this paper, we analyze an auto-insurance dataset with telematics data collected from a major European insurer. Through a detailed discussion of the telematics data structure and related data quality issues, we elaborate on practical challenges in processing and incorporating telematics information in loss modelling and ratemaking. Then, with an exploratory data analysis, we demonstrate the existence of heterogeneity in individual driving behaviour, even within the groups of policyholders with and without claims, which supports the study of telematics data. Our regression analysis reiterates the importance of telematics data in claims modelling; in particular, we propose a speed transition matrix that describes discretely recorded speed time series and produces statistically significant predictors for claim counts. We conclude that large speed transitions, together with higher maximum speed attained, nighttime driving and increased harsh braking, are associated with increased claim counts. Moreover, we empirically illustrate the learning effects in driving behaviour: we show that both severe harsh events detected at a high threshold and expected claim counts are not directly proportional with driving time or distance, but they increase at a decreasing rate.

Memory in Temperature and its Impacts on Weather Insurance and Derivatives under a Fractional Ornstein-Uhlenbeck process

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Global warming and the recent proliferation of heat insurance products emphasize the pressing need for a reliable temperature model. We introduce the generalized fOU temperature model that can flexibly incorporate long-run weather patterns and encapsulate the persistent memory effects of temperature series. We show that the generalized fOU process normalizes to a zero-mean fOU process, which can differ substantially from its memoryless OU counterpart in terms of its statistical properties and predictive power, highlighting the importance of not assuming independent errors and properly accounting for autocorrelation structure.

We derive a simple covariance expression for the fOU process and provide closed-form solutions for the prices of weather insurance contracts. We also fit the fOU model across the USA and establish the existence of the persistent memory phenomenon. Lastly, we illustrate that the fOU model possesses superior forecast accuracy for average-type insurance contracts (aka Asian options), and using a Bertrand price competition game model, we show that the fOU insurer commands a higher profitability.

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