INSURANCE MATHEMATICS & ECONOMICS 2023

Tuesday 4 – Friday 7 July 2023

Hosted by Heriot-Watt University

Edinburgh, Scotland

PROGRAMME

HERIOT WATT UNIVERSITY

UK | DUBAI | MALAYSIA

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- Wei Wei (Heriot-Watt University)
- Anke Wiese (Heriot-Watt University)
- Gordon Willmot (University of Waterloo)
- Hailiang Yang (The University of Hong Kong)

**Sadly, Professor Ken Seng Tan passed away on 1 January 2023.*

Programme Overview

Tuesday 4 July		
Time	**Event**	**Location**
17.00 – 19.00	Registration and welcome reception	James Watt Centre II

Wednesday 5 July		
Time	**Event**	**Location**
08.00 – 09.00	Registration	James Watt Centre II
	Refreshments	James Watt Centre II
09.00 – 09.10	Opening ceremony	James Watt I
09.10 – 10.10	**Keynote 1 – Julia Eisenberg (TU Vienna)**	James Watt I
10.10 – 10.40	Coffee break	James Watt Centre II
10.40 – 12.00	**Parallel sessions 1**	Hub 1 and Hub 2
12.00 – 13.30	General lunch	James Watt Centre II
	Networking lunch: Climate Risk	Hub 2 Lunch and Coffee Area
12.15 – 13.15	IME Editorial Board (by invitation)	EM 1.82
13.30 – 14.30	**Parallel sessions 2**	Hub 1 and Hub 2
14.30 – 14.40	Short break	
14.40 – 15.40	**Parallel sessions 3**	Hub 1 and Hub 2
15.40 – 16.10	Coffee break	James Watt Centre II Hub 2 Lunch and Coffee Area
16.10 – 17.30	**Parallel sessions 4**	Hub 1 and Hub 2
17.30 – 18.45	Reception with canapés	James Watt Centre II

Thursday 6 July		
Time	**Event**	**Location**
09.00 – 10.20	**Parallel sessions 5**	Hub 1 and Hub 2
10.20 – 10.50	Coffee break	James Watt Centre II Hub 2 Lunch and Coffee Area
10.50 – 12.10	**Parallel sessions 6**	Hub 1 and Hub 2
12.10 – 13.30	General lunch	James Watt Centre II
	Networking lunch: Pensions and Annuities	Hub 2 Lunch and Coffee Area
13.30 – 14.30	**Keynote 2 - Mario Wüthrich (ETH Zürich)**	James Watt I
14.30 – 14.40	Short break	
14.40 – 15.40	**Parallel sessions 7**	Hub 1 and Hub 2
15.40 – 16.10	Coffee break	James Watt Centre II Hub 2 Lunch and Coffee Area
16.10 – 17.10	**Parallel sessions 8**	Hub 1 and Hub 2
18.30	Buses depart from campus to Gala Dinner	Bus stop outside Leonard Horner Hall (see campus map)
19.15 – 00.00	Gala Dinner	National Museum of Scotland

Friday 7 July		
Time	**Event**	**Location**
09.00 – 10.20	**Parallel sessions 9**	Hub 1 and Hub 2
10.20 – 10.50	Coffee break	James Watt Centre II Hub 2 Lunch and Coffee Area
10.50 – 11.50	**Parallel sessions 10**	Hub 1 and Hub 2
11.50 – 12.00	Short break	
12.00 – 13.00	**Keynote 3 - Séverine Arnold (University of Lausanne)**	James Watt I
13.00 – 13.30	IME remarks & closing ceremony	James Watt I
13.30	Packed lunches	James Watt Centre II

Keynote Speakers

(alphabetical by surname)

Séverine Arnold, University of Lausanne

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

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

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

Title: Actuarial Science vs Social and Sustainable Development: What is the link?

Abstract:
In 2015, all United Nations Member States adopted an agenda for sustainable development that should be reached by 2030. That agenda is composed of 17 goals, known as the 17 United Nations Sustainable Development Goals (UN SDGs) and is aiming for peace and prosperity for the people and the planet, now and into the future, through a global partnership across all nations.

Many academics from different disciplines were interested in these goals and analysed them through their respective subjects. However, very few actuaries and experts in risk management were involved in the discussions and looked at these 17 UN SDGs. In many of these SDGs, if not in all of them, risks are involved. Therefore, actuaries and related professions have different tools and can further develop new means that can help promote and achieve the UN SDGs.

In this talk, we will present the journey a few academics started in collaboration with an UN agency. Three academic papers in connection with the UN SDGs and using an actuarial perspective will be discussed and presented as examples of what can be achieved by our discipline that is of interest to the UN. The first paper is discussing notional defined contributions pension schemes and shows: 1) why many countries using such systems cannot reach a financial equilibrium; 2) how such systems could finance a minimum pension. The second paper shows how tools from Ruin Theory can be used to demonstrate how inclusive insurance may help households to get out of poverty. The third paper shows that mixing pay-as-you-go and funded systems is optimal for all members at all times in a pension scheme, and thus superior over pure financing systems.

Julia Eisenberg, TU Vienna

Dr. Julia Eisenberg is currently Associate Professor at the TU Wien, Austria. She received her doctorate at the University of Cologne, Germany, and completed her habilitation (the highest qualification issued through the process of a university examination) at the TU Wien, Austria. She was awarded a prestigious Elise-Richter fellowship, granted by FWF (Austrian Science Fund).

Among her research interests are control theory, stochastic optimisation in insurance, risk theory and pensions.

Title: Life And Non-Life Under Control

Abstract:
When considering a life or a non-life insurance portfolio, it is a natural wish to control and if possible to minimise the risk or to maximise the profit or to do both under a preference order. The spectrum of risk measures is wide and includes, for instance, value-at-risk, ruin probability, expected discounted cash flow, expected utility, Wasserstein distance.

In this talk, we consider several control problems in life and non-life insurance frameworks. The set of admissible controls is designed in line with the long-term aims of the insurer, incorporating, for example, a terminal distributional constraint on the insurer's surplus.
Our target is not necessarily to find a/the optimal strategy, minimising or maximising the chosen risk measure, but rather to reflect on the feasibility and fairness of the available controls.

Mario Wüthrich, ETH Zürich

Mario Wüthrich is Professor in the Department of Mathematics at ETH Zurich and Honorary Visiting Professor at Bayes Business School, City, University of London.

Mario is Study Director of Actuarial Science at ETH Zurich. He holds a PhD in Mathematics from ETH Zurich, he is fully qualified actuary, and he is Editor-in-Chief of ASTIN Bulletin.

Title: Auto-calibration and isotonic recalibration

Abstract:
Insurance pricing systems should fulfill the auto-calibration property to ensure that there is no systematic cross-financing between different price cohorts in the pricing system. Often, regression models are not auto-calibrated. We present the method of isotonic recalibration to a given regression model which gives us the auto-calibration property. As a nice side result we see that under a low signal-to-noise ratio, this isotonic recalibration step leads to explainable pricing systems because the resulting isotonically recalibrated regression functions have a low complexity.

Parallel Sessions 1

Hub	Hub 1					Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Non-Life and Discrimination-Free Pricing**	**InsurTech and FinTech**	**Credibility and Loss Modelling**	**Optimal Dividend**	**Ruin Theory I**	**Impact of Climate Risks I**	**Dependence I**	**Data Science Techniques in Life and Health**	**Mortality and Multi-State Modelling in Life Insurance**
Chair	*Mary Hardy*	*Runhuan Feng*	*Andrei Badescu*	*Jean-Francois Renaud*	*Stephane Loisel*	*Han Li*	*Alexander McNeil*	*Shu Li*	*Martin Bladt*
10.40 – 11.00	Nils Engler	Hong Chih Huang	Özenç Murat Mert	Paul Krühner	Eric Cheung	Elia Smaniotto	Liyuan Lin	Lucas Reck	Giovanna Bimonte and Maria Russolillo
11.00 – 11.20	Benxuan Shi	Muhsin Tamturk	Georgios Pitselis	Jean-Francois Renaud	Lea Enzi	Jinggong Zhang	Claude Lefèvre	Hyukjun Gweon	Atibhav Chaudhry
11.20 – 11.40	Munir Hiabu	Emiliano Valdez	Michael Klamser		Kira Henshaw	Alaric Müller	Dimitrios Konstantinides	Annika Schneider	Wenjun Zhu
11.40 – 12.00	Mary Hardy	Runhuan Feng	Andrei Badescu		Stephane Loisel	Han Li	Alexander McNeil	Shu Li	Martin Bladt

Parallel Sessions 2

Hub	Hub 1					Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Pensions and Annuities I**	**Longevity I**	**Pandemic and Mortality Modelling**	**Demographic Risk and Genetics**	**Solutions for Model Uncertainty**	**Portfolio Theory I**	**Pensions and Optimization I**	**Claim Count Modelling I**	**Dividend and Reinsurance**
Chair	*Moshe Arye Milevsky*	*Pietro Millossovich*	*Şule Şahin*	*Nan Zhu*	*Tak Kuen Siu*	*Vali Asimit*	*Servaas van Bilsen*	*George Tzougas*	*Ran Xu*
13.30 – 13.50	Marco Morales	Jens Robben	Joe Meagher	Francesco Della Corte	Jean-François Bégin	Urban Ulrych	Immacolata Oliva	Zezhun Chen	Daniela Escobar
13.50 – 14.10	Jonathan Ziveyi	Patrick Wong	Aasmund Hausken Sande	Oytun HACARIZ	Yunshen Yang	Kwok Chuen Wong	Elena Vigna	Despoina Makariou	Phuong Nguyen
14.10 – 14.30	Moshe Arye Milevsky	Pietro Millossovich	Şule Şahin	Nan Zhu	Tak Kuen Siu	Vali Asimit	Servaas van Bilsen	George Tzougas	Ran Xu

Parallel Sessions 3

Hub	Hub 1					Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Autocalibration in Non-Life**	**Telematics and Usage-Based Insurance**	**Probability and Extremes**	**Annuities I**	**Long Term Care Insurance**	**Reinsurance**	**Pensions and Optimization II**	**Mathematical Finance**	**Consequences of Practising Corporate Social Responsibility**
Chair	*Julien Trufin*	*Yi-Fan Chen*	*Phillip Yam*	*Catherine Donnelly*	*Leonie Le Bastard*	*Hanspeter Schmidli*	*Abraham Hernández-Pacheco*	*Oleksii Mostovyi*	*Philipp Büchner*
14.40 – 15.00	Julie Huyghe	Yu-Ying Tzeng	Oskar Laverny	Aleksandar Arandjelović	Wen-Yen Hsu	Alexandra B. de Moura	Gaurav Khemka	Hauke Stier	Leonard Gerick
15.00 – 15.20	Filip Lindskog	Pierre-Alexandre SIMON	Zhongyi Yuan	Sascha Günther	Aleksandr Shemendyuk	Emma Kroell	Enrico Biffis	Oleksii Mostovyi	Philipp Büchner
15.20 – 15.40	Julien Trufin	Yi-Fan Chen	Phillip Yam	Jianjie Shi	Leonie Le Bastard	Hanspeter Schmidli	Abraham Hernández-Pacheco		

Parallel Sessions 4

Hub	Hub 1					Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Data Science Techniques in Non-Life: Methodology I**	**Risk Capital Allocation**	**Risk Sharing**	**Climate Risk and Investment**	**Loss Modelling I**	**Health Insurance and Medical Expenses**	**Mortality Modelling**	**Optimal Control I**	**Pensions I**
Chair	*Mathias Lindholm*	*Silvana Pesenti*	*Mario Ghossoub*	*Stefan Trueck*	*Stephane Loisel*	*George Streftaris*	*Kenneth Zhou*	*Michel Vellekoop*	*Claudio Tebaldi*
16.10 – 16.30	Feng Zhou	Francesca Centrone	Michael Zhu	Pasin Marupanthorn	Simon Pojer	Alex Jose	Fabio Viviano	Ilaria Stefani	Barbara Sanders
16.30 – 16.50	Yevhen Havrylenko	Jiajun Liu	Ziwei Chen	Chi Truong	Lewis Ramsden	Andrey Ugarte Montero	Mengyi Xu	Shang-Yin Yang	Li Yang
16.50 – 17.10	Mathias Lindholm	Chong Yu	Fallou NIAKH	Stefan Trueck	Zijia Wang	Pei-Ying Chen	Xiaobai Zhu	Yuanyuan Zhang	Claudio Tebaldi
17.10 – 17.30		Silvana Pesenti	Mario Ghossoub			George Streftaris	Kenneth Zhou	Michel Vellekoop	

Parallel Sessions 5

Hub	Hub 1					Hub 2		
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01
Session Name	**Memorial Session for Ken Seng Tan**	**Climate Risk Management I**	**Risk Measures I**	**Stochastic Analysis**	**Ruin Theory II**	**Life Products Pricing and Investment**	**Statistics and Probabilistic Aspects of Insurance**	**Volatility and Option Pricing**
Chair	*Mary Hardy*	*Pietro Millossovich*	*Zinoviy Landsman*	*Stefan Thonhauser*	*Jae-Kyung Woo*	*George Zanjani*	*Giovanni Rabitti*	*Chih-Chiang Wu*
09.00 – 09.20	Mary Hardy	Kaveh Salehzadeh Nobari	Mücahit Aygün	Edit Rroji	Rui Cardoso	Mathias D. Plovst	Pierre-O Goffard	Sarath Kumar Jayaraman
09.20 – 09.40	Wei Wei	Samuel Asante Gyamerah	Akif Ince	Anatoliy Swishchuk	Dina Finger	Yongzhao Chen	Francesco Ungolo	Özge Tekin
09.40 – 10.00	JIAYUE ZHANG	Mélina Mailhot	Emanuela Rosazza Gianin	HIRBOD ASSA	Charles Minier	Peter Hieber	Timothy Johnson	Ling Wang
10.00 – 10.20	Yanbin Xu	Pietro Millossovich	Zinoviy Landsman	Stefan Thonhauser	Jae-Kyung Woo	George Zanjani	Giovanni Rabitti	Chih-Chiang Wu

Parallel Sessions 6

Hub	Hub 1					Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Impact of Climate Risks II**	**Discrimination-Free Pricing and Fairness**	**Reserving and Insurance Coverage**	**Stochastic Ordering and Risk Preferences**	**Mortality Cause of Death**	**Strategies for Public Pension Schemes**	**Reverse Mortgage**	**Machine Learning in Finance**	**Optimal Control II**
Chair	*Jose Garrido*	*Fei Huang*	*George Zanjani*	*Alfred Mueller*	*Torsten Kleinow*	*Jennifer Alonso-García*	*Sharon Yang*	*Thai Nguyen*	*Michel Vellekoop*
10.50 – 11.10	Anna Maria Fiori	Hong Beng Lim	Gabriele Pittarello	Félix Belzunce	YINYEE LEONG	Ivan Alexis Fonseca Diaz	Tianxiang Shi	Eva Verschueren	Chunli Cheng
11.10 – 11.30	Lisa Gao	Lorenzo Marchi	Marie Michaelides	Ozan Hur	Rabia Naqvi	Massimiliano Menzietti	Yung-Tsung Lee	Bowen Jia	Marina Di Giacinto
11.30 – 11.50	Peixin Liu	Andreas Tsanakas	Pradip Tapadar	Ki Wai Chau	Andrés Villegas	Zuochen Song	Sharon Yang	Thai Nguyen	Felix Fießinger
11.50 – 12.10	Jose Garrido	Fei Huang	George Zanjani	Alfred Mueller	Torsten Kleinow	Jennifer Alonso-García			

Parallel Sessions 7

Hub	Hub 1					Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Tontines**	**Pandemic Risk Pricing and Management**	**Data Science Techniques in Non-Life: Methodology II**	**Behaviour and Lapsing on Life Products**	**Optimal Control and Stopping**	**Cyber Risk Modelling I**	**Dependence II**	**Claim Count Modelling II**	**Pensions II**
Chair	*Carole Bernard*	*Mogens Steffensen*	*Giovanni Rabitti*	*Ko-Lun Kung*	*Hoi Ying Wong*	*Olivier Lopez*	*Alexandra Dias*	*Lluis Bermudez*	*Pradip Tapadar*
14.40 – 15.00	Doreen Kabuche	Cem Yavrum	Tsz Chai Fung	Jin-Lung Peng	Duo Xu	Stefano Chiaradonna	Christopher Blier-Wong	Spark Tseung	Morten Wilke
15.00 – 15.20	Arnold Shapiro	Daniel Linders	Oskar Laverny	Mario Marino	Josha Dekker	Petar Jevtic	Etienne Marceau	Xueyuan Wu	Pradip Tapadar
15.20 – 15.40	Carole Bernard	Mogens Steffensen	Carol Troy	Ko-Lun Kung	Hoi Ying Wong	Olivier Lopez	Alexandra Dias	Lluis Bermudez	

Parallel Sessions 8

Hub	Hub 1					Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	Wardlaw Room A/B	Carnegie Room B	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Climate Risk, Sustainability, and Economics**	**Data Science Techniques in Non-Life: Application**	**Risk Control and Mitigation**	**Reserving II**	**Portfolio Theory II**	**Variable Annuities**	**Mortality and Asset Dependence**	**Longevity II**	**Pensions III**
Chair	*Jing Yao*	*Peng Shi*	*Guo Liu*	*Boris Choy*	*Kwok Chuen Wong*	*Len Patrick Dominic Garces*	*Ayse ARIK*	*Hamza Hanbali*	*Barbara Sanders*
16.10 – 16.30	Laura Iveth Aburto Barrera	Lina Palmborg	Raphael Iten	Anas Abdallah	Ragnar Gudmundarson	Rosario Maggistro	Benjamin Roelants du Vivier	Mei Choi Chiu	Diba Daraei
16.30 – 16.50	Emanuele Vannucci	Mariaelisa Pelle	Alexander Voß	Sebastián Calcetero Vanegas	Zhenzhen Huang	Raghid Zeineddine	Nida Siddiqui	Hamza Hanbali	Chul Jang
16.50 – 17.10	Jing Yao	Peng Shi	Guo Liu	Boris Choy		Len Patrick Dominic Garces	Ayse ARIK		William Lim

Parallel Sessions 9

Hub	Hub 1			Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Climate Risk Management II**	**Data Science Techniques in Non-Life: Bayesian and Clustering**	**Reinsurance and Optimal Transport**	**Risk Measures II**	**Optimal Control III**	**Multi-State Modelling in Life Insurance**	**Loss Modelling II**
Chair	*Mathieu Boudreault*	*Patrick Laub*	*David Saunders*	*Emanuela Rosazza Gianin*	*Hansjörg Albrecher*	*Christian Furrer*	*Fraser Daly*
09.00 – 09.20	Fabio Bellini	Bavo D.C. Campo	Brandon García Flores	Silvia Faroni	Tak Wa Ng	Theis Bathke	Taehan Bae
09.20 – 09.40	Giuseppe Brandi	Charlotte Jamotton	Yuanying (Michelle) Guan	Corrado De Vecchi	Andrea Perchiazzo	Oliver Sandqvist	Meelis Käärik
09.40 – 10.00	Yue Shi	Yaojun Zhang	Seva Shneer	Zhanyi Jiao	Ming Qiu	Jorge Yslas	Fraser Daly
10.00 – 10.20	Mathieu Boudreault	Patrick Laub	David Saunders	Rodrigue Kazzi	Julie Bjørner Søe	Christian Furrer	Sergey Foss

Parallel Sessions 10

Hub	Hub 1			Hub 2			
Room	James Watt I	James Watt II Hall	Craig Room	EM 1.82	EM 1.83	CM G.01	CM S.01
Session Name	**Cyber Risk Modelling II**	**Neural Networks**	**Portfolio Theory III**	**Pensions and Annuities II**	**Pensions and Longevity**	**Mortality Data and Algorithms**	**Reserving III**
Chair	*Gabriela Zeller*	*Salvatore Scognamiglio*	*Andrea Molent*	*Catherine Donnelly*	*Kai Kaufhold*	*Karim Barigou*	*Matus Maciak*
10.50 – 11.10	Jaehun Cho	Yubo Rasmussen	Daniele Mancinelli	Thomas Bernhardt	Lukas Stake	Andres Barajas Paz	Michal Pesta
11.10 – 11.30	Marco Pirra	Xenxo Vidal-Llana	Zhiwei Tong	Yumin Wang	Luca De Mori	Guillaume Biessy	Gülçin Akarsu Şengöz
11.30 – 11.50	Gabriela Zeller	Salvatore Scognamiglio	Andrea Molent	Catherine Donnelly	Giovanna Apicella	Karim Barigou	Matus Maciak

Parallel Session Abstracts

(alphabetical by presenter surname)

Recurrent Neural Networks vs Copula Regression for Multivariate Loss Reserving and Risk Capital Analysis

Anas Abdallah
McMaster University

Non-life insurance companies consider reducing the risk of unpaid claims for long-term survival. In fact, the insurer must keep claim reserves for future payments based on the total loss reserve prediction. Still, few tools have been developed that integrate dependence between multiple business lines and quantify risk measures.

In this paper, we investigate the DeepTriangle method, a recurrent neural network (RNN) that models complex dependence between two lines of business. The main contribution of our work is the extension of this DeepTriangle model, so that we capture the dependence between business lines, and obtain the predictive distribution of the total reserve, which is very informative for actuaries. For this purpose, we will have recourse to Generative Adversarial Networks (GANs), as well as CopulaGANs. We show that the RNN models provide more flexibility than classical copula regression models.
We apply and calibrate these methods to a dataset from a major property-casualty insurer.

Co-authors:
Frank Cai, McMaster University
Pratheepa Jeganathan, McMaster University

Return to programme

A Systematic Literature Review on Sustainability Issues along the Value Chain in Insurance Companies and Pension Funds

Laura Iveth Aburto Barrera
University of Lausanne

Sustainability is a priority issue that governments, businesses and society must address in the short term. In their role as major global institutional investors and risk managers, insurance companies and pension funds are strategic players in building sustainable development. To gain a comprehensive understanding of the current state of action on ESG factors in the insurance and pension sectors, we conduct a systematic literature review. We analyze academic publications up to the year 2022 and refer to studies outside of scientific research. We introduce a classification framework along the insurance value chain including external stakeholders. The main findings reveal that underwriting and investment management are the most researched areas. Specifically for the environmental factor, further studies can be conducted on the impact of climate change-related risks on modelling, risk management, and solvency. Given the current nature of the sustainability challenges, this literature review is relevant to academics and practitioners alike.

Co-authors:
Joël Wagner, Professor, University of Lausanne, Switzerland

Return to programme

Time-varying Approach to Stochastic Reserve Prediction
Gülçin Akarsu Şengöz
Institute of Applied Mathematics, Middle East Technical University

Non-life reserve estimation is an essential concept of solvency structure for insurance and reinsurance companies. It contains two main components: premium reserve and risk (claim) reserve. Literature offers considerably different claim reserve methods, which are also developed by practitioners. Deterministic methods, such as Chain-Ladder (CLM) and Bornhutter-Ferguson, are the most common ones for claim reserve estimation, and development factors are the main tools for predicting the future value of claim reserves. Stochastic claim reserving is expected to be more robust to capture the uncertainty of the claim amounts. We implement a time-varying Geometric Brownian Motion model and CLM to predict the development factors and ultimate reserves. We compare the models' performances by backtesting applied to the liability insurance dataset.

Co-authors:
Prof. Dr. A. Sevtap Selçuk-Kestel, Institute of Applied Mathematics, Middle East Technical University

Return to programme

Guaranteeing the unsustainable: A framework for mixed pension schemes
Jennifer Alonso-García
Université Libre de Bruxelles

Public pension systems are usually financed on a pay-as-you-go (PAYG) basis where current contributions cover current pension expenditure. However, some countries combine funding and PAYG elements within the mandatory pension scheme. We aim to find funding strategies that allow for a liquid public pension scheme under a VaR constraint. A part of the funding returns is saved in a buffer fund, with the aim of absorbing future demographic and economic shocks that affect negatively the financial sustainability of the PAYG part.

Co-authors:
María del Carmen Boado-Penas, Heriot-Watt University
Julia Eisenberg, TU Wien

Return to programme

The Gender Longevity Gap: improving economic decisions through demographic literacy.
Giovanna Apicella
Department of Economics and Statistics, University of Udine

Women have historically experienced lower mortality rates than men. We study a measure of the gender gap in mortality rates, we call “Gender Gap Ratio”, for several ages and for four countries: France, Italy, Sweden and USA. We show the stylized facts that characterize the historical trend of the Gender Gap Ratio and obtain 10-years ahead future projections. Furthermore, we monetize the Gender Gap Ratio, in the framework of life annuities.
Against the same amount invested in a temporary life annuity, a Gender Gap Ratio between 1.5 and 2.5, depending on age and country, implies a reduction of up to 25% in the benefits for women with respect to men. In light of the crucial economic effects of longevity awareness, we advocate the importance to advance the level of demographic literacy among individuals and policy-makers.

Co-authors:
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Return to programme

Life cycle insurance and life annuity loads
Aleksandar Arandjelović
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We re-examine insurance purchases when life insurance and life annuities carry loads.
The life cycle literature says that it is optimal to participate in these insurance markets throughout life, even under loads.
A life annuity phase backs directly onto a life insurance phase.
However, the reason for this continuous participation turns out to be an implicit assumption that annuity loads are negative rather than positive.
Realistic examples with positive loads on both products reveal up to two distinct periods of non-participation, one in midlife and the other adjoining the maximum age.
We also investigate age-varying bequest motives whereby bequests are necessities during most of working life and luxuries during retirement.
Positive annuity loads and age-varying bequest motives together explain why a substantial demand for life insurance during working life can co-exist with negligible demand for life annuities.
A realistic 18 percent load on both products generates this outcome.

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Return to programme

The Impact of Simultaneous Shocks to Financial Markets and Mortality on Pension Buy-out Prices
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In this study we determine the fair value of a pension buy-out contract under the assumption that changes in mortality can have an impact on financial markets. Our proposed model allows for shocks to occur simultaneously in mortality rates and financial markets, so that strong changes in mortality rates can affect interest rates and asset prices. This approach challenges the common but very strong assumption that mortality and market risk drivers are independent. A simulation based pricing framework is applied to determine the buy-out premium for a hypothetical fully funded pension scheme. The results of an extensive sensitivity analysis show how buy-out prices are affected by changes in mortality and financial markets. Surprisingly, we find that the impact of shocks is similar whether or not these shocks occur simultaneously or not, although there are some differences in annuity prices and buy-out premiums.

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Return to programme

Pricing weather derivatives under volatility uncertainty for climate risks in Agriculture
Samuel Asante Gyamerah
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Weather derivatives have developed into a promising market-based risk financing solution for agricultural weather risk. However, most of the pricing approaches in weather derivatives are sensitive to model uncertainty, and this can be mitigated by making models more robust to volatility. The conventional method to mitigate the volatility in most conventional weather derivative models is to model the volatility of the underlying weather variable by a stochastic process. However, this method leads to model uncertainty. In this paper, we develop a new theoretical framework for modelling and pricing growing degree-day for weather derivatives under volatility uncertainty. The diffusion process of the underlying weather variable (temperature) is driven by a G-Brownian motion which represents the volatility uncertainty. In particular, we present a robust pricing method for growing degree-days indexed weather derivatives with a non-linear Brownian motion. Our pricing technique can be used to manage climate risk in the agricultural sector.

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Return to programme

Risk Budgeting, Diversification and Risk Optimisation
Vali Asimit
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Risk optimisation has been reconsidered in a portfolio selection set-up by Markowitz in 1952 and it has been ever since the cornerstone of modern finance. Various portfolio selection methods based on risk optimisation criteria have been proposed over the time, and a residual benefit is the diversification effect. More recently, risk budgeting methods have been considered in the literature as an effective risk management that a decision-maker uses to create a risk portfolio with a pre-determined risk profile; the residual effect of diversification could be observed for such risk budgeting methods as well. I will also discuss portfolio selection methods based on optimising the diversification effect and compare the three branches of portfolio selection based on real-life data, but also provide the theoretical background that underpins such methods.

Return to programme

Typological systematic models and their risk management
HIRBOD ASSA
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Departing from the existing models in the literature, which are either homogeneous or have no structure, this paper introduces typological systematic models that incorporate a structure on the pool's typology and consider both systematic and idiosyncratic shocks. The paper demonstrates different examples, discusses their properties, and examines their risk management through portfolio risk at infinity. It also proves an L^{1}-law of large numbers and provides an interpretation, as well as a universal rule for ex-post valuation, showcasing the expectation law's universality despite its simplicity.

Return to programme

Elicitability of Return Risk Measures
Mücahit Aygün
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Informally, a risk measure is said to be elicitable if there exists a suitable scoring function such that minimizing its expected value recovers the risk measure. In this paper, we analyze the elicitability properties of the class of return risk measures (i.e., monotone and positively homogeneous risk measures). First, we provide dual representation results for convex and geometrically convex return risk measures. Next, we establish new axiomatic characterizations of Orlicz premia (i.e., Luxemburg norms). More specifically, we prove, under different sets of conditions, that Orlicz premia naturally arise as the only elicitable return risk measures. We provide a general family of consistent scoring functions for Orlicz premia and a myriad of specific examples. Finally, we illustrate the applicability of our results to evaluating point forecasts and model performance by means of numerical simulations.

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Return to programme

Optimal reinsurance in a Cox Process
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We study the optimal reinsurance problem, from the ceding insurance company's perspective. The wealth of the cedent is modelled through a Cox process with a Poisson shot noise intensity for the claim arrivals, introducing dependencies between inter-arrival times. The inclusion of dependences, through externally excited jumps, on the number of claims process intensity allows to model the impact of external events such as climate risk triggered events or other catastrophes. The goal is the maximization of the expected utility of the insurer's wealth. The utility function is assumed to be non-decreasing, so that higher profit is preferred to lower profit, and concave, introducing risk aversion. Optimality conditions verified by the optimal reinsurance treaty are derived analytically and used to obtain numerical illustrations.

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Return to programme

A Credibility Index Approach for Effective a Posteriori Ratemaking with Large Insurance Portfolios
Andrei Badescu
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Credibility in insurance relies on Bayesian models to determine premiums that account for policyholders' attributes and claim history. Most data-driven Bayesian models don't have closed-form expressions, and therefore credibility premiums are obtained via numerical methods e.g MCMC. However, such methods can be computationally expensive and prohibitive for large insurance portfolios. Similarly, these are "black-box" procedures as there is no expression linking the claim history and the upgraded premiums. Here , we propose a methodology to derive a closed-form expression to compute credibility premiums for a Bayesian model. We do so by introducing a credibility index, an efficient summary statistic of the claim history of a policyholder, and illustrate how to use it as the main input to approximate any credibility formula. The closed-form solution can reduce the computational burden of a posteriori ratemaking for large portfolios via the principle of surrogate modelling, and provides a transparent interpretation of credibility premiums.

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Return to programme

A weighted Lognormal mixture as a robust alternative to Erlang mixture for modeling left-truncated loss data
Taehan Bae
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The Erlang mixture with a common scale parameter has been one of many popular models for modeling insurance losses. However, some limitations of this model to approximate heavy-tailed distribution have already been recognized and discussed in the actuarial literature. As a robust alternative to the Erlang mixture for modeling left-truncated insurance losses with a heavy tail, we propose a weighted truncated Lognormal mixture. Some theoretical properties such as the weak-denseness and the tail behavior, and a regularized EM algorithm with Shannon's entropy for parameter estimation, will be discussed. An application of the proposed model on six real data sets related to Norwegian Fire losses will be illustrated.

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Return to programme

Age heaping in population data of emerging countries
Andres Barajas Paz
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Mortality analyses have commonly focused on countries represented in the Human Mortality Database that have good quality mortality data. In this paper, we address the challenge that, in many countries, population and deaths data can be somewhat unreliable. In many countries, for example, there is signi cant misreporting of age in both census and deaths data: referred to as \age heaping". The purpose of our research is to develop Bayesian computational methods for fi tting a new model for misreporting of age for countries where their population data and death counts have been affected by age heaping. The innovation of our model is that it allows us to detect misreporting, identify age preferences and estimate the true underlying distribution of ages.

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Return to programme

Gaussian Process-Based Mortality Monitoring using Multivariate Cumulative Sum Procedures
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This paper presents a multivariate cumulative sum (MCUSUM) procedure to detect changes in mortality intensity, which plays a critical role in risk management for insurance companies and pension funds. The MCUSUM algorithm is built on Gaussian process-based non-parametric mortality forecasts and tracks differences between predicted and realized mortality rates in real-time. Unlike univariate methods, the MCUSUM accounts for interdependence between age-groups and provides a more comprehensive analysis of mortality trends. The efficacy of the MCUSUM method is demonstrated through a comparison to univariate control charts and a case study of recent mortality data in France, Japan, Canada, and the USA.

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Return to programme

Two-dimensional forward and backward transition rates
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Forward transition rates were originally introduced with the aim to evaluate life insurance liabilities market-consistently. While this idea turned out to have its limitations, recent literature repurposes forward transition rates as a tool for avoiding Markov assumptions in the calculation of life insurance reserves. While life insurance reserves are some form of conditional first-order moments, the calculation of conditional second-order moments needs an extension of the forward transition rate concept from one dimension to two dimensions. Two-dimensional forward transition rates are also needed for the calculation of path-dependent life insurance cash-flows as they occur upon contract modifications. Forward transition rates are designed for doing prospective calculations, and by a time-symmetric definition of so-called backward transition rates one can do retrospective calculations.

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Return to programme

Ensemble Economic Scenario Generators: Unity Makes Strength
Jean-François Bégin
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Over the last 40 years, various frameworks have been proposed to model economic and financial variables relevant to actuaries. These models are helpful but searching for a unique model that gives optimal forecasting performance can be frustrating and ultimately futile. This study therefore investigates whether we can create better economic scenario generators by combining them. We first consider eight prominent economic scenario generators and apply Bayesian estimation techniques to them, thus allowing us to account for parameter uncertainty. We then rely on predictive distribution stacking to obtain optimal model weights that prescribe how the models should be averaged. An empirical study based on three economies is performed. We find that the optimal weights change over time and differ from one economy to another. The out-of-sample behaviour of the ensemble model compares favourably to the other eight models. Creating ensembles is thus beneficial from an out-of-sample perspective.

Return to programme

A methodology for generating multivariate climate risk scenarios
Fabio Bellini
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We propose a methodology for generating multivariate extreme weather scenarios regarding temperature, precipitations and winds, that are among the main components of climate risk. Following the lead of McNeil and Smith (2012) we construct multivariate scenario sets by means of depth functions, that are a flexible tool for identifying central regions of non-elliptical distributions introduced in Tukey (1975). Some classes of depth functions are strictly related to univariate risk measures; we consider in particular the Tukey depth, the zonoid depth (see e.g. Mosler, 2002) and the recently introduced expectile depth (Cascos and Ochoa, 2021).
The empirical analysis is based on the dataset underlying the computation of the European Extreme Events Climate Index, developed following a methodology similar to the Actuarial Climate Index, that is widely applied in the actuarial literature (see e.g. Li and Tang, 2022).

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Return to programme

Testing a new stochastic dominance criterion for dependent random variables
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In this paper we present a new statistical tool for the comparison of paired data based on a new criterion of stochastic dominance that takes into account the dependence structure of the random variables under comparison. This tool provides an alternative to the usual stochastic dominance criterion which only considers the marginal distributions in the comparison. We show how this new tool can be fruitfully used for the comparison of paired asset returns.

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Return to programme

Bivariate random effects models to allow for time and cross dependence assumptions between claim counts

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In recent years, insurers have accumulated longitudinal information on their policyholders. A growing body of literature has developed panel count data models to fit this kind of data, allowing for time dependence, and random effects models have been showed as the best option for computing the next year's premium. In parallel, another body of literature has developed count data models to account for cross dependence between types of claims. To consider both the correlation between claims from two coverage types and the serial correlation between the observations of the same policyholder over time, some bivariate random effects models are presented. Starting from a bivariate Poisson regression model, different random effects assumptions are introduced to allow for time dependence and overdispersion. These models are applied to an automobile insurance claims data set to compare them and analyse the consequences in ratemaking.

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Return to programme

Smart Contract Tontine

Carole Bernard
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When entering into a tontine, the value of the tontine for the participant highly depends on its composition. However, participants typically subscribe to the scheme without any knowledge of either the composition of the tontine, or even its exact payout scheme. Herein, we quantify the value of this information using a theoretical approach that allows us to obtain bounds on the value of a tontine subject to uncertainty on certain characteristics. Thereafter, we propose a smart contract that offers full disclosure of information in a tontine. We discuss the practical implementation of such a tontine and some new risks that it could face.

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Return to programme

Subsidising small pooled annuity funds with temporary annuities
Thomas Bernhardt
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Pooled annuity funds adjust the income of its members with observed mortality rates to cope with the uncertainty of life expectancy while keeping solvency capital low. However, even if we ignore systematic mortality and financial risks, there is still considerable volatility in the payments to its members. That is, in particular, an issue for funds in their infancy when the number of members is initially a few hundred people. We consider temporary annuities to control the volatility within those funds and analyse how the need for those phases out over time. We show the need to control the volatility for a long time until the fund reaches a critical number of people.

Return to programme

Revisiting Whittaker-Henderson Smoothing
Guillaume Biessy
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Introduced a century ago, Whittaker-Henderson (WH) smoothing remains as of today widely used among actuaries to build both unidimensional and bidimensional decrement tables for mortality and other biometric risks. This presentation aims at revisiting WH smoothing from a modern statistical perspective and tackles 5 related questions of special practical relevance.
First, enlighten the choice of the observation and weight vectors to which WH smoothing should be applied when building a decrement table, by connecting it to a maximum likelihood estimator introduced in a survival analysis framework. Second, adopt a bayesian interpetation of WH smoothing to obtain credibility intervals around its results. Third, cover selection of smoothing parameters, relying on maximisation of the restricted maximum likelihood. Fourth, improve numerical performances in cases where the number of observations, and therefore parameters, becomes overwhelming. Finally, extrapolate the results of WH smoothing while maintaining the consistency between fitted and extrapolated values.

Return to programme

Wage Rigidity and Retirement in Optimal Portfolio Choice
Enrico Biffis
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We study an agent's lifecycle portfolio choice problem with stochastic labor income, borrowing constraints and a finite retirement date. Similarly to [8], wages evolve in a path-dependent way, but the presence of a finite retirement time leads to a novel, two-stage infinite dimensional stochastic optimal control problem, which we fully solve obtaining explicitly the optimal controls in feedback form. The identification of the optimal feedbacks is more delicate than in [8] due to the two-stage structure and to the presence of time-dependent state constraints, which appear to be new in the infinite dimensional stochastic control literature. The explicit solution allows us to study the properties of optimal strategies and discuss their implications for portfolio choice.

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Return to programme

Combining mortality forecasting by using the Shapley value
Giovanna Bimonte & Maria Russolillo
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Mortality is a dynamic process and actuaries need appropriate tools to forecast future longevity. The accurate modelling and projection of mortality rates and life expectancy represent an issue of great interest in the actuarial literature. Starting from the assumption that any procedure for projecting mortality begins with a careful analysis of past trends, recent studies find that stochastic mortality models are sensitive to the fitting period and forecast horizon. Our objective is to compare the prediction accuracy between single model-based forecasts and the proposed model averaging method by using a novel approach to the assembled model selection.
In particular, we consider an optimal weights scheme based on the Shapley value to capture the marginal contribution of each forecast; to rank the models and construct the conditional forecast combination; to compare the obtained result with the forecasts from time series models, highlighting the strengths and weaknesses of the new approach.

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Return to programme

Conditional Aalen-Johansen estimation
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Aalen-Johansen estimation targets transition probabilities in multi-state Markov models subject to right-censoring. In particular, it belongs to the standard toolkit of actuaries specializing in health and disability insurance. We introduce for the first time the conditional Aalen-Johansen estimator, an innovative kernel-based estimator that allows for the inclusion of covariates and, importantly, is also applicable in non-Markov models. We establish uniform strong consistency and asymptotic normality under very lax regularity conditions; here, the theory of empirical processes plays a central role and leads to a transparent treatment. We also illustrate the practical implications and potential of the estimation methodology.

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Return to programme

Risk aggregation with Bernstein copulas
Christopher Blier-Wong
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This talk presents new results on risk aggregation when the dependence structure is a Bernstein copula. Bernstein copulas are a flexible family of copulas. Indeed, they are often used for non-parametric estimation. We provide expressions for the moments of aggregate random variables in terms of the order statistic moments of their marginals. When risks are mixed Erlang random variables, we show that the aggregate distribution is also mixed Erlang and develop convenient methods to compute the new parameters. We consider subfamilies of Bernstein copulas that exhibit desirable dependence structures for insurance risks. We study the minimal and maximal dependence within the family of Bernstein copulas and study the effect of dependence on the resulting aggregate risk. We also develop allocation rules for conditional mean risk-sharing and Euler-based TVaR allocation.

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Return to programme

From climate models to financial risk management: applications to flooding in Canada and the United States

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With mounting pressure coming from regulators and other bodies worldwide, the financial services industry will soon need to disclose and stress-test their solvency and profitability to various climate scenarios. Physical risk assessment of the impacts of climate change remains however an important challenge for the (re)insurance industry and the actuarial profession. Bridging gaps between actuarial and climate sciences is therefore essential to increase resilience of the (re)insurance industry.
In this presentation, we introduce a top-down catastrophe modeling framework founded on climate models to quantify the impacts of climate change at a meaningful spatial and temporal resolution. We present models for fluvial and pluvial flooding over Canada and the United States, blending statistical and machine learning with regional climate models. We analyze different insurance portfolios over various future time horizons and find losses should increase significantly for pluvial flooding whereas it is much less clear for fluvial flooding.

Return to programme

Unsupervised model selection in climate stress testing

Giuseppe Brandi
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We consider hot model bias in climate risk projections and its impact on stress testing exercises. We study unsupervised approaches to climate model selection to address such bias and show how they translate into constraints on structural model parameters. The approach is shown to be most effective when downscaling projections to spatial resolutions of interest to market participants, as constraints are shown to require considerable customization. The economic importance of the results is demonstrated with reference to benchmark portfolios of exposures in Southeast Asia.

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Return to programme

Corporate Social Responsibility: How much investment is optimal?
Philipp Büchner
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Corporate Social Responsibility (CSR) becomes an increasingly important topic for firms. While there have been many empirical studies which find a positive relationship between financial success and social responsibility, there are very few studies which examine the theoretical impact of CSR expenditures on the value of a firm. In the present paper, we explicitly incorporate the influences of the CSR investment on the firm's asset and liability process, and consequently the default mechanism. In a continuous time setting, we aim to quantify the impact of CSR investment on the benefits of a firm's equity and debt holders and find conditions under which the positive long-term effects of a CSR engagement outweigh the forgone profits in early periods. Consequently, we aim to determine the optimal CSR investment which enhances the firm's value.

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Return to programme

Claim Reserving via Inverse Probability Weighting: The Micro-Level Chain-Ladder.
Sebastián Calcetero Vanegas
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Claim reserving is primarily accomplished using macro-level or aggregate models, with the Chain-Ladder method being the most popular one. However, these methods are heuristically constructed, rely on oversimplified data assumptions, neglect the heterogeneity of policyholders, and so lead to a lack of accuracy. In contrast, micro-level reserving leverages granular information for improved predictions, but usually comes at the cost of more complex models that are unattractive for practitioners. In this talk, we introduce a novel framework for claim reserving by viewing it as an inference problem in survey sampling. We propose a simplistic and practical approach to aggregate reserving using inverse probability weighting techniques, enabling the integration of policyholder attribute information in the same manner as propensity scores. The framework provides a statistically sound method for aggregate claim reserving, including Chain-Ladder-based methods as a special scenario, while also incorporating the capability to utilize granular information, like in a micro-level model.

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Return to programme

On clustering levels of a hierarchical categorical risk factor
Bavo D.C. Campo
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Handling hierarchically structured nominal covariates with a large number of categories is challenging for both statistical and machine learning techniques. We commonly rely on methods such as the random effects approach to incorporate these covariates in our predictive model. Nonetheless, in certain situations, even the random effects approach results in estimation problems. We propose the data-driven Partitioning Hierarchical Risk-factors Adaptive Top-down (PHiRAT) algorithm to reduce the hierarchically structured risk factor to its essence, by grouping similar categories at each level of the hierarchy. We work top-down and we engineer several features to characterize the risk profile of the categories at a specific level in the hierarchy. These features are used as input in a clustering algorithm to group similar categories. Our method substantially reduces the number of categories and results in a grouping that is generalizable to out-of-sample data. Moreover, we obtain a better differentiation between high-risk and low-risk companies.

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Return to programme

Numerical calculation of finite-time ruin probabilities in the dual risk model
Rui Cardoso
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In the dual risk model the ultimate ruin probability has an exact and simple formula, but, as usual, for finite time horizon, mathematics are much more complicated and the literature on this topic is scarce. Therefore, numerical approximations are calling for. For this purpose, we developed an algorithm by adapting the methodology described in Cardoso and Egídio dos Reis (2002), which was successfully applied for several risk models, e.g. Cardoso and Waters (2003) and Cardoso (2014), by means of discrete-time Markov chains and allowing to consider several distributions for the amount of individual earnings without major changes. We also adapted the methodology developed by De Vylder and Goovaerts (1988). Both algorithms give the same numerical values.
We work out some examples building approximate values for the density of the time to ruin and we compare, in the long run, our approximations with the exact values for the ultimate ruin probability.

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Return to programme

Capital allocation rules and generalized collapse to the mean
Francesca Centrone
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In risk management, a key problem consists in deciding how to share the capital to be allocated among different business lines of a risky activity: this implies the definition and axiomatic study of capital allocation rules (CARs) induced by a risk measure. A well-known CAR is the Gradient allocation, that, intrinsically, assumes Gateaux differentiability of the underlying coherent risk measure. In this case, the CAR ''collapses to a mean", that is, it reduces to the expectation w.r.t. the Gateaux derivative. Under conditions weaker than differentiability, the Gradient allocation has been generalized by means of the subdifferential capital allocation, also in (quasi)convex setting.
We investigate conditions under which a CAR reduces to an expectation w.r.t a suitable probability measure or, better, to the subdifferential allocation, thus extending a well known result for Gateaux differentiable risk measures. Our results can be seen as a generalized collapse to the mean (involving a probability measures not necessarily coinciding with the one given a priori).

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Return to programme

Comparative Risk Aversion vs. Threshold Choice in the Omega Ratio
Ki Wai Chau
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In this paper, we study conditions under which the threshold parameter in the Omega ratio represents risk aversion in the sense of monotonicity of risk premia. To this end, we derive asymptotic expansions for risk premia associated with taking a small additional risk on top of a background risk. These risk premia have the expected monotonicity behavior if the variance of the additional risk decreases with the background risk and if the density of the background risk is log-concave. When these conditions are violated, the threshold in the Omega ratio does not represent risk aversion in general. Finally, we compare our sufficient conditions for the Omega ratio to those needed to guarantee the monotonicity of risk premia with an expected utility criterion under background risk. We argue that the conditions required for the Omega threshold to represent risk aversion are comparable to those of exponential utility functions.

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Return to programme

Modelling Mortality Dependence with Time Series Vine-Copulae - A unified Approach for Serial and Cross-correlation

Atibhav Chaudhry
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Time series vine copulas, which can handle non-linearity and asymmetry in the serial and cross-dependence of multivariate time series, have been found to have superior forecasting performance for financial data compared to the widely used Vector Autoregressive (VAR), ARIMA-vine-copula, and Sparse VAR approaches. This paper explores the application of time series vine copulas in mortality dependence modelling. We consider four types of time series vine copulas: multivariate S-vine, M-vine, D-vine, and Stationary-COPAR. We assess the suitability of these models for mortality data and demonstrate the estimation and forecasting process. We also simplify the estimation process for the Stationary-COPAR model. Our results indicate that time series vine copulas often provide more accurate mortality forecasts than VAR, Sparse VAR, and ARIMA-vine-copula. Furthermore, we show that the complex dependence structure captured by the time series vine copulas can significantly impact the pricing of a longevity bond similar to KORTIS.

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Return to programme

The Valuation of Lifetime Critical Illness Insurance Policies with Limited Coverage

Pei-Ying Chen
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Insurance companies currently use a traditional actuarial approach and rely on expected value to determine the premium for lifetime health insurance policies with restricted coverage. Yang, Wang, and Huang (2016) proposed a theoretical framework for evaluating fair premiums for these types of policies. They found the conventional actuarial pricing method can cause significant overpricing issues when the coverage limit is not very low or very high. This study focuses on the regular premium case of lifetime critical insurance policies with limited coverage. For the regular premium case, we discovered that the overpricing issue persists when the coverage limit is low, but it disappears as the coverage limit increases and eventually transitions to underpricing.

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Return to programme

How to Encourage Customers Purchase Usage-based Auto Insurance? - Evidence from Taiwan Market

Yi-Fan Chen
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Usage-based insurance (UBI) can apply valuable information collected by drivers into insurance product design, which can also mitigate the asymmetric information problem in auto insurance market. Despite all the advantages from a theoretical and practical point of view, the UBI insurance market in Taiwan has never been able to get off the ground. In this study, we focus on the consumers' incentive of willing to buy UBI products and related privacy issues. We investigate the tradeoff between concerns about privacy and the premium discount. Using the data from Taiwan's market, our empirical results indicate that insurance companies should increase the premium discount to attract consumers or reduce the consumer concerns about their private information. However, the effect of lowering premiums by UBI insurances are not enough to the consumers. Based on our results, we also suggest that product design of UBI products can focus on unconcealed information of drivers.

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Return to programme

Valuation of GMxB with Equity-dependent Lapse

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Guaranteed Minimum Benefit (GMxB) contracts are currently a popular class of variable annuities on the market, and are sold by many companies in the industry. In pricing these products, It is important yet mathematically difficult for insurers to incorporate the important factor of policyholders' lapse behavior, among other realistic factors such as stochastic interest rates. Indeed, the resulting pricing formula includes path-dependent integrals, rendering closed-form solutions unavailable; the most commonly adopted numerical approach in this case is the well-known Monte Carlo method, yet it is known to be extremely time-consuming. In this work, we shall overcome this increased difficulty by computing the Laplace transform of the terms in the pricing formula via an ODE approach, and applying inverse Laplace transforms to numerically obtain the price. This approach is time-efficient since it does not rely on the sample path, and can also be conveniently rerun upon modifications in model parameters.

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Return to programme

Multivariate zero-inflated INAR(1) model with an application in automobile insurance

Zezhun Chen
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The aim of this paper is to propose a multivariate INAR(1) model for addressing all the challenges in high-dimensional non-life claim count data sets that exhibit time and cross dependence and a zero-inflation attribute. In particular, the innovation terms are modelled using a multivariate zero-inflated Poisson distribution or a multivariate zero-inflated hurdle Poisson distribution which can handle extra zeros in the data. Furthermore, the proposed modelling framework can take into account the influence of individual and coverage-specific covariates on the mean parameters of each model which enables the calculation of tailored made insurance premiums according to different risk profiles. Maximum likelihood estimation of the model parameters is achieved through a novel Expectation-Maximization algorithm which is demonstrated to perform satisfactorily when we exemplify our approach on the European Motor Third Party Liability claim count data.

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Return to programme

Optimal insurance model with multiple risk environments

Ziwei Chen
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This talk is about an insurance model with multiple risk environments from the insurer's point of view. The insurer orders its risk preferences via Value-at-Risk (VaR) or Conditional Value-at-Risk (CVaR) and adopt a premium principle satisfying some general assumptions. This setting allows us to reduce the infinite dimensional optimisation problem to a finite one, which can be solved using would require numerical optimisation. Characterising the shape of the complex risk transfer that is optimal from the insurance point of view, i.e. a layer type indemnity for each environment, and but also provide and interpret the optimal contracts by using some real-life insurance data.

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Return to programme

Reference Health and Investment Decisions
Chunli Cheng
Lingnan College, Sun Yat-sen University

This paper considers how reference health influences medical spending and decreasing health and their interaction with consumption and investment choices. We focus on the reference point's adaptiveness in a dynamic model of an agent facing a series of health shocks in a continuous-time optimal control framework. The agent trades off current consumption against out-of-pocket medical costs and the expected lifetime utility stream while optimizing portfolio composition. While a static reference point implies heavy medical spending, an adaptive reference health reduces medical spending while boosting consumption, assets and, lifetime utility. Furthermore, failure to anticipate the adaptive reference health, that is, a projection bias, induces consumption and investment choices to fall between the ones for static and adaptive reference health with anticipation.

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Return to programme

Cumulative Parisian ruin in finite and infinite time horizons in a renewal risk process
Eric Cheung
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In this presentation, we consider the cumulative Parisian ruin problem in a renewal risk model with general interclaim times and exponential claims, where the cumulative Parisian ruin time is the first time the total time spent by the surplus process below level zero exceeds a certain time length. The infinite-time cumulative Parisian ruin probabilities are derived under a deterministic Parisian clock and under an Erlang clock, where the latter case can also serve as an approximation of the former. The finite-time cumulative Parisian ruin probability is subsequently analyzed when the time horizon is another Erlang random variable. Our formulas can be easily applied in numerical examples where the interclaim times follow gamma, Weibull, or Pareto distribution. We demonstrate that the choice of the interclaim distribution does have a significant impact on the cumulative Parisian ruin probabilities when one deviates from the exponential assumption.

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Return to programme

Framework for Cyber Risk Loss Distribution of Multi-Tenant Smart Building Networks: A Bond Percolation Approach

Stefano Chiaradonna
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In 2021, fires caused over $40 billion in property damages to commercial and residential buildings in the United States. To reduce such catastrophic losses and mitigate future risks, increasingly networked Internet of Things (IoT) devices and sensors, such as smart fire alarms and smoke detectors, are being deployed across these building environments. This creates novel cyber-physical environments whose deployment further exposes the buildings to disastrous cyber risks. For example, cyber-attacked IoT devices, such as fire alarms, may become defective, resulting in the inability to prevent fires from causing catastrophic financial damages. To assess potential losses in these new environments, we propose a structural framework of an aggregate loss distribution for the cyber risk of a multi-tenant smart building network. We contextualize the problem in the appropriate probabilistic graph-theoretical framework and use a bond percolation model to compute the mean and variance of the aggregate loss distribution relevant to insurance pricing.

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Return to programme

Equilibrium longevity hedging with long-range dependent cointegration

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Empirical studies with publicly available life tables identify long-range dependence (LRD) in national mortality rates. While the longevity market is supposed to benchmark against the national mortality rate, an insurer concerns more on that associated with her portfolio. When two mortality rates are cointegrated, the longevity hedging strategy should take LRD and cointegration of mortality rates into account. This paper studies an equilibrium longevity hedging problem with this background in mind. A two-dimensional Volterra process is adopted to capture LRD and cointegration between the insurer's experienced mortality and the national mortality rates. We show that the LRD-cointegration offers an economic rationale for modeling mortality rate with a mixed fractional Brownian motion of the Riemann–Liouville type. The open-loop equilibrium hedging strategy is explicated obtained and the uniqueness of the strategy is investigated. Our numerical studies examine the effect of cointegration with LRD on the longevity hedging strategy.

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Return to programme

Firm size and industrial heterogeneity in cyber risks: An application with the Lee and Carter model
Jaehun Cho
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In this study, we investigate the impact of firm size, industry, and time on cyber risk frequency and severity by using the Lee and Carter (L-C) model. Using a large data set of cyber risk, we find that large organizations and those in the financial, information, and public sectors are more exposed to cyber risks and that mostly the frequency and severity of cyber risks increase over time. The findings support evidence of the literature and the results offer a new approach to improving cyber risk modeling by applying a mortality model to the study of cyber risk. Our approach can help to better understand the longitudinal effects of firm-specifics and time on cyber risk.

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Return to programme

A class of non-elliptical probability distributions and its applications in stochastic loss reserving
Boris Choy
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A class of non-elliptical multivariate probability distributions is proposed. These distributions are derived from the mean-variance mixtures. They are heavier-tailed than the multivariate normal distribution and offer very flexible kurtosis. Pairwise linear correlation coefficients can be derived analytically. The mean-variance mixture of the probability density function allows effective model implementation using Markov chain Monte Carlo and expectation-maximization algorithms, identification of potential outliers and protection of statistical inference from the distorting effect of the outliers. In the empirical study, loss data in the form of multiple run-off triangles are modelled using this class of non-elliptical error distributions. It is shown that this class of non-elliptical distributions outperforms its elliptical counterparts in stochastic loss reserving.

Return to programme

Central limit theorem and related results for the aggregation of equally correlated claims
Fraser Daly
Heriot-Watt University

Let Y be an aggregated claim, made up of a sum of exchangeable individual claims which are independent of the random number of claims N. Classically, the individual claim amounts are assumed to be independent, in which case central limit theorems and other distributional approximation results for Y are well known. However, this assumption of independent claims may be unrealistic in some applications. We relax this restriction, instead assuming that these random variables come from a generalized multinomial model which interpolates between the independent and comonotone settings via a correlation parameter. In this setting, we prove error bounds in Gaussian, Gamma and Poisson approximations for Y which allow us to investigate the effect of this correlation parameter on the quality of the approximation, while also providing competitive bounds in the special case of independent claims. Proofs make use of Stein's method in conjunction with size-biased and zero-biased couplings.

Return to programme

A ruin-theory approach to model safe withdrawal rate for retirees
Diba Daraei
Department of Statistical and Actuarial Sciences, Western University

Due to the significance of being able to cover living expenses after retirement as well as the quality of life in retirement, it is crucial for people to be aware of how long their savings will last. In this study, we use a ruin-theory approach to model the outflows and inflows of retirees' investments. We analyze transactional data that are available to the Canada's Financial Wellness Lab from a registered investment provider.
We use advanced ruin-theory models to calculate the probability that retired clients run out of funds during their lifetime, the expected time of such an event in case it occurs, and a safe withdrawal rate, considering the average lifespan of men and women in Canada. In the final phase of this work, we compare the outcomes of our proposed withdrawal rate with a few other widely used approaches for spending during retirement.

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Return to programme

Multi-population Mortality Forecasting: a Model Averaging approach
Luca De Mori
Bayes Business School

The analysis of the evolution of life expectancy, both at birth and at retirement age, is extremely important for the insurance sector and pension funds, due also to the systematic trend in mortality rates (longevity risk). Over the last few decades, many models for mortality forecasting have been introduced. In this paper, we consider some of the most significant multi-population mortality models and compare some model averaging approaches: equal weights, weights based on past performance, and on trimming. These approaches allow to obtain forecasts for life expectancies, or other longevity metrics, consistently for different populations significantly stabilizing the predictions and avoiding large forecasting errors. We assess the performance of both the multi-population models and the model averaging approaches on mortality data, extracted from the HMD database, of males and females in 10 different countries.

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Return to programme

Risk bounds under tail uncertainty
Corrado De Vecchi
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We study upper and lower bounds for the values that a spectral risk measure can attain when there is uncertainty regarding the probability distribution of large losses. Starting with the case in which only the lower tail of the random variable of interest is known, we gradually add information on the moments of the distribution, up to the second. For all cases considered, we provide closed-form bounds and we discuss their sharpness. An important aspect of our analysis is showing that while the sole knowledge of the lower tail leaves unbounded a spectral risk measure, a joint assumption on the lower tail and on the first two moments of the distribution can lead to a significant improvement of the worst-case scenario, with respect to the standard case, studied in Li (2018), in which only the mean and the variance are fixed.

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Return to programme

Optimal Stopping with Stochastic Exercise Opportunities
Josha Dekker
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Motivated by asset-liquidity spirals, we analyse optimal stopping problems in which opportunities to exercise an option are stochastically constrained and the option's underlying asset price and the occurrence of exercise opportunities are interrelated.

We introduce a model with Hawkes optional stopping times (HOST) designed to allow for a variety of feedback effects between the asset price process and the process that generates the exercise opportunities.

We derive some analytic properties of the corresponding value function and optimal stopping times. We recast the problem into a discrete time framework, for which we need to modify existing algorithms such as the Longstaff-Schwartz algorithm to obtain prices.

We find in numerical examples that there are premia paid on market frictions for these options which can be decomposed into two components stemming from average market frictions and from the extent of stochastic variation in market frictions.

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Return to programme

A cohort-based Partial Internal Model for demographic risk
Francesco Della Corte
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We investigate the quantification of demographic risk in a framework consistent with the market-consistent valuation imposed by Solvency II. We provide compact formulas for evaluating inflows and outflows of a portfolio of insurance policies based on a cohort approach. In this context, we maintain the highest level of generality in order to consider both traditional policies and equity-linked policies: therefore, we propose a market-consistent valuation of the liabilities. Therefore, we evaluate the Solvency Capital Requirement of idiosyncratic risk, linked to accidental mortality, and the systematic risk one, also known as trend risk, proposing a formal closed formula for the former and an algorithm for the latter. We show that accidental volatility depends on the intrinsic characteristics of the policies of the cohort (Sums-at-Risk), on the policyholders age and on the variability of the sums insured; trend risk depends both on accidental volatility and on the longevity forecasting model used.

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Return to programme

An infinite dimensional stochastic control framework for optimal execution
Marina Di Giacinto
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In this paper, we solve a problem left open by Di Giacinto, Tebaldi, and Wang (2022) and characterize the optimal execution in a financial market populated by a continuum of heterogeneous market makers, that have limited inventory-carrying and risk-bearing capacity. The investor maximizes their profits in the presence of the uncertainty of order fills empirically observed in Carmona and Leal (2021). Within this framework, we show that the optimal execution can be modeled as an infinite dimensional linear-quadratic stochastic optimal control problem. The problem is studied by applying the dynamic programming method. The value function and the associated optimal trading strategies can be obtained semi-explicitly by solving an operator Riccati equation and using a verification-type argument. The additional flexibility added by considering this limiting case is shown to be necessary to characterize optimal execution strategies in empirically relevant cases.

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Return to programme

Maximum pseudo-likelihood estimation in copula models for small weakly dependent samples
Alexandra Dias
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Maximum pseudo-likelihood (MPL) is a semiparametric estimation method often used to obtain the dependence parameters in copula models from data. It has been shown that despite being consistent, and in some cases efficient, MPL estimation can overestimate the level of dependence especially for small weakly dependent samples. We show that the MPL method uses the expected value of order statistics and we propose to use instead the median or the mode of the same order statistics. In a simulation study we compare the finite-sample performance of the proposed estimators with that of the original MPL and the inversion method estimators based on Kendall's tau and Spearman's rho. Our results indicate that the modified MPL estimators, especially the one based on the mode of the order statistics, have better finite-sample performance, while still enjoying the large-sample properties of the original MPL method.

Return to programme

Pooled annuity funds: a solution to the DC decumulation crisis?
Catherine Donnelly
Heriot-Watt University

Pooled annuity funds aim to provide their participants with a lifelong income in retirement. They do this by pooling the participants' longevity risk directly with each other. Concretely, this means that the funds of those who have died are shared out among the surviving participants. This provides the survivors with an additional return on top of their investment return. Consequently, the survivors can withdraw a higher income than if they didn't pool longevity risk together.
To operate one of these funds in practice, some basic questions need answered. How many participants are needed to adequately pool longevity risk? Should the fund be open or closed to new members? Does the profile of the participants affect the income paid out?
This talk will discuss results which aim to address the questions above, as well as the motivation for pooled annuity funds in the current UK pensions context. No prior knowledge of the topic is required.

Return to programme

Approximations of multi-period liability values by simple formulas
Nils Engler
Stockholm University

This paper is motivated by computational challenges in multi-period valuation in insurance. Insurance regulation requires that capital requirements for future liability cashflows are computed for a one-year horizon, by considering cashflows during the year and end-of-year liability values. Therefore, liability values must be computed backward recursively, starting from the year of the most distant liability payments. Solving such backward recursions algebraically is rarely possible, and numerical solutions give rise to major computational challenges.
The aim of this paper is to provide explicit and easily computable expressions for multi-period valuations that appear as limit objects for a sequence of multi-period models that converge in terms of conditional weak convergence. Such convergence appears naturally if we consider large insurance portfolios such that the liability cashflows, appropriately centered and scaled, converge weakly as the size of the portfolio tends to infinity. https://doi.org/10.48550/arXiv.2301.09450

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Return to programme

Computational methods for PDMP type risk models
Lea Enzi
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We consider the surplus of an insurance company, modelled by a piecewise deterministic Markov process (PDMP). This framework incorporates a state dependent premium rate and a non-constant jump intensity. Since functionals connected to the time of ruin (like Gerber-Shiu functions) can hardly be computed explicitly, we focus on numerical methods. Fortunately, the particular Markovian structure of the process allows for a characterization by means of integral equations, so that Monte Carlo or quasi-Monte Carlo integration can be applied. As an interesting alternative we discuss a quantization technique. As ruin is a rare event, we perform an appropriate change of measure to obtain ruin almost surely and increase the precision of the approximations. Finally, we consider an example to compare the different methods and discuss their applicability.

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Return to programme

Designing optimal reinsurance contracts under dividend strategies
Daniela Escobar
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Reinsurance is a risk sharing strategy between two parties, the insurer (the cedent) and the reinsurer (the reinsurance company), in which the reinsurer would be responsible for an amount of the insurer's loss in exchange of a premium. The optimal reinsurance problem is a well-known and extensively studied problem. We propose to find a sequence of optimal reinsurance contracts by maximising the aggregated discounted dividends under different settings. These settings include the usual budget constraints, capital requirements and the inclusion of pre-defined dividend strategies. Additionally, we do not specify the reinsurance type but use a general form as proposed in Assa (2015), using marginal indemnification functions.
We formulate an infinite dimensional optimisation problem and obtain optimal reinsurance contracts that depend on the distribution of the losses. This is a joint work with Hirbod Assa.

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Return to programme

Stability of High-Order Moments: a Risk-Management Approach for Assessing the Risk of Insurance Companies

Silvia Faroni
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Risk management aims at reducing financial risks in an uncertain future. When avoiding the normality assumption in the assessment of market risks, a risk manager should take in account the high order moments of the returns' distribution. Indeed, the extant literature examines the importance of heavy tails (kurtosis) and left tailed events (skewness) to explain the behavior of financial assets. However, little research has been produced on the statistical reliability of the various high order moments. In this work, we study the stability of annual higher-order moments in equity indexes among markets. We extend our study to conditional annual higher order moment using different quantiles. The aim of this empirical study is to help risk managers to identify which moment is more stable over time, which will lead him to a more reliable assessment of the future market risk and thus to more robust investment and risk management practices.

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Return to programme

Pricing by stake in DeFi insurance

Runhuan Feng
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In blockchain architectures, consensus mechanisms, such as proof-of-stake, have been used for processing transactions and building new blocks in a blockchain. It requires participants to stake digital assets to validate transactions in order to settle disagreements. The concept has been extended in decentralized finance (DeFi) applications to use staking mechanisms for decision-makings in financial services. In this article, we examine the pricing by stake in DeFi insurance applications, where the ratemaking is replaced by pricing formulas of digital assets staked on underwritten insurance policies. We show that such a consensus mechanism may not always lead to a Nash equilibrium and, when it does, the mechanism may fail to reflect the true risk of underwritten policies. While such a mechanism is intuitive and can be the only viable approach for emerging risks such as smart contract risks without long history of claims data, it may not be economically viable over time.

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Return to programme

Time-Consistent Asset Allocation for Risk Measures in a Lévy Market
Felix Fießinger
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We consider a time-consistent asset allocation problem to maximize the expected utility with a penalty through a law-invariant, normalized, cash- or shift-invariant, and positive homogeneous risk measure plugged in a general function. Unlike most other papers, we concentrate on optimizing gains instead of terminal wealth. We model the market via a generalized version of the multi-dimensional Black-Scholes model using alpha-stable Lévy processes and give supplementary results for the classical Black-Scholes model. The optimal solution to this problem is a Nash subgame equilibrium given by the solution of an extended Hamilton-Jacobi-Bellman equation, a partial integro-differential equation. Moreover, we show that the optimal solution is deterministic and unique (in the strict case).

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Return to programme

Ruin and profitability in cryptomining: analysis of pools and empirical evidence
Dina Finger
University of Lausanne

In this talk we will discuss to what extent it is of interest to join a mining pool that reduces the variance of the return of a miner for a specified cost for participation. Using insights and techniques from ruin theory and risk sharing in insurance, we quantitatively study the effects of pooling in this context and derive several explicit formulas for quantities of interest. The results will be illustrated in numerical examples for parameters of practical relevance. Furthermore, some empirical evidence from the Bitcoin market will be presented and compared to the theoretical results. In particular, we consider transaction fees attached to a block as part of the miner's income. We will also perform a comparative analysis with other cryptocurrencies

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Return to programme

Frequency-severity modeling of natural catastrophe losses
Anna Maria Fiori
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Understanding severe climate events, in terms of their occurrence rate and socio-economic impact, is crucial to gauge future risk and loss potential for communities in different geographic areas. Based on the "US Billion-Dollar Weather and Climate Disasters" dataset [1], this work proposes a specific frequency-severity framework to analyze and forecast natural catastrophe losses in the presence of a trend in the number of yearly events. While the "frequency" component is modeled by a count time series with possible covariate effects [2], the "size" component is fitted by either parametric or semi-parametric methods accounting for a Paretian behavior of the upper tail [3]. The outcomes of both components are combined in a simulation algorithm that generates future loss scenarios and point predictions of related risk measures. The results are compared with an alternative model for record values of non i.i.d. observations, originally proposed in Pfeifer [4].

Return to programme

Optimal Multiperiod Mixture Between Pay-as-you-go and Funded Financing Systems for Social Security.
Ivan Alexis Fonseca Diaz
University of Lausanne

The answer to the question of whether fully funded systems are superior or not to pay-as-you-go systems remains unclear. Since both financing schemes are complementary in terms of risk and profitability, it would be more convenient to reformulate the question and instead investigate whether mixtures between them could be superior. In the existing literature, some mixtures have been proposed, however, given the impossibility to reinvest the capital allocated in the pay-as-you-go part, they remain time-inconsistent in the multiperiod case. We propose a Nash equilibrium and Pareto optimal capital allocation of coexisting generations investing between pay-as-you-go and funded systems. In addition to reaching the cooperative and non-cooperative optimal welfare at every time, our model guarantees time-consistency in the multiperiod case. Our framework also allows us to show that optimality is not reached by using a pure pay-as-you-go or a pure funded system, but by a mixture between them.

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Return to programme

Uniform asymptotics for ruin probabilities over random-time intervals for continuous-time stochastic models in the presence of heavy tails

Sergey Foss
Heriot-Watt University

We assume that a risk process is modelled either by a compound renewal process or by a Lévy process.
We derive the distributional tail asymptotics for the ruin probability over random time horizon that does not depend on the future increments of the process.
Our asymptotic results are uniform over the whole class of such random times.
Particular examples are given by stopping times and by times independent of the processes.
We link our results with the random walk theory.
The talk is based on a recent joint work with Dmitry Korshunov and Zbigniew Palmowski (https://arxiv.org/abs/2303.17315).

Return to programme

Diagnostic Tests Before Modeling Longitudinal Actuarial Data

Tsz Chai Fung
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In non-life insurance, it is essential to understand the serial dynamics and dependence structure of the longitudinal insurance data before using them. Existing actuarial literature primarily focuses on modeling, which typically assumes a lack of serial dynamics and a pre-specified dependence structure of claims across multiple years. To fill in the research gap, we develop two diagnostic tests, namely the serial dynamic test and correlation test, to assess the appropriateness of these assumptions and provide justifiable modeling directions. The tests involve the following ingredients: i) computing the change of cross-sectional estimated model parameters and the empirical residual correlations of the claims across time, which serve as the indications to detect serial dynamics and peculiar serial dependence of claims; ii) quantifying estimation uncertainty using the randomly weighted bootstrap approach; iii) developing asymptotic theories to construct proper test statistics. The proposed tests are tested by simulated data and applied to multiple non-life insurance datasets, revealing that the real insurance datasets can behave very differently.

Return to programme

Extension of as-if-Markov modeling to scaled payments
Christian Furrer
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In multi-state life insurance, as-if-Markov modeling has recently been suggested as an alternative to Markov modeling in case of deterministic sojourn and transition payments. Incidental policyholder behavior, on the contrary, gives rise to duration-dependent payments in the form of so-called scaled payments. This talk establishes as-if-Markov modeling also for scaled payments. We focus on the general probabilistic and actuarial concepts and ideas as well as their relation to and consequences for actuarial practice.

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Return to programme

Risk Modeling of Hail Damage Insurance Claims Using a Factor Copula Regression for Replicated Spatial Data
Lisa Gao
University of Waterloo

The localized nature of hailstorms leads to a concentration of correlated risks that can substantially amplify aggregate storm-level losses. We propose a spatial factor copula to characterize the dependence between hail property damage claims arising from a common storm when analyzing its financial impact. The factor copula captures the spatial dependence among properties that decays with distance, as well as the aspatial dependence induced by the common shock of experiencing the same storm. The framework allows insurers to flexibly incorporate the observed heterogeneity in marginal models of skewed, heavy-tailed, and zero-inflated insurance losses, while retaining the model interpretation in decomposing latent sources of dependence. We present a likelihood-based estimation to address the computational challenges from the discreteness in the outcome and the factor copula in high dimensions. Using replicated spatial hail damage insurance claims data from a U.S. insurer, we demonstrate the effect of dependence on reinsurance and retention decisions.

Return to programme

Variable annuities: a closer look at ratchet guarantees, hybrid contract designs, and taxation
Len Patrick Dominic Garces
University of Technology Sydney

Recently, providers of variable annuity (VA) contracts have launched products which offer potentially higher guaranteed benefits through a ratcheting mechanism in conjunction with an array of investment options, including a cash fund. In some contract designs, the cash fund serves as an intermediate repository of earnings. For example, in a VA with a guaranteed minimum withdrawal benefit (GMWB), the policyholder has the option to withdraw less than the guaranteed withdrawal amount, with the difference being deposited into the cash fund, which appreciates at a benchmarked rate until the contract matures. We consider the valuation of a VA contract with a GMWB rider in which the policyholder has access to a cash fund. Assuming a ratcheting mechanism for the guarantee, we determine the optimal withdrawal strategy and provide numerical examples of cash flows emanating from the contract. We also investigate the implications of taxation on the value of the VA contract.

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Return to programme

On random reinsurance contracts and optimal transport
Brandon García Flores
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We use the notion of random reinsurance treaties introduced by Guerra and Centeno (2012) to set a general framework for the study of optimal reinsurance problems. We show that for a wide selection of risk measures commonly found in applications, these problems can be phrased as constrained optimal transport problems, thus enabling us to use the tools from the area to provide novel solutions to old and new problems. We discuss what the existence or non-existence of an optimal transportation map implies for the reinsurance business and discuss possible extensions of this approach.

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Return to programme

Climate indexes and their ability to predict insurance losses
Jose Garrido
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Actuaries use climate indexes as proxies, to assess the impact that climate risk can have on insurance portfolios. For instance, the main professional actuarial organization in North America have defined the Actuaries Climate IndexTM (ACI, see [1]). It is an index of climate risks, similar to the Consumer Price Index, based on a basket of extreme climate events and changes in sea level. If the ACI increases in a given quarter, it points out to an increase in the occurrence of extreme climate events.
Similarly, actuarial professional organizations in other countries have created tasks forces to study how to best quantify climate risk in their own jurisdictions. We review here some of the indexes that are being considered and how they correlate with any observed increase in the frequency or severity of some insured events, such as excess deaths or natural catastrophes.

Return to programme

Valuation of CSR investments
Leonard Gerick
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In our paper, we analyze a company's investment in CSR from a Real Option perspective to value the investment and determine the optimal time to invest. The idea to study CSR investments as Real Options was introduced by Husted (2005) and further extended by Cassimon et al. (2016) by adding opportunity costs to the model. Here, we allow the firm to invest in CSR at specific time points and include opportunity costs in the form of discrete dividends. We describe the value of the arising Bermudan option on a dividend-paying asset with a PDE that can be solved numerically. Additionally, we introduce a random development of the CSR expenditure, addressing the fact that, unlike the strike price for a traditional Call option, the cost for future investment in CSR is not yet known. Last, we examine a real-world example to demonstrate the practical applicability of our model.

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Return to programme

Risk Sharing Rules with Informational Frictions
Mario Ghossoub
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The Conditional Mean Risk Sharing (CMRS) rule of Denuit and Dhaene (2012) plays an important role in decentralized risk sharing, but it requires that each agent's information be given by the sigma-algebra generated by the total loss S. Recently, Jiao et al. (2022) provided an axiomatic characterization of the CMRS, as a risk sharing rule. We extend this approach to account for situations in which the individuals in the pool differ in the information they have available, and hence the CMRS might not be implementable. We consider risk-sharing mechanisms that rely only on the coarsest information set shared by all agents. As such the market mechanism accounts for frictional information costs. We provide an axiomatic characterization of risk-sharing rules that admit a representation as robust conditional expectations with respect to the coarsest information set of all agents. We call such mechanisms Information-Robust Conditional Mean Risk Sharing (IRCMRS) rules.

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Return to programme

Sequential Monte Carlo samplers to fit and compare insurance loss models
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Insurance loss distributions are characterized by a high frequency of small claim amounts and a lower, but not insignificant, occurrence of large claim amounts. Composite models, which link two probability distributions, one for the "body" and the other for the "tail" of the loss distribution, have emerged in the actuarial literature to take this specificity into account. The parameters of these models summarize the distribution of the losses. One of them corresponds to the breaking point between small and large claim amounts. The composite models are usually fitted using maximum likelihood estimation. A Bayesian approach is considered in this work. Sequential Monte Carlo samplers are used to sample from the posterior distribution and compute the posterior model evidences to both fit and compare the competing models. The method is validated via a simulation study and illustrated on an insurance loss dataset.

Return to programme

Ambuguity Aversion and State-Dependent Insurance
Yuanying (Michelle) Guan
DePaul University

It has been established that ambiguity aversion increases the optimal demand of (self-) insurance due to the resulting mean-preserving contraction in the distribution of expected utility. We extend the existing framework by further permitting the insurance indemnities to vary based on realized states of the world. We show that ambiguity-averse agents will always strictly prefer state-dependent insurances over ones with fixed indemnities. Our results also hold when the underlying states cannot be directed observed, but are (partically) correlated with some observable indicators based on which indemnities can be further contingent.

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Return to programme

Assessing Portfolio Diversification via Two-Sample Graph Kernel Inference. A case study on the influence of ESG screening.
Ragnar Gudmundarson
Heriot-Watt

In this work we propose a novel method that asses how different screening rules may influence the diversification benefits of portfolios by introducing the so-called kernel two-sample test. The problem arises naturally in the area of Environmental, Social, and Governance (ESG) based investing practices as practitioners need to select subsets of the total available assets using screening rules of ESG ratings. Here the samples are sequences of graph-valued data points that represent a dynamic portfolio obtained by a certain ESG screening rule and portfolio optimization criteria. The problem is natural for kernel two-sample testing as one can use so-called graph kernels. A failure to reject the null hypothesis would indicate that ESG screening does not affect diversification. We apply the framework to demonstrate the workflow one can use in asset management to test for structural differences in diversification of portfolios under different ESG screening rules.

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Return to programme

Equity-indexed annuities - from simple parametric models to model-free approaches
Sascha Günther
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Equity-indexed annuities are popular insurance products whose performance depends on an underlying fund or investment portfolio that is complemented by an investment guarantee of an insurance provider. A technically complex version is a so-called cliquet-variant where a minimal annual return is granted. Its path-dependent payoff leads to some complexity in valuation and risk management. We investigate model-free, data-driven approaches to valuing these products and compare them to results obtained when modelling interest rates stochastically. Under a Vasicek-Black-Scholes model, the Laplace-Transform can be efficiently and accurately approximated through a novel scenario matrix method. Hence, this allows for a comprehensive risk analysis.

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Return to programme

A hybrid data mining framework for variable annuity portfolio valuation
Hyukjun Gweon
Western University

A variable annuity is a modern life insurance product that offers its policyholders participation in investment with various guarantees. To address the computational challenge of valuing large portfolios of variable annuity contracts, several data mining frameworks based on statistical learning have been proposed in the past decade. Existing methods utilize regression modeling to predict the market value of most contracts. Despite the efficiency of those methods, a regression model fitted to a small amount of data produces substantial prediction errors and thus it is challenging to rely on existing frameworks when highly accurate valuation results are desired or required. In this talk, we propose a novel hybrid framework that effectively chooses and assesses easy-to-predict contracts using the random forest model while leaving hard-to-predict contracts for the Monte Carlo simulation. The effectiveness of the hybrid approach is illustrated with an experimental study.

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Return to programme

Advances in Genetics and Insurance
Oytun HACARIZ
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Since DNA-based genetic testing existed in the 1990s, societal concerns caused insurers to be banned from using genetic test results in underwriting in many countries. Contrarily, insurers concerned to expose adverse selection, meaning that they would charge the same ordinary premium for genetically affected individuals with higher risk of mortality. The `high-risk' adversely selected individuals were discussed to exhibit different behavior by: (a) being more likely to buy insurance; (b) choosing higher sums insured than normal; and (c) being less likely to lapse policies. Largely in the North America, (b) and (c) were attributed to life settlement companies where they may be a threat for `life insurance companies' by monetizing genetic test results. The talk will present the findings of six-years of research evaluating (a), (b) and (c) using Hypertrophic Cardiomyopathy (HCM) and Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC), regarded to be the most common and expensive genetic disorders, respectively.

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Return to programme

Mean-variance longevity risk-sharing for annuity contracts
Hamza Hanbali
Monash University

Longevity risk-sharing is investigated to address the sustainability and affordability problems in the annuity market, and in particular how much longevity risk could be transferred back to policyholders. First, new risk-sharing rules are derived for annuities in a dynamic framework. Second, the contract properties are studied from the perspectives of both the provider and policyholders. Third, in policyholders' decision, two levels of uncertainty and two levels of correlation induced by longevity risk are highlighted. Fourth, necessary and sufficient conditions on the premium loading and the share of transferred risk are derived such that both parties prefer risk-sharing. The results offer a deeper understanding of the effects of systematic and diversifiable risks on the preferences of each party regarding risk-sharing. A comprehensive numerical study of the area defining the viable risk-sharing indicates that the products risk-sharing are suitable retirement solutions.

Return to programme

Discrimination-free premiums using causal inference
Mary Hardy
University of Waterloo

We develop a discrimination-free premium, following Lindholm et al (2022), but using a causal inference framework. This gives us a natural way to identify risk factors as a subset of rating factors. It also leads us to criteria for applying discrimination-free premiums in practice. We then use a micro simulation model to assess whether the discrimination-free formula can mitigate indirect or proxy discrimination in a practical setting.

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Return to programme

Detection of interacting variables for generalized linear models using neural networks
Yevhen Havrylenko
University of Copenhagen

The quality of generalized linear models (GLMs), frequently used by insurance companies, depends on the choice of interacting variables. The search for interactions is time-consuming, especially for data sets with a large number of variables, depends much on expert judgement of actuaries, and often relies on visual performance indicators. Therefore, we present an approach to automating the process of finding interactions that should be added to GLMs to improve their predictive power. Our approach relies on neural networks and a model-specific interaction detection method, which is computationally faster than the traditionally used methods like Friedman H-Statistic or SHAP values. In numerical studies, we provide the results of our approach on artificially generated data as well as open-source data. Our presentation is based on [1].

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Return to programme

On a risk process with deterministic investment and multiplicative jumps: An application to poverty trapping

Kira Henshaw
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In this talk, we adopt a risk process with deterministic investment and multiplicative jumps to model the capital of a low-income household. The household is assumed to be susceptible to capital shocks that are a random proportion of their accumulated capital. These shocks may be due to, for example, severe illness, the death of a household member or breadwinner and catastrophic events such as floods and earthquakes. For remaining proportions of capital after shock events that follow a special case of the beta distribution, closed-form expressions for the probability of a household falling below the poverty line (the trapping probability) are derived via analysis of the Laplace transform of the infinitesimal generator of the process. Exploring the impact of insurance on this probability, which mimics an insurer's ruin probability, an insurance product offering proportional coverage is considered and the corresponding probability derived by recursively solving the associated integro-differential equation.

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Return to programme

A probability of ruin approach to optimize pension fund investments
Abraham Hernández-Pacheco
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We use a novel concept of ruin probabilities to optimize the asset allocation for various asset classes in a DB pension fund. We present an alternative methodology to the classical Asset Liability Management techniques that consider the long-term effects of returns versus volatility, along with funding levels and funding policy. For several combinations of asset allocation, under a proper concept of ruin probability, newly defined, our approach estimates the portfolio's probability of ruin. We particularly study the asset allocation of a portfolio that minimizes the probability of reaching a threshold, which either defines the need to increase contributions or curtail benefits (in our ruin concept), under a set of various assumptions of initial funding, future contributions, and financial forecasting models. We will call such portfolio the Minimum Ruin Probability (MRP) portfolio.

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Return to programme

On functional decompositions, post-hoc machine learning explanations and fairness
Munir Hiabu
University of Copenhagen

Current state-of-the-art machine learning algorithms are black-box models. As such, they make it seemingly hard to understand the relationship between predictors and response.
Current post-hoc machine learning explanations usually only focus on explaining an approximation of the fitted model or merge interaction effects into local explanations.
In this talk I will discuss that if predictions are the composition of low dimensional structures, then interpretation of the exact model is possible via a functional decomposition of the output function. A functional decomposition unifies the notion of local explanations, global explanations, and causal effects. The latter can be used for individual fairness considerations and discrimination-free pricing.
Examples of machine learning predictors that are compositions of low dimensional structures are gradient boosting machines and random planted forests.
This talk is based on [1].
An accompanying R-package is available at https://github.com/PlantedML/glex.

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Return to programme

Insurer`s management discretion: Self-hedging participating life insurance
Peter Hieber
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We challenge the commonly held assumption that participating life insurance investment strategies are exogenously determined (or even deterministic). This simplifies reality as the insurer may want to adapt the investment strategy according to the value of liabilities and/or asset-liability ratios. We demonstrate the importance of considering endogenously chosen investment strategies and their impact on contract values and solvency risks. We present a data-driven neural network approach to derive the optimal (endogenous) hedging strategy for participating life insurance contracts, highlighting the differences between exogenous and endogenous liabilities.

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Return to programme

The Role of Insurance Producers and Policyholder Lapse Decisions in Long-Term Health Insurance
Wen-Yen Hsu
Feng Chia University

Insurance is typically distributed through two distinct channels: the exclusive and independent agency systems. Many studies find that insurers using independent agencies incur higher expense ratios than do those employing exclusive agencies. This raises the question of how a higher-cost distribution system can survive in the insurance marketplace. The product-quality hypothesis states that independent agencies earn higher expense payouts by providing better product quality. This paper hypothesizes that independent agents provide higher service quality that reduces the lapse ratio. We obtain data on 249,364 long-term health insurance policies from a Taiwanese life insurer effective in 2016 and observe the lapse decision during the subsequent 5-year period. We use the Cox Proportional Hazards Model to identify the determinants of policy lapse. If independent agents provide better services, such as individualized contact to identify customer needs and ability to pay premiums, then there should be fewer lapses in their front-loaded policies.

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Return to programme

Welfare Implications of "Fair" Insurance Pricing Policies
Fei Huang
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While the anti-discrimination (fairness-aware) machine learning tasks have attracted attention from practitioners, regulators, and academicians for many applications, their consequence in terms of stakeholders' welfare is under-explored, especially via empirical studies and in the context of insurance pricing. Insurance pricing is a complicated process that may involve cost modeling, demand modeling, and price optimization, depending on the line of business and jurisdiction. While cost modeling can be regarded as a machine learning task, anti-discrimination regulatory constraints can be applied to both the cost and pricing stages of the insurers' decision-making. In this paper, we evaluate the impact of existing and potential anti-discrimination insurance pricing regulations on both consumer welfare and firm profit over the entire pricing process. Specific anti-discrimination insurance policies (such as the US price optimization ban and EU gender-neutral pricing) will be analyzed. Applying the empirical framework to a dataset of the French auto insurance market, our main results show that anti-discrimination policies on cost modeling alone cannot achieve fairness in the market price or welfare, while they can significantly harm the insurer's profit and consumer welfare, particularly of females. Depending on the competition level of the insurance market, different consumer groups could potentially benefit from certain policies. This paper will present the welfare implications under different market scenarios and make policy recommendations.

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Return to programme

The application of AI Investment Strategy to Unit-Link Policies
Hong Chih Huang
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Due to the implementation of the new accounting system IFRS 17, Investment Link Product will replace endowment policies and become the main policies in the insurance companies, but the choice of fund pools for Investment Link Product has always been an overwhelming issue for policyholders. This paper aims to use fintech technologies to construct an optimal investment strategy and provide it to policyholders as a reference for investment. This paper uses both technical indicators and machine learning models to predict the stock market. It configures investment portfolios according to different risk levels, and uses back-testing to check the performance. We classify stocks with different fluctuations. The stocks are grouped and scored. We then combine LSTM, XGBOOST and SVR to do ensemble learning, and predict the future stock return. The result of this paper shows that the use of fintech technologies provides satisfied investment returns.

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Return to programme

Statistical Classification Modeling for the Combined Portfolio Strategy
Zhenzhen Huang
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Due to the well-known estimation risk problem in traditional portfolio management, the combined portfolio strategy utilizes the 1/N rule as a shrinkage point to improve the performance of a sophisticated portfolio strategy. We propose a statistical classification framework to construct the desirable combination coefficient for the combined portfolio with the following advantages. First, the framework is flexible in incorporating exogenous factors in determining the combination coefficients. Second, the framework is adaptable to obtain the combination coefficient for any pair of ingredient portfolios without complex computation of the expected out-of-sample portfolio criteria. Third, various statistical classification models in machine learning research can be explored to construct the combination coefficient. We carry out extensive out-of-sample analysis on empirical datasets. Our proposed combined portfolio strategy possesses promising out-of-sample performance and outperforms the optimal analytic one under the unrealistic normal distribution assumption.

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Return to programme

Multi-fractional Stochastic Dominance
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We introduce a novel family of multi-fractional stochastic dominance (MFSD) that extends the concept of fractional stochastic dominance (FSD) proposed by Müller et al. (2016) to interpolate between integer degree dominance relations. The MFSD family is characterised by an arbitrary non-decreasing function that has a dual significance: (i) it captures the preferences of decision-makers in terms of risk aversion and greediness at a local level, and (ii) it enables a local interpolation between first and second stochastic dominance on different parts of the distributions' supports. Our generalization allows for the ordering of distribution functions that cannot be ordered by FSD in non-trivial cases. We will discuss both the mathematical and economic properties of MFSD and demonstrate how it offers a more comprehensive framework for decision analysis.

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Return to programme

Testing for auto-calibration with Lorenz and Concentration curves
Julie Huyghe
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Kruger and Ziegel (2021) introduced the important concept of auto-calibration ensuring that estimators can be used without bias correction. Denuit, Charpentier and Trufin (2021) demonstrated the usefulness of this concept in insurance studies and described a practical way to auto-calibrate a candidate estimator, referred to as balance correction. An alternative approach has been proposed by Wuthrich and Ziegel (2023), referred to as isotonic recalibration. Auto-calibration is particularly useful in applications where it is desirable that sums of estimates match sums of observations as closely as possible, at both global and local scales.
In this presentation, we will begin by revisiting the concept of autocalibration. We will then demonstrate that autocalibration can be defined as the coincidence of the estimator's Concentration and Lorenz curves. Lastly, we will outline a statistical test procedure to verify autocalibration.

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Return to programme

Constructing elicitable risk functionals with penalised distance scores
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We introduce a new class of elicitable risk functionals on an Orlicz space that generalise a wide range of risk measures including expectiles, quantiles, M-quantiles, L_p-quantiles, lambda quantiles and shortfall risk measures. Specifically, we consider scoring functions that are constructed using a distance function and a weight function. We prove well-known properties including existence, finiteness, convexity, homogeneity, translation invariance, monotonicity, and sub-additivity. Moreover, we derive first order conditions of these elicitable functionals which allows for efficient computation.
We further prove that under certain conditions these elicitable functionals can be expressed as a generalised quantile, i.e. the infimum at which a probability distribution function exceeds a confidence level function. This provides novel representations of expectiles, M-quantiles, L_p-quantiles and shortfall risk measure. Finally, our approach gives flexibility to construct new risk measures with desired properties by suitable choices of the scoring function.

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Return to programme

The value of prevention as a determinant of older adults' smart home adoption.
Raphael Iten
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Several aspects invite to study Smart Home(SH) adoption for prevention benefits among older people: Changing demographics, preference to age at home, and rising digital affinity. SH comes with various prevention benefits but introduces new risks or changes existing ones that become relevant for insurance products, underwriting, and pricing. Hence better knowledge of these dynamics is important.
This work investigates the value of prevention on SH adoption by identifying preferences for different prevention areas and putting their contribution in relation to SH interest. The analysis is based on novel survey data from Switzerland(N=1'515) and applies Partial Least Squares method to study the hypothesized relationship.
We find a positive relationship between SH interest and all prevention areas. Further, there are correlations between different areas. Benefits relating to fitness impact health, and security influence convenience. Finally, we discuss how perceived prevention benefits will impact existing risk protection and financing systems relating to insurance.

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Return to programme

Insurance analytics with clustering techniques
Charlotte Jamotton
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The k-means algorithm and its variants are popular clustering techniques. Their purpose is to uncover group structures in a dataset. In actuarial applications, these partitioning methods detect clusters of policies with similar features and allow one to draw up a map of dominant risks. The main challenge lies in defining a distance between two observations exclusively characterised by categorical variables. This research paper starts with a review of the k-means algorithm and develops an extension based on Burt's framework to manage categorical rating factors. We then focus on a mini-batch version that keeps computation time under control when analysing a large-scale dataset. We next broaden the scope of application of the fuzzy k-means to fully categorised datasets. Lastly, we conclude with a thorough introduction to spectral clustering and work around the dimensionality issue by reducing the size of the initial dataset with k-means.

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Return to programme

Effects of tax rules on lifetime retirement savings and annuitization decisions
Chul Jang
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We are investigating ideal tax rules on long-term (retirement) savings and general savings accounts to maintain government revenue stability and maximize the utility of socio-economic groups by labour income level. The groups show different mortality rates. Each socio-economic group's risk preferences are represented by standard power utility with regard to lifetime consumption and bequest from remaining wealth invested in tradable assets. A stochastic programming model is devised and solved numerically in terms of lifetime consumption, investment and annuity decisions. Conventional tax rules like TEE and EET are explicitly included. Our numerical results show that welfare gains are achieved with earlier purchases of annuities when contributions and returns are tax-exempted and income at retirement is taxed, relative to the case in which contributions are taxed while returns and retirement income are tax-advantaged. Further investigations and studies are ongoing.

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Return to programme

Option Pricing with Fractional Inverse Gaussian GARCH Models
Sarath Kumar Jayaraman
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This article studies the impact of long memory on volatility modelling and option pricing. We propose a discrete-time pricing framework based on affine multi-component volatility models with Inverse Gaussian innovations that admit ARCH(∞) representations. This framework nests all the previously studied Inverse Gaussian affine models for European options pricing. Using an infinite sum characterization of the log-asset price's cumulant generating function, we derive semi-explicit expressions for the valuation of European-style derivatives under a variance-dependent stochastic discount factor. Moreover, we estimate parameters using the classic return-based maximum likelihood estimation and option-based sequential estimation using cross sections of S&P 500 options over the period 1996 to 2019. Overall, we find that the inclusion of long-memory dynamics in volatility in the Inverse Gaussian framework is beneficial for improving the out-of-sample option pricing performance.
Keywords: Fractional affine models; ARCH(∞) representations; Volatility components; Variance-dependent pricing kernels; Inverse Gaussian; Sequential estimation

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Return to programme

Cyber Risk Loss Distribution of Drone Delivery Systems: A Study of Amazon Drone Deliveries in College Station, TX

Petar Jevtic
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In 2022, over 2,000 commercial drone deliveries were occurring daily worldwide, mainly in the U.S. and China. Global corporate efforts such as the recent Amazon trials at College Station, TX, authorized by the FAA, are poised to make this activity ubiquitous. The potential various-scale applications will lead to substantial cyber risk exposure of deployed drone networks leading to cyberattacks such as hijacking and signal disruption, as evidenced by recent military applications. Thus in the commercial realm, these attacks may result in substantial financial losses ranging from costly property damages and operations disruptions to hefty regulatory fines. The limited availability of relevant historical losses presents a significant challenge in pricing these risks. Thus, we propose a structural model of an aggregate loss distribution for the cyber risk of drone delivery operations on a random spatial network. We contextualize the problem in the probabilistic graph-theoretical framework using bond percolation models.

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Return to programme

Deep impulse control

Bowen Jia
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We develop a novel deep learning framework to estimate the optimal policy for impulse control problems involving multiple stochastic processes. Through the utilization of deep neural network, our numerical method allows for a general class of stochastic processes and even incorporates co-integrated processes which are uncontrollable. Our method is applicable to high-dimensional cases for both the controllable and uncontrollable stochastic processes. We investigate some mathematical properties of the proposed approach. We demonstrate its applications a wide range of problems, such as irreversible reinsurance, interest rate intervention and stochastic inventory control problems.

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Return to programme

Worst-case upper partial moments risk measures with application in finance and insurance
Zhanyi Jiao
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Upper partial moments (UPM) are measures of risk based on the upper tail of a loss distribution, which plays an important role in portfolio selection and insurance premium principles. In this paper, we calculate the worst-case first and second-order UPM risk measures analytically given the mean and variance information as well as symmetry and non-negative of the underlying distribution. In addition, we obtained the closed-form solutions to the second-order UPM with several budget constraints. For insurance applications, we consider the robust reinsurance problem with the second-order stop-loss premium principle and calculate the optimal deductible. Moreover, an optimal robust portfolio with UPM objectives can be analytically obtained given the mean and variance information with symmetry distribution.

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Return to programme

Calvin's Theology and the Emergence of Mathematical Insurance
Timothy Johnson
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It is well-known that the first mathematically managed insurance fund was established by in 1746 by ministers of the Reformed Scottish Church. From this simple observation, we shall argue that the sudden emergence of mathematical probability in the 1650s was a consequence of Calvin's theology, which changed perceptions of chance from being particular to inconsequential in the context of "God's Providence". This change in conception would have a profound on mathematics and commerce and its effects are still manifest in current policy debates.

Return to programme

Zero-inflated neural network models for predicting admission counts related to respiratory diseases in the US

Alex Jose
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The main objective is to develop interpretable zero-inflated neural network models to predict hospital admission rates related to respiratory diseases among the working population in the United States. The models developed, namely the Zero-inflated neural network (ZINN) and the Zero-inflated combined actuarial neural network (ZICANN), accommodate the excess zero nature of admission count data. Previously, in Jose et al. (2022), we employed neural network (NN) modelling methodology, including a combined actuarial neural network (CANN) approach of Wüthrich and Mertz (2019), and modelled admission numbers by embedding count regression models. Here, we also adopt and extend the LocalGLMnet approach developed by Richman and Wüthrich (2022) to interpret the neural network model results, which help to analyze the impact of various factors on admission rates. Thus, the ensemble of models can facilitate informed and accurate rate-setting decisions by insurance companies through its strong predictive performance and interpretation capabilities.

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Return to programme

Lambert W random variables and their applications in non-life insurance

Meelis Käärik
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We introduce the Lambert W distribution as an alternative approach in loss modelling. The Lambert W approach can be considered as transforming a known random variable rather than creating a new one. Thus, we can construct a Lambert W skewed version from any distribution. The properties and applications of Lambert W random variables are of interest when dealing with asymmetric/skewed data. Since the Lambert W function is double-valued, we distinguish the corresponding branches. Both the principal and non-principal branches are analyzed theoretically. We obtain the values of the skewness parameters leading to the extreme values of the Lambert W function. In the practical part, the suitability of corresponding location-scale distributions and Lambert W transformed exponential distribution is assessed on real insurance data. The performance is compared with the well-known loss distributions.

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Return to programme

POOLING FUNCTIONAL DISABILITY AND MORTALITY IN LONG TERM CARE INSURANCE AND CARE ANNUITIES: A MATRIX APPROACH FOR MULTI-STATE POOLS

Doreen Kabuche
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Mortality risk sharing pools such as pooled annuity funds and tontines provide an attractive and effective solution for managing longevity risk. They have been widely studied in the literature. However, such arrangements have received little attention for individuals in need of long-term care (LTC) insurance. Recovering these designs can help not only to provide higher benefits but also to reduce the cost of LTC insurance. In this paper, we present a matrix-based approach for pooling mortality risk across heterogeneous individuals classified by functional disability states and chronic illness statuses. Based on multi-state models of functional disability and health statuses, we demonstrate how individuals with different health risks can share mortality risk in a pooled annuity design. A multi-state pool is formed by pooling annuitants vulnerable to longevity risk and LTC insurance policyholders vulnerable to disability risk and determining actuarially fair annuity benefits based on the individual state.

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Return to programme

Risk bounds for unimodal right-skewed distributions under partial information

Rodrigue Kazzi
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Choosing a loss model can be an issue when only limited information is known about the risks. We propose a new approach where we consider all models that are consistent with some available partial information and derive the maximum value a risk measure can reach over these models. This maximum can be used as a benchmark to prevent excessive under- or overestimation of capital requirements.
The novelty of the approach resides in the various pieces of information that can be selected. We are concerned with insurance losses and focus on unimodal right-skewed distributions. In addition, the modeler can choose a transformation, or a set of transformations, that is deemed to transform the loss distribution to a symmetric one (such as the logarithmic and power transformations). Furthermore, partial information can be added on the median, interquartile range, and moments. We illustrate our findings using real-world datasets.

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Return to programme

A Simple Lifecycle Strategy that is Near-Optimal and Requires No Rebalancing
Gaurav Khemka
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We propose a simple lifecycle strategy entailing contributions made during accumulation being invested entirely into a risky portfolio until pre-specified 'switch age' and then entirely into a risk-free portfolio after the switch age, followed by withdrawing during decumulation from both portfolios based on annuitization factors that vary with age according to remaining life expectancy. First, we show analytically that the strategy is optimal for range of investors with HARA risk preferences, and derive the dynamics of the investment strategy. Second, we demonstrate numerically that the proposed strategy delivers limited loss of utility versus an optimal solution for investors with CRRA preferences and lower levels of risk aversion, while significantly outperforming strategies commonly used in practice. The proposed strategy offers an attractive alternative for use in practical settings as it is simple to follow and removes the need for portfolio rebalancing.

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Return to programme

Lapse Ratio-model together with prognosis of discount rates for large fleets – 1 practical example
Michael Klamser
German Actuarial Association

So as to better steer the large fleet portfolio at Allianz Commercial Motor Department,
I developped a lapse model for the large-fleet model "cred/new calc" (i. e. fleets which have to be calculated anew each year on the basis of credibility) together with a model for the prognosis of the discount rates, granted by the underwriters during the renewal of portfolio fleets
(the actually valid Authorities have also to be taken into account).
With the latter one, the multinomial distribution of the Generalized Linear Model comes into play.
So as to check the validity of both models, I'm going to perform a so-called
"backtesting procedure" on the data of the following renewal. - with the aim to compare
the prognosed KPIs with the actually observed ones.
With this presentation, I intend to show a way how to effectively steer the large fleet portfolio towards higher profitability whilst applying classical statistical methods.

Return to programme

Mortality trends by cause of death
Torsten Kleinow
Research Centre for Longevity Risk, University of Amsterdam

During the past decade, improvements in all-cause mortality rates and life expectancies for males and females in some countries have slowed down. In this talk, cause-specific mortality data for England and Wales from 2001 to 2018 are used to investigate the cause-specific contributions to the slowdown in improvements. Trends in the mortality for different causes are also compared to similar data for the Netherlands and other European countries where the slowdown in improvements has been less severe. Based on this analysis, cause-specific scenarios for future mortality rates in England and Wales are generated on the basis of two assumptions: a reversion of post-breakpoint temporal trends for certain causes to pre-breakpoint improvement rates and cause-specific rates based on expert judgement. The effects of these changes on all-cause age-standardised mortality rates and period life expectancies are examined. Similar projections and scenarios are then generated for other European countries.

Return to programme

Multivariate regular varying insurance and financial risks in d-dimensional risk model.
Dimitrios Konstantinides
University of the Aegean

Multivariate regular variation is a key concept which has found its use in insurance, finance, and risk management. This paper proposes a new assumption via a framework of multivariate regular variation, which includes a wide type of dependence structure
like Asimit-Jones Dependence. Then, asymptotic analyses for multidimensional risk models are studied in the continuous-time and the discrete-time cases,
respectively, under the conditions that insurance and financial risks follow this
Assumption.

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Return to programme

Optimal robust reinsurance with multiple insurers
Emma Kroell
University of Toronto

We study a reinsurer who faces multiple sources of model uncertainty. The reinsurer offers contracts to n insurers whose claims follow different compound Poisson processes. As the reinsurer is uncertain about the insurers' claim severity distribution and frequency, they design reinsurance contracts that maximize their utility subject to an entropy penalty. Insurers also seek to maximize their utility, but without ambiguity. We solve this continuous-time Stackelberg game in the cases of proportional reinsurance and excess-of-loss insurance. We obtain explicit solutions when the reinsurer's ambiguity aversion parameter scales with its value function. Moreover, in the case without scaling, we develop an asymptotic expansion of the solution, prove it is correct to the specified accuracy, and find that the optimal solution interpolates between the barycenter of the insurers' models and the scaled entropy solution.

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Return to programme

Measuring sub optimality of some ad-hoc strategies
Paul Krühner
WU Vienna

Optimal dividend problems make assumptions on the optimality criterion and model parameters. In some of them, a lot of effort is used to find the best strategy in a given setting. However, in practice parameters are not exactly known and sometimes even the optimality criterion is not clear. A practical way out is to choose an ad-hoc strategy and stick with it. In this talk, we investigate from a theoretic perspective how well a chosen ad-hoc strategy performs -- compared to the best strategy -- with and without knowledge of the optimal strategy.

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Return to programme

Dynamic lapse model of policyholder's behavior
Ko-Lun Kung
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In this paper, we study the lapse of insurance policies. We assume the tendency of lapse takes the form of a subjective belief of mortality. If the policyholder thinks he or she is more likely to live longer than the actuarial probability implies, the insurance may seem more unattractive than the cash value. The estimated belief reflects whether the policyholder acts rationally according to the actuarial survival probability. We use a proprietary dataset with more than 200,000 policies sold by a Taiwanese insurer. The paper estimates a dynamic discrete choice model for the lapse rate of life insurance. We control other factors that may affect lapse choices such as interest rate and cash value, as well as policy characteristics.

Return to programme

The Minimum Variance Squared Distance Risk Functional
Zinoviy Landsman
University of Haifa, Israel

In this talk, we introduce a novel multivariate functional that represents a position where the intrinsic uncertainty of a system of mutually dependent risks is maximally reduced. The proposed multivariate functional defines the location of the minimum variance of squared distance (LVS) for some n-variate vector of risks X. We compute the analytical representation of LVS(X), which consists of the location of the minimum expected squared distance, LES(X), covariance matrix A, and a matrix B of the multivariate central moments of the third order of X. From this representation it follows that LVS(X) coincides with LES(X) when X has a multivariate symmetric distribution, but differs from it in the non-symmetric case. As LES(X) is often considered a neutral multivariate risk measure, we show that LVS(X) also possesses the important properties of multivariate risk measures: translation invariance, positive homogeneity, and partial monotonicity. The results are demonstrated with real data of Danish fire losses.

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Return to programme

Approximate Bayesian Computation and Insurance
Patrick Laub
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Approximate Bayesian Computation (ABC) is a statistical learning technique to calibrate and select models by comparing observed data to simulated data. This technique bypasses the use of the likelihood and requires only the ability to generate synthetic data from the models of interest. In work with Pierre-Olivier Goffard (Université de Strasbourg), we apply ABC to fit and compare insurance loss models using aggregated data.

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Return to programme

Local moment matching with Gamma mixtures under automatic smoothness penalization
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We consider the class of Erlang mixtures for the task of density estimation on the positive real line when the only available information is given as localized moments, such as a histogram with potentially higher order moments in some bins. By construction, the obtained moment problem is ill-posed and requires regularization. Several penalties can be used for such a task, such as a lasso penalty for sparsity of the representation, but we focus here on a simplified smoothness penalty coming from the P-splines literature. We show that the corresponding hyperparameter can be selected without cross-validation through the computation of the so-called effective dimension of the estimator, which makes the estimator practical and adapted to these summarized information settings. The flexibility of the local moments representations allows interesting additions such as the enforcement of Value-at-Risk and Tail Value-at-Risk constraints on the resulting estimator, making the procedure fitted for heavy tailed estimations.

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Return to programme

Parametric divisibility of stochastic losses

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A probability distribution is n-divisible if its nth convolution root exists. While modeling the dependence structure between several (re)insurance losses by an additive risk factor model, the infinite divisibility, that is the n-divisibility for all n, is a very desirable property. Moreover, the capacity to compute the distribution of a piece (i.e., a convolution root) is also desirable. Unfortunately, if many useful distributions are infinitely divisible, computing the distributions of their pieces is usually a challenging task that requires heavy numerical computations. However, in a few selected cases, particularly the Gamma case, the extraction of the distribution of the pieces can be performed fully parametrically, that is with negligible numerical cost and zero error. We show how this neat property of Gamma distributions can be leveraged to approximate the pieces of other distributions, and we provide several illustrations of the resulting algorithms.

Return to programme

Identifying Transition Rates for Different Disability Definitions with an Application to Long-Term Care Insurance Market

Leonie Le Bastard
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In an insurance context, Long Term Care (LTC) products cover the risk of permanent loss of autonomy.
The dependency of an insured is defined by the impossibility or the difficulty of performing alone all or part of the activities of daily living (ADL) such as washing, eating, moving or dressing.
In the LTC insurance market, differing disability definitions are used in different insurance providers or for different insurance policies. In particular, some policies include a deferred period, whereas some cover the cost of disability at the date of loss of autonomy. Our research question is to compare the two disability definitions in terms of the transition rate as well as the resulting costs. We propose a new way to aggregate different datasets without losing information. The performance of our method is analyzed with a real-world dataset.

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Return to programme

Reverse Mortgage Design and Its Application: A Taiwan Case
Yung-Tsung Lee
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Reverse mortgages (RMs) have become an important financing mechanism for seniors' retirement planning. In Taiwan, RMs were launched about seven years ago with unique product designs, such as "monthly interest repayment" and "no interest is charged for the on-account interest". In this paper, we first introduce the Taiwanese RMs; we then compare the Taiwanese RMs with the HECM product and investigate the feasibility of applying the unique product designs to the HECM product. We highlight that the Taiwanese RMs provide a novel design to simultaneously increase the loan-to-value ratio and decrease the mortgage insurance costs, which potentially increases the marketability of RMs.

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Return to programme

Partially Schur-constant models with applications
Claude Lefèvre
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Partially Schur-constant models are introduced which are associated with partially exchangeable vectors. First, their survival copulas, called partially Archimedean, are explicitly obtained and analyzed. Then, a particular attention is paid to the construction of such models for two groups of exchangeable variables. Finally, an application to the problem of ruin is presented.

Return to programme

Modeling cause-of-death mortality data using coherent model approach
YINYEE LEONG
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Data richness and quality have improved significantly in the past 20 years, and this is particularly true for mortality studies. Now the mortality data are available not only for the advanced ages but also for the causes of death. Exploring the trend of cause-of-death mortality rates can provide us with more insights for choosing mortality models and predicting human longevity. Relying solely on age-specific mortality rates is not sufficient for mortality studies. However, cause-of-death mortality data often suffer from sample size problems resulting in unstable estimation. To deal with the issue, we apply coherent model, common age factor model, and compare them with Lee-Carter model. Furthermore, we also use principal component analysis to identify the homogeneity structure. Based on UK and Taiwan data, we find that combining age and grouping cause-of-death improves in terms of fitting error.
Keywords: cause-of-death mortality, Lee-Carter model, Li-Lee model, common age factor model.

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Return to programme

An EVT Approach to Quantifying Mortality Risk of Extreme Temperatures
Han Li
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Climate risk has recently been at the forefront of insurers' agendas. Yet, there is a gap in life insurers' understanding of how climate change will impact their balance sheets in the medium to long term. This presentation will introduce our ongoing research on how extreme temperatures impact human mortality from an actuarial perspective. Catastrophic weather events and mortality experience can simultaneously trigger large losses across different lines of insurance business. For life insurance business, "shocks" in climate change may trigger "shocks" in mortality experience. As a first step, we need a way of measuring dependencies between climate variables and mortality. Building on a prior study of Li and Tang (2022), we introduce a bivariate peaks-over-threshold (POT) approach as the mathematical foundation for estimation of tail dependence coefficients.

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Return to programme

Active leaning for variable annuity portfolio valuation: When to consider the prediction bias?
Shu Li
Western University

As an alternative to metamodeling approaches, the active learning approach based on prediction variance has shown its efficiency for large variable annuity valuation. In this talk, we consider prediction bias, another important measure for prediction error, in the active learning framework. As active learning consists of an iteration between the model training stage and sampling stage, we propose different methods to make utilize of prediction bias in these stages and investigate their effectiveness in the application of variable annuity portfolio valuation (as well as the Greeks). Empirical results on simulated data are discussed.

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Return to programme

Discrimination-free Actuarial Decision-making via Debiased Data Representations
Hong Beng Lim
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Insurers have traditionally claimed compliance with nondiscrimination laws by excluding protected group labels, such as gender and race, from use in insurance processes. Such an approach no longer suffices given the increasing deployment of machine learning algorithms, which are able to infer protected group labels from apparently unrelated data. This has created recent interest among actuarial researchers in methodologies which guarantee fair outcomes for protected groups. Existing such methods require complete information on protected group labels: an untenable requirement for sensitive information such as race or religion. We propose a neural network approach which utilizes adversarial learning to learn debiased data representations under partially observed protected group labels. We demonstrate that such networks are a marked improvement in accuracy over methods requiring complete protected group labels, while only a small proportion of observed labels (e.g. 5%) is needed to produce fairness gains not substantially worse than complete information.

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Return to programme

Aligning retirement goals with inflation
William Lim
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Pension investors are exposed to the risk of inflation eroding the purchasing power of their savings over many decades. However, few pre-retirement investment strategies incorporate explicit inflation-proofing. It is shown that ignoring inflation is costly in terms of a retiree's welfare, with reductions of up to 25% possible for the average retiree. In a second study, constraints on the amount of pension savings at retirement are imposed. Such constraints may be expressed in either real or nominal terms. However, ignoring inflation by using nominal constraints gives a potential reduction in welfare of up to 36% for the average retiree. The results illustrate that nominal constraints are ineffective at reducing the risk of inflation. We conclude that pre-retirees ignore inflation at their peril. It must be included explicitly in retirement savings targets to improve retirement outcomes. Consequently, there should be greater investment in an index-linked bond or a similar asset.

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Return to programme

Joint mixability and notions of negative dependence
Liyuan Lin
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Negative dependence notions play an important role in risk assessment, risk aggregation, and risk sharing. A joint mix, defined as a random vector with a constant component-wise sum, is usually regarded as a concept of extremal negative dependence. In this paper, we explore the connection between the joint mix structure and one of the most popular notions of negative dependence in statistics, called negative association (NA). In general, a joint mix does not have NA, but some natural classes of joint mixes have. For Gaussian margins, we also derive a necessary and sufficient condition for the existence of an NA joint mix. We show that an NA Gaussian joint mix solves a multi-marginal optimal transport problem under uncertainty on the number of components for identical marginal distributions. Analysis of this optimal transport problem with heterogeneous marginals reveals a trade-off between NA and the joint mix structure.

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Return to programme

The P2P pandemic swap: decentralized pandemic-linked securities
Daniel Linders
University of Amsterdam

In the wake of the 2014 Ebola outbreak, the World Bank created the first ever pandemic bond in 2017, an innovative solution to provide emergency financing to poor countries facing pandemic risk. However, the bond has been slow to payout in the COVID-19 pandemic, drawing mounting criticism for failing to deliver its promise of emergency funding. Many called for structural reforms of the pandemic bond in order to address fundamental flaws of the funding mechanism exposed by COVID-19. The paper presents a new class of pandemic-linked securities which combine financial derivatives for pandemic risk with a peer-to-peer (P2P) structure. The P2P structure offers more flexibility with payment triggers catering to the needs of individual countries and better inclusion of co-funding agencies beyond investors. The work is intended to bring fresh perspectives to the ongoing debate on the development of international framework for health emergency preparedness and response.

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Return to programme

Multi-parametric gradient boosting machines with non-life insurance applications
Mathias Lindholm
Stockholm University

A general multi-parametric gradient boosting machine (GBM)
approach is introduced. The starting point is a standard univariate GBM, which is generalised to higher dimensions by using cyclic coordinate descent. This allows for different covariate dependencies in different dimensions. The suggested approach is also easily extended to, e.g., multi-parametric versions of XGBoost.
Given weak assumptions the method can be shown to converge for convex negative log-likelihood loss functions, which is the case, e.g., for d-parameter exponential families. Further, when having d-parametric distribution functions, it is important to design appropriate early stopping schemes. A simple alternative is introduced and more advanced schemes are discussed. The flexibility of the method is illustrated both on simulated and real insurance data examples using different multi-parametric distributions, with both convex and non-convex losses

Return to programme

Local bias adjustment, duration-weighted probabilities, and automatic construction of tariff cells
Filip Lindskog
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We study non-life insurance pricing and a general procedure for constructing a locally unbiased predictor of the risk premium based on any initially suggested predictor. The resulting predictor is piecewise constant, corresponding to a partition of the covariate space, and by construction auto-calibrated. Two key issues are the appropriate partitioning of the covariate space and the handling of randomly varying durations, acknowledging possible early termination of contracts. A basic idea in the present paper is to partition the predictions from the initial predictor, which as a by-product defines a partition of the covariate space. Two different approaches to create partitions are discussed: duration-weighted equal-probability binning, and binning by duration-weighted regression trees. The size of the partition to be used is obtained using cross-validation, and yields an automatic data-driven tariffication procedure, where the number of tariff cells corresponds to the size of the partition.

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Return to programme

Optimal self-protection and insurance design under contagious cyber risks
Guo Liu
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In this paper, we study the optimal self-protection policies and insurance contract under contagious cyber risks by investigating a dynamic principal-agent problem, where the insurer maximises the expected operating profit by offering an insurance contract with the optimal lump-sum premium and the optimal coverage function. The insured company decides whether to purchase the cyber insurance product and choose optimal self-protection policies to minimise the expected aggregate cost until a fixed terminal time. In addition, the insured company is subject to contagious cyber attacks, where one attack on one node can trigger future attacks on itself and other nodes. According to the dynamic programming principle and an iterative numerical scheme, we obtain the optimal self-protection strategy and insurance contract with different coverage functions. Finally, we present numerical examples to demonstrate the impact of attack intensities under two fundamental insurance contracts.

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Return to programme

Asymptotics for Risk Capital Allocations based on the Higher Moment Risk Measure
Jiajun Liu
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In this talk, we consider risk capital allocations based on the higher moment risk measure and link them to a high confidence level. The tail behaviour of capital allocation is investigated, with the help of general notions of Extreme Value Theory (EVT). As the main contribution, we establish asymptotic approximations of the capital allocation with the different settings on the extremes of the margins and the strength of dependence amongst the system components. Numerical studies are conducted to illustrate our theoretical findings. In the context of interest, the EVT approach has an immediate implication for parameter sensitivity analysis.

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Return to programme

Progress, Curse, or Mixed Blessing: The Impacts of Multiple Climate Ambiguities on the Optimal Carbon Emission Abatement Policy
Peixin Liu
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Integrated assessment models (IAMs) are under criticism for their key compo- nents fall short of sufficient scientific justification and lack robustness. When using IAMs for policy assessment, a decision-maker might encounter ambiguities (Knightian uncertainties) with many facets. We develop a stylized climate decision model that accommodates three primary sources of ambiguity: (1) climate sensitivity to carbon emissions, (2) economic damages caused by climate change, and (3) cost-efficiency of the abatement policy. We show that various ambiguities affect the optimal carbon emission abatement policy in different directions. Considering the ambiguities jointly leads to optimal abatement policies significantly departing from those obtained by considering the ambiguities separately. The difference is shaped by the ambiguities' individual effects, relative dominance, and relationships perceived by the decision-maker.

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Return to programme

On the Devylder-Goovaerts conjecture in ruin theory
Stephane Loisel
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In this paper, we provide counterexamples to the Devylder-Goovaerts conjecture, that claims that ruin with equalized claim amounts is always less likely than in the classical model. We note that a simplified version of the conjecture holds true in the discrete-time risk model when one equalizes aggregate claim amounts. We use properties of Pareto distribution in risk theory and other ideas to target candidate counterexamples.

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Return to programme

Identifying a network structure in an insurance portfolio in cyber insurance
Olivier Lopez
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Cyber insurance portfolios are particularly exposed to the accumulation risk, that is the simultaneous occurrence of claims. Anticipation of this risk is difficult, because the potential links between categories of policyholders are hard to capture: the network of relationship between them (caused by digital links or by the use of commonly shared tools) is hidden. In this work, we propose a methodology that allows, from portfolio data, to identify such connexions and relationships, in order to measure how diversified our portfolio is. The hidden factor modeling technique that we develop are inspired by tools widely used in statistics for ecology, where a similar network structure exists (links between different systems).

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Return to programme

Infinitely stochastic micro reserving
Matus Maciak
Charles University

Stochastic forecasting and risk assessment are now front burners in a list of applied and theoretical sciences. In this work, we propose an unconventional tool for a stochastic prediction of future expenses based on the individual (micro) developments of recorded events. The aim lies in predicting future sub-event flows coming from already reported, occurred but not reported, and yet not occurred events. The emerging forecasting methodology involves marked time-varying Hawkes process with marks being other time-varying Hawkes processes. The estimated parameters of the model are proved to be consistent and asymptotically normal under simple and easily verifiable assumptions. The empirical properties are investigated through a simulation study. In the practical part of our exploration, we elaborate a specific actuarial application for micro claims reserving.

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Return to programme

The interaction between providers and customers of variable annuities under a dynamic approach
Rosario Maggistro
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We consider an insurer that offers his policyholders different variable annuity contracts with the GLWB guarantee. All the contracts have the same structure, but differ for the contractual parameters or the risk/return profile of the reference fund in which the single premium is invested. For comparability, all contracts have the same single premium and are fairly priced. The insurer, by fixing a risk-neutral measure, computes the initial contract value as if the policyholder chose a withdrawal strategy to maximize the expected present value of her future cash-flows. The policyholder, instead, acts to maximize the expected discounted utility, under the physical measure, of the cash-flows. This leads to a ranking of the contracts from the policyholder's perspective and, in turn, for the insurer, since the expected present value, under the insurer’s probability, induced by the actual policyholder's strategy does not exceed the single premium, thus leaving room for a gain.

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Return to programme

Random Forests for Wildfire Insurance Applications
Mélina Mailhot
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Homeowners' insurance in wildfire-prone areas can be a very risky business that some insurers may not be willing to undertake. We create an actuarial spatial model for the likelihood of wildfire occurrence over a fine grid map of North America. Several models are used, such as generalized linear models and tree-based machine learning algorithms. A detailed analysis and comparison of the models show a best fit using random forests. Sensitivity tests help in assessing the effect of future changes in the covariates of the model. A downscaling exercise is performed, focusing on some high-risk states and provinces. The model provides the foundation for actuaries to price, reserve, and manage the financial risk from severe wildfires.

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Return to programme

A bivariate mixed-Poisson claim count regression model with varying dispersion and shape
Despoina Makariou
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We consider a family of bivariate mixed-Poisson regression models with varying dispersion and shape for approximating the different types of claims and their associated counts in non-life insurance. Our main contribution is that we develop an Expectation Maximization (EM) algorithm for estimating the parameters of the models. We exemplify our approach by fitting the bivariate Poisson generalised regression model with varying dispersion and shape parameters to property damage and bodily injury count data from a European motor insurer.

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Return to programme

Optimal design of a new class of Proportion Portfolio Insurance strategy in a jump-diffusion framework

Daniele Mancinelli
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In this paper, we propose a modified version of the Proportional Portfolio Insurance (PPI) strategy where the manager invests in a risk-free and a risky asset which is modelled by a jump-diffusion process. We aim to find investment strategies that include a minimum guarantee at maturity or provide the minimum loss in case of gap-risk (i.e. the risk of falling below a given threshold, called the floor, failing to guarantee the desired amount). To reach this goal, we solve a two-step optimal control problem. First, by using standard dynamic programming techniques, we determine the optimal multiplier of the strategy that maximizes the CRRA utility function. Second, if the portfolio value falls below the floor, we apply the quadratic hedging method to characterize the optimal proportion of wealth invested in the stock, the so-called Guaranteed Minimum Equity Exposure, which minimizes the loss at maturity.

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Return to programme

Collective risk models with FGM dependence

Etienne Marceau
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We study copula-based collective risk models when the dependence structure is defined by a Farlie-Gumbel-Morgenstern copula. By leveraging a one-to-one correspondence between the class of Farlie-Gumbel-Morgenstern copulas and multivariate symmetric Bernoulli distributions, we find closed-form expressions for the moments and Laplace-Stieltjes transform for the aggregate random variable defined from collective risk models with Farlie-Gumbel-Morgenstern dependence. Furthermore, even if the Farlie-Gumbel-Morgenstern copula may only induce moderate dependence, we illustrate through numerical examples that the cumulative effect of dependence can generate large ranges of values for the expected value, the standard deviation, the Tail-Value-at-Risk and the entropic risk measure of aggregate loss random variables within these collective risk models.

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Return to programme

Fairness through regularization: an approach to mitigate group disparities for multiple protected features.

Lorenzo Marchi
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Recent advances in machine learning allow for the development of complex models that achieve high predictive accuracy. However, they also reveal latent societal inequalities in decision-making processes, which may lead to detrimental effects on certain sub-groups in society. We model data which display those latent inequalities, and propose a novel approach to reduce the effect of those on model output. Our regularization approach is compatible with any modelling approach that optimizes an objective. Furthermore, and contrary to existing such methodologies, it allows for the mitigation of multiple (and categorical) protected features, and it does this “in-sample” (as opposed to a modification of data prior to modelling, or correction of outputs after modelling). We show that our methodology performs competitively to some of the state-of-the-art methods that address a single protected feature. Furthermore, we demonstrate how it extends to account for multiple protected features jointly.

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Return to programme

A two-step CANN approach for estimating surrenders and withdrawals in a life insurance portfolio

Mario Marino
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With the introduction of the Solvency II directive and the standard IFRS 17, lapse risk has been identified as the major risk for the life insurance business. It affects the profitability and the solvency of the insurer, and modeling policyholders’ lapse behavior has become a crucial task. Consequently, actuarial researchers and practitioners have proposed different approaches to shape policyholders’ behavior, particularly concerning surrender and withdrawal activities. In the present work, we aim to estimate surrender and withdrawal cash flows for a life insurance portfolio by using a mixture of distributions and a Neural Network model. Through the former, we model surrender and withdrawal rates, while the latter is employed for estimating the mixture parameters according to the policyholders’ risk factors. The resulting Combined Actuarial Neural Network (CANN) model (Schelldorfer and Wüthrich (2019)) is tested on a real-life insurance portfolio, providing high accuracy in predicting surrender and withdrawal cash flows.

Return to programme

Mechanisms to incentivize fossil fuel divestment and implications on portfolio risk and returns
Pasin Marupanthorn
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Mechanisms to incentivize divestment strategies, such as divestment schedules, are an important component of carbon reduction strategies. We find that the risk/return profile of divested S&P500 portfolios is typically indifferent to divestment schedules, but instantaneous divestment benefits management structure. Regarding ESG attributes, faster divestment rates are preferred at the expense of higher tracking errors. Rapid divestment by shorting may induce higher management fees and tracking errors. Divesting from energy and utilities sectors reduces carbon footprint, with ETFs divesting offering more substantial reductions. Investing in funds with low carbon footprints results in lower dividend returns and management fees. Even though the return profile of ETFs is insensitive to divestment strategies, their risk profile is proportionally to their carbon intensity affected by such strategies. Our study underscores the importance of considering investors' demographics, such as dividends, management structure, and carbon reduction targets, on divestment strategies.

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Return to programme

On the attainability of Kendall's tau rank correlation matrices and concordance signatures
Alexander McNeil
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In many real-world applications an actuary is required to impute missing information on the dependencies between variables, typically in the form of correlations. This problem is particularly common in risk management where data on certain risks are often sparse or non-existent. Some financial institutions use copulas parameterized in part by expert-elicited correlations to build joint models of key risks affecting their solvency and profitability.
In this talk we solve the attainability problem for Kendall rank correlation matrices. We derive methods for testing the attainability of putative matrices of Kendall's tau rank correlations and for determining the possible values for missing correlations in partially specified Kendall's tau matrices. More generally, methods are developed for checking and completing systems of bivariate and multivariate Kendall's tau concordance probabilities, which underlie bivariate and multivariate Kendall correlations.

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Return to programme

Assessing epidemic curves for evidence of superspreading
Joe Meagher
Hymans Robertson

Superspreading, where some individuals give rise to many secondary infections while others infect few or none, is a feature of many epidemics. The phenomenon is a consequence of heterogeneous disease reproduction, whereby the expected number of secondary infections varies from one individual to the next due to myriad host, pathogen, and environmental factors. Identifying these factors a priori is difficult, if not impossible, however, incorporating their effect in statistical models for the spread of disease is crucial to accurate uncertainty quantification and risk. Here, I present a simple branching process model for the spread of epidemic disease and apply it the Irish COVID-19 epidemic. This analysis offers insight into superspreading dynamics. For example, this method allows us to estimate that the 20% most infectious index cases account for approximately 75–98% of the expected secondary infections with 95% posterior probability.

Return to programme

Longevity heteogeneity and pension design
Massimiliano Menzietti
Università della Calabria

Many pension systems require change to maintain long-term sustainability. Most developed countries' policymakers have been pushed to reform their pension systems in order to preserve or re-establish financial sustainability. As longevity heterogeneity is frequently disregarded in the policy chosen, the pursuit of financial sustainability is done at the expense of intra-generational actuarial fairness.
We propose a pension system management system comprising two adaptation mechanisms:
- The first dynamic mechanism is integrated directly into the pension formula and corrects the heterogeneity of longevity between the agents of the pension scheme.
- A steering mechanism for both the contribution rate and the mean benefit ratio respects Musgrave's rule, which makes it possible to distribute the demographic risk between working people and retirees.

In order to capture both effects and incorporate a mortality component into the pension formula, we model longevity heterogeneity and ageing in a pension scheme using different multipopulation mortality models.

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Return to programme

TIME DEPENDENT STOP-LOSS REIUNSURANCE AND EXPOSURE CURVES VIA STOCHASTIC JUMP DIFFUSION

Özenç Murat Mert
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Insurance markets play an essential role in the economy of the world and its structure requires reinsurance policies due to the growth in populations, extreme (catastrophic) events, political and economical perspectives. In this study, stop-loss contracts are covered for two different contract types: (i) contracts with retention and (ii) contracts with both retention and cap. This study covers stochastic behaviors of the claim amounts for the analysis of loss modeling, the costs of insurer and reinsurer, and exposure curves to obtain a fair premium share. Pareto-Beta stochastic jump diffusion (PBJD) model and its theory are implemented for capturing possible extreme losses. The analytical derivations for the costs and the exposure curves under PBJD are collected. The emphasis on the applications of real-life data is made. For the forecasts values of the loss amounts, the expected costs, and the exposure curves, ARIMA family models are applied the time-varying parameters.

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Return to programme

Individual claims reserving with dependent censored data

Marie Michaelides
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We study the dependence between the different insurance coverages offered within a single policy when a claim occurs and the impact that this dependence has on the total reserves amount. We propose an individual claims reserving model that allows to estimate the development of each claim through the different insurance coverages that it impacts. More specifically, for a single claim, we jointly model the activation delays of the coverages. We then complete the model by estimating not only the correlated activation delays of the different coverages but also the subsequent development of each claim, namely the payments that might occur after activation of the coverages and their corresponding severities. We finally propose an illustration of our model using a recent automobile dataset from a Canadian insurance company.

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Return to programme

Adam Smith's Reversionary Annuity: Money's Worth, Default Options, and Autoenrollment
Moshe Arye Milevsky
York University (Toronto)

When Adam Smith – author of Wealth of Nations (1776) and Theory of Moral Sentiments (1759) – joined the University of Glasgow in 1751, he participated in a unique insurance and investment scheme which provided a lifetime income to a surviving spouse and lump-sum benefit to children, possibly the first of its kind. This article (i.) explains the benefit scheme in financial economic terms, (ii.) values Smith's reversionary annuity using actuarial techniques and (iii.) presents archival data to examine choices made by literati of the 18th century Enlightenment who participated in this scheme; all managed by the Church of Scotland. It seems that debates around choice architecture, default options, autoenrollment and anti-selection, which infuse the pension and insurance literature in the 21st century, were prevalent in the mid 18th.

Return to programme

A class of changes of measure for climate sensitive valuation and stress testing
Pietro Millossovich
Bayes Business School

We introduce a class of changes of measures for marked point processes accommodating salient features of physical climate risk along various climate pathways and counterfactual scenarios. The framework is computationally tractable, yet general enough to jointly allow for realistic changes in physical risk dynamics and the evolution of risk premia consistent with widely used regulatory scenario narratives, including the abrupt repricing of climatic risks following forceful policy intervention. Use of the model is illustrated with reference to a large mortgage portfolio.

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Return to programme

A Regression Based Approach for Valuing Longevity Measures
Pietro Millossovich
City, University of London

This paper addresses the problem of approximating the distribution of future life expectancy and lifespan disparity, and indeed any biometric statistics, with a cohort-based perspective. In contrast to the usual period-based approach, forecasting longevity indices with a cohort-based method requires the computation of conditional expectations for which explicit solutions often do not exist. We suggest an application of the Least-Squares Monte Carlo approach, therefore avoiding the straightforward nested simulations method. This method is extremely general and flexible, and indeed can be used with any mortality model, regardless of its complexity and, further, it may be adopted for approximating other longevity measures at future dates. The method is applied to single and multi-population mortality models to showcase its effectiveness in evaluating longevity metrics and to stress the difference and risk resulting from replacing cohort-based valuations with period-based ones.

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Return to programme

On a ruin model built from INAR processes
Charles Minier
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To take into account reserving aspects or loss adjusting expenses, one often incorporates some by-claims in ruin theory processes.
In this paper, we use INAR processes and associated processes to propose some new claim arrival processes that correspond better to certain real-world features of insurance payment streams.
The main covariance results are computed, and some first ruin results have been proved, involving exponential or Pareto distributions. This talk is based on a joint work with Stéphane Loisel and Naushad Mamode Khan.

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Return to programme

Non-Deep Hedging
Andrea Molent
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In this talk, we discuss a method for determining an optimal strategy for hedging a derivative product. Recently, some authors have proposed approaches that exploit neural networks to address the problem of dynamic hedging of a derivative. Although these methods are very promising, they have some weaknesses: the computation time is high, sometimes they do not converge to the optimal solution, and they still work as black boxes. For this reason, we propose an alternative method, which avoids the use of machine learning and is based on traditional optimization and interpolation techniques. The proposed method proves efficient and reliable, and the results are easy to interpret. In addition, it also allows the evaluation of American options. Despite the apparent simplicity of the proposed algorithm, the numerical results confirm the validity of the procedure.

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Return to programme

Decreasing Bequest Embedded Annuities: A Feasible Pension Product
Marco Morales
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One of the reasons for the Annuity Puzzle, could be the bequest motive. A way out of this issue is the possibility of money-back guaranteed annuities.
In a Cash-Refund Annuity we should solve a recursivity problem, since the price of the annuity depends on the expected bequest which also depends on the price of the annuity. Moreover, the guaranteed period is endogenous (unknown) at the time of retirement.
To simplify such a product, the bequest must be independent of the price of the annuity. This requires defining in advance the guaranteed period, and then the bequest amount. Once the bequest is priced, the remaining premium is used to buy the annuity.
With the annuity factor independent of the bequest, the guaranteed period, the expected bequest, and the annuity lifetime income are known from the beginning. In addition, the cost of the bequest is explicit in terms of lifetime income.

Return to programme

On Perturbations of Preferences and Indifference Price Invariance
Oleksii Mostovyi
University of Connecticut

We investigate indifference pricing under perturbations of preferences in small and large markets. We establish stability results under small perturbations of preferences, where the latter can be stochastic. Here, we obtain a sharp condition in terms of the associated concave and convex envelopes and provide two counterexamples demonstrating that, in general, stability fails. Next, in deterministic utility settings, we investigate a class of models where the indifference price does not depend on the preferences (or the initial wealth). Here we show that the class of indifference price invariant models is equivalent to the second-order stochastic dominance of the dual domain. We also provide a counterexample showing that this result does not hold over stochastic utilities in general. Our results apply to both small and large markets, and thus, in particular, we introduce large stochastically dominant models, give examples of such models, and characterize them as the indifference price invariant ones.

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Return to programme

Decisions under uncertainty: sufficient conditions for almost stochastic dominance
Alfred Mueller
University Siegen

Decision making under risk involves a ranking of distributions. As it is typically difficult to assess a concrete risk measure or premium principle for ranking distributions, it is a well established idea to use stochastic dominance rules in form of stochastic orders to compare distributions. However, it is often equally difficult to completely specify a distribution. Therefore it is an interesting question whether one can derive unambiguous decisions under partial knowledge of the distributions. In this talk we in particular address this question under the condition that we only know the mean and variance of the involved distributions or that we know the marginal distributions but not the copulas in a multivariate context. Under such assumptions we derive sufficient conditions for concepts of almost stochastic dominance that are based on restrictions on marginal utilities.

Return to programme

Can one quantify Climate Change for Flood Risk? A Spatial and Temporal Analysis based on Functional Data Analysis.

Alaric Müller
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Floods are responsible for a large part of insurance losses due to natural hazards. The modelling of corresponding losses suffers from intricate spatial dependence patterns. In addition, they typically exhibit non-stationary behaviour over time, which can be partly attributed to climate change. In this talk, we intend to study this climate change component by investigating the spatial and temporal dependence structure of flood occurrences under minimal assumptions. Using long-time flood occurrence records from 27 lakes in the European Alpine region, we adapt and employ functional data analysis techniques to study the empirical dependence structure of flood risk over time and space. We then use the results to extrapolate an implied spatial and temporal flood occurrence model in that region. We test its sensitivity when including further covariates like long-time temperature records of specific locations and explore long-term implications for the insurability of flood risk in that region.

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Return to programme

Season-related regional variation in slowdown of mortality decline in the United Kingdom 2001 - 2018.

Rabia Naqvi
University College, Cork (UCC)

The aim of this study is to examine differences in the slowdown of mortality decline, identified in many developed low-mortality countries across the world from around 2011, on a major cause-of-death and, crucially, seasonal basis. The UK presents an ideal context to investigate linkages between shifts in mortality characteristics and season related cause-specific developments amid differing regional public health settings of England & Wales and Scotland respectively. There have been many hypotheses proposed to explain changes in the mortality rate trends from 2011. Explanations for faltering gains in life expectancy bifurcate between economic austerity and emphasis on the role of influenza. This study highlights a winter-led health dimension to the slowdown in mortality improvements rates among older age groups. Further the extent of the slowdown in season-related cause-specific rates of improvement is more pronounced in England & Wales than Scotland, though a seasonal cause-specific dimension is present in both regions.

Return to programme

Optimal Collective Investment under Limited Expected Loss and Financial Fairness

Tak Wa Ng
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Considering a group of tied-together investors with heterogeneous risk preferences, we study a collective investment problem under a limited expected loss (LEL) constraint in a complete market setting. By the static Lagrangian method, we obtain the optimal collective terminal wealth and develop a LEL-constrained Pareto-optimal (LELPO) sharing rule thereon. Under the LELPO sharing rule, the payoffs distributed to each investor solve their individual LEL-constrained optimal asset allocation problem, suggesting a re-composition result and introducing expected-loss type risk measures to their shared wealth. With the additional financial fairness condition, we single out a unique LELPO sharing scheme under mild technical conditions. Our numerical illustrations analyze the impact of the collective LEL constraint on individual welfare, risk level, and incurred implicit cost.

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Return to programme

Optimal reinsurance for minimal probability of Parisian ruin
Phuong Nguyen
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Parisian ruin allows for a grace period after the company's reserve goes below the critical threshold, during which the company can attempt to sort its finances to avoid ruin. In this work, we consider the optimal reinsurance from the point of view of a cedent seeking to minimize its probability of Parisian ruin. We provide optimality conditions and some numerical examples.

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Return to programme

CONTINUOUS-TIME OPTIMAL INVESTMENT: A REINFORCEMENT LEARNING APPROACH
Thai Nguyen
Université Laval

We study an exploration version of the continuous-time expected utility maximization problem with reinforcement learning (RL). We manage to show that the optimal feedback policy of the exploratory problem with exploration is Gaussian. The solution to the exploratory problem can be obtained in closed form which converges to the classical expected utility counterpart when the the exploration weight goes to zero. For interpretable RL algorithms, a policy improvement theorem is provided. Finally, we devise an implementable reinforcement learning algorithm by casting the optimal problem in a martingale framework. Numerical examples are also provided for illustrations.

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Return to programme

A fixed-point approach to compute actuarially fair Pareto optimal risk sharing rules
Fallou NIAKH
CREST ENSAE

Economic agents, insurance companies and investors are often faced with the risk of insolvency when a peril occurs. For this reason, risk sharing has received considerable attention as a mechanism to protect against such risk without requiring additional capital. In the literature, a particular class of interest is risk sharing rule that is actuarially fair Pareto optimal (AFPO). However, in practical situations, one may encounter difficulties in computing such risk sharing rules in general setting. In this paper, we establish a one-to-one correspondence between finding a AFPO risk sharing rule and finding a fixed point of a function constructed for this purpose. The main advantage of this representation is that we can compute AFPO risk sharing rule in a general setting. Therefore, this framework is very important for several application such as Peer-to-Peer insurance, investment profit sharing, and tontines, among others.

Return to programme

Pension fund with longevity risk: an optimal portfolio insurance approach
Immacolata Oliva
Sapienza University of Rome

This paper investigates an optimal investment problem within a defined contribution (DC) pension scheme, providing minimum guarantee protection and including longevity risk. The representative fund members' contributions are allocated into a risky asset and a bond following a proportional portfolio insurance strategy, to provide fund members with a life annuity at retirement. More precisely, we employ a strategy whose floor is linked to the actuarial present value of the annuity to be purchased at maturity. The picture is completed by including a stochastic force of mortality and a stochastic interest rate, following a mean-reverting square-root process and a Vasicek model, respectively. We further assume that the DC pension fund contribution rate is stochastic and correlated with the risk factors mentioned above. We solve the resulting optimization problem using standard dynamic programming techniques and provide a numerical study to measure the impact of longevity risk on the investment strategy's performance.

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Return to programme

Reinforcement learning in search of optimal premium rules
Lina Palmborg
Stockholm University

In simplified settings, optimal premium rules can be derived by classical approaches such as dynamic programming methods providing solutions to a Bellman equation. Realistic insurance settings involve features such as reporting/payment delays and fluctuations in the number of policyholders, partly in response to varying premium levels. In such settings, classical approaches are not applicable due to the size of the state space and lack of explicit expressions for transition probabilities.
I will discuss how to design efficient algorithms in search of optimal premium rules in realistic insurance settings requiring reinforcement learning combined with function approximation. Both theoretical properties and practical aspects of such algorithms will be presented.
The talk is based on Palmborg & Lindskog (2022) and current work.

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Return to programme

Machine learning techniques for solvency ratio validation
Mariaelisa Pelle
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In recent years, machine learning and artificial intelligence techniques have made a substantial contribution to the reorganization of business processes. These techniques can provide a contribution in risk control and monitoring system. Solvency II regulation allowed to standardize the risk control and management system by providing all the elements for determining the solvency ratio. The coefficient determination process is highly structured and involves several areas. The control activity is also very demanding for the auditors and the supervisory authority. An initial screening to identify priority items to check could help. In this article, using machine learning techniques, a model is developed to carry out an initial screening of insurance companies in order to verify the calculation of the solvency ratio starting from simple public information and therefore to identify the companies that present results that deviate from the predictions by calibrating the machine learning model on data from insurance companies.

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Return to programme

Do People Feel the Risk and Buy More Insurance? Evidence from the Natural Disaster Events
Jin-Lung Peng
National Chengchi University

This study aims to determine the impact of natural disasters on individuals' insurance decisions. Based on actual life insurance company data, we investigate whether natural disasters influence insurance purchase behavior by utilizing detailed information on accident insurance contracts. We find that the occurrence of natural disasters significantly increases the amount of insurance purchased by policyholders. This result implies that after a natural disaster, our risk perceptions are affected, deepening our anxiety about future losses, and increasing the amount of accident insurance. However, we also find that responses to natural disasters varied depending on the frequency of natural disasters by area. People in areas where natural disasters often occur are much less affected by natural disasters. Moreover, different types of natural disasters do not have significantly different effects. Our results provide new evidence on the relationship between insurance amounts and natural disasters.

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Return to programme

Multivariate Portfolio Choice via Quantiles
Andrea Perchiazzo
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We first show how the quantile approach used for univariate optimal portfolio choice can be also useful to solve the multivariate case. When the multivariate allocation problem (in the absence of a financial market) can be solved explicitly, the multivariate optimal portfolio choice reduces to a one-dimensional problem using the quantile approach. In the general case, we develop a numerical approach to obtain approximate solutions for the multivariate optimal portfolio selection problem.

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Return to programme

Risk Budgeting Allocations for Dynamic Risk Measures
Silvana Pesenti
University of Toronto

We develop an approach for risk budgeting allocation -- a risk diversification portfolio strategy -- where risk is measured using time-consistent dynamic risk measures. For this, we introduce a notion of dynamic risk contributions that generalise the classical Euler contributions and which allow us to obtain dynamic risk contributions in a recursive manner. Moreover, we show how the risk allocation problem may be recast as a convex optimisation problem and develop an actor-critic approach to solve for risk allocations using deep learning techniques.

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Return to programme

Functional Data Techniques for Claims Reserving
Michal Pesta
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One of the most fundamental tasks in non-life insurance is risk reserving assessment analysis, which amounts to predict stochastically the overall loss reserves to cover possible claims. The most common reserving methods are based on different parametric approaches using aggregated data structured in the run-off triangles. We propose a rather non-parametric approach, which handles the underlying loss development triangles as functional profiles and predicts the claim reserve distribution through permutation bootstrap. Three competitive functional-based reserving techniques, each with slightly different scope, are presented; their advantages - effortless implementation, robustness against outliers, and wide-range applicability - are discussed. Empirical performance of the designed methods and a full scale comparison with standard (parametric) reserving techniques are carried on several hundreds of real run-off triangles against the known real loss outcomes. An important objective is to promote the idea of natural usefulness of the functional reserving methods among the reserving practitioners.

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Return to programme

Parametric Cyber Insurance through Data Breaches Dynamic Modeling
Marco Pirra
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This work aims at providing a possible solution for the reduction of the gap between supply and demand of cyber insurance. We set up a model for the dynamics of data breaches trough an Integer Valued GARCH model to consider time-dependent effects. In order to better capture the dynamics of data breaches we refer to INGARCH models that assume data breaches have a zero-inflated Negative Binomial distribution with the purpose of considering the fact that the victims of the breach might not report the attack. We refine loss estimates and risk assessment by looking for lead-lag relationships between cyber risks and economic variables (see De Giovanni et al. (2021)) . We define a parametric insurance product as a possible way to overcome some of the issues to be faced in analyzing and managing cyber risks described in details in Eling et al. (2021), and discuss the implications through numerical applications.

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Return to programme

Weighted Credibility Distribution Estimation with Applications to Insurance and Finance
Georgios Pitselis
University of Piraeus

This paper extends the results of Jewell (1974) of forecasting the distribution of individual risk in cases where the observations are weighted or are grouped in intervals. The credibility estimation is obtained by restricting the class of admissible functions, leading to the so-called linearized credibility results and the optimal projection theorem is also applied for credibility estimation. In addition, distribution credibility estimators are also established and numerical illustrations are herein presented. Two examples of distribution credibility estimation are given, one with insurance loss data and the other with industry financial data.

Return to programme

Chain ladder Plus: a versatile approach for claims reserving
Gabriele Pittarello
La Sapienza, Università di Roma

This paper introduces yet another stochastic model replicating chain ladder estimates and furthermore considers extensions that add flexibility to the modeling. We show that there is a one-to-one correspondence between chain-ladder's individual development factors and averaged hazard rates in reversed development time. We introduce a new model that is able to replicate chain ladder's development factors. The replicating model is a GLM model with averaged hazard rates as response. This is in contrast to the existing reserving literature within the GLM framework where claim amounts are modeled as response. Modeling the averaged hazard rate corresponds to modeling the claim development and is arguably closer to the actual chain ladder algorithm. Furthermore, the resulting model only has half the number of parameters compared to when modeling the claim amounts; because exposure is not modeled. The lesser complexity can be used to easily introduce model extensions that may better fit the data.

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Return to programme

Pricing Systematic Longevity Risk in Pension Schemes
Mathias D. Plovst
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A global transition in pension schemes is observed, as an increasing number of countries move from relatively ’safe’ schemes, as seen from the individual, towards more ’risky’ schemes. This is mainly caused by historical low interest levels, increasing life expectancies, and Solvency II capital requirements. We suggest a new way of measuring systematic longevity risk by studying historical deviations in mortality forecasts. We model the impact of these unanticipated changes in forecasted life expectancies on DB and DC pension products and examine how individuals' payout profiles during retirement differ between these two types of products. Both products differ in their exposure towards systematic longevity risk and financial risk. Moreover, we quantify the cost of systematic longevity risk using a utility framework and determine the indifference price for a voluntary transition.

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Return to programme

The Markovian Hawkes model: ruin probabilities and their asymptotic behaviour
Simon Pojer
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One way to generalize the classical Cramér-Lundberg model is to replace the Poisson process with a more general counting process, driven by a stochastic intensity. In our model, we consider a risk process, whose counting process is a Markovian marked Hawkes process. Hawkes processes are characterized by their self-exciting property, which means that every jump of the process itself increases the probability of further jumps, a behaviour that can be observed in the occurrence of cyber-attacks. By the Markovian structure of the underlying model, we identify suitable exponential martingales and corresponding alternative measures under which ruin occurs almost surely. Exploiting the positive Harris recurrence of the intensity process and its stationary distribution, we use a renewal equation to determine the asymptotic behaviour of the ruin probability.

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Return to programme

Optimal risk sharing and dividend strategies under default contagion: A semi-analytical approach
Ming Qiu
The University of Melbourne

We investigate the risk control and dividend optimization problem of an insurance group in a general setting and propose an innovative semi-analytical approach to the problem. The group consists of multiple subsidiaries and is subject to exogenous default risk. The default intensity is subject to the contagious effect. The recursive system of Hamilton-Jacobi-Bellman variational inequalities (HJBVIs) is derived together with the verification theorem. To the best of our knowledge, the proposed work is the most generalized model to study the dividend and risk sharing for multiple subsidiaries within an insurance group. We propose a semi-analytical approach that formulates a group of candidate functions and find the candidate function that coincides with the solution to the HJBVI. We further present a numerical example of a three-subsidiary insurance group to demonstrate the semi-analytical method and illustrate the recursive computation procedures that are extendible to cases with more subsidiaries.

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Return to programme

A non-parametric measure for variations of the quantity of interest unexplained by covariates
Giovanni Rabitti
Heriot-Watt University

It is well known that non-life insurance datasets contain covariates which do not fully explain the observed variations in the claim frequency. For example, the driving style is an important covariate for the claim frequency, but it is unobserved. How much does it matter actually?
In this work we want to measure the amount of variations unexplained by covariates. Hossjer et al. (2009) consider this problem specifying a Poisson distribution for the claim frequencies. We construct a non-parametric index which is model-free and remains defined with whatever quantity of interest (not only claim counts/frequency) and with whatever dependence of the covariates.
We apply this measure to non-life datasets with different characteristics (geography, number of policyholders, number and type of covariates, etc). We find that telematics data have the lowest value of this measure, meaning that the telematic covariates contain high information on the claim frequency.

Return to programme

Capital Injections with Deficit Dependent Delays: A Fredholm Integral Approach.
Lewis Ramsden
University of York, UK

We consider the Cramér–Lundberg risk model, with delayed capital injections when the surplus is negative. If the deficit is less than a critical value, it is covered by available funds and received instantaneously. On the other hand, if the deficit exceeds the critical value the capital injection is received after some time delay to allow for administrative procedures. For this model, we derive Fredholm integral equations of the second kind for the Gerber-Shiu function and obtain explicit expressions in terms of quantities of risk models without capital injections. The results are extended to critical layers and exact deficit dependence. In the latter case, explicit results are no longer obtainable and the Gerber-Shiu function is expressed in terms of a Neumann series. Finally, we show similar results hold when claims arrive according to a Markov Arrival Process, for which systems of second order Fredholm integral equations are derived and solved.

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Return to programme

Neural Network Embedding of the Pareto Regression Model for Claims Severity
Yubo Rasmussen
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The Pareto regression model has been widely used by the actuarial community for predicting claim sizes based on important risk factors in non-life insurance. The aim of this paper is to extend the framework of this model by embedding it into a Neural Network architecture following the Combined Actuarial Neural Network (CANN) from Wüthrich and Merz (2023). We exemplify our approach by implementing the blended model for fitting claim sizes from a European Motor Third Party Liability (MTPL) insurance company. We illustrate that the Neural Network boosting of the Pareto regression model enables us to explore missing interactions of nonmultiplicative type, that cannot be approximated by the Pareto regression model.

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Return to programme

Multistate analysis of policyholder behaviour in life insurance - Lasso based modelling approaches
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Holders of life insurance policies can exercise various options that lead to contract modifications, e.g. full surrender, partial surrender, paid-up and dynamic premium increase options. Transitions between these contract states materially affect (current and future) cash flows, and thus represent a serious source of uncertainty for an insurance company. It is common practice to model these transitions independently, i.e. without considering joint determinants of the different aspects of policyholder behaviour. Our paper shows how consistent best estimate transition rates for multiple status transitions can be derived using data science methods. More specifically, we extend existing multivariate approaches with the Lasso method such that the key drivers for each transition can be identified automatically. We discuss the performance, the complexity and the practical applicability of the different modelling approaches based on data from a European insurer.

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Return to programme

De Finetti's optimal dividends problem with a path-dependent bound on the payment rate
Jean-Francois Renaud
UQAM

We consider De Finetti's control problem for absolutely continuous dividend strategies with a payment rate bounded by a function of the current surplus level. In a Brownian model, we prove that a generalized mean-reverting strategy is optimal.

Return to programme

Regime switch in a stochastic multi-population mortality projection model
Jens Robben
KU Leuven

The overall pattern of mortality rates over time, commonly referred to as the mortality trend, began to decline in Europe during the early 19th century. This declining mortality trend is disrupted by occasional and temporary mortality shocks. These shocks can be caused by conflicts like World War I and World War II, or by pandemics and epidemics like a cholera outbreak, the Spanish flu, or, more recently, the COVID-19 pandemic. In this paper, we develop a stochastic multi-population mortality improvement model that comprises two components. The first component aims to simulate the overall decreasing mortality trend, while the second component aims to incorporate the mortality shocks using a regime-switching process. Additionally, we incorporate the age pattern of mortality shocks. Our paper serves as a scenario generator for the inclusion of future mortality shocks and finds that the uncertainty in the mortality forecasts is significantly higher.

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Return to programme

Impact of correlation between interest rates and mortality rates on the valuation of various life insurance products

Benjamin Roelants du Vivier
Université Libre de Bruxelles

n this paper we establish the expression of the best estimate of a zero-coupon survival bond when modelling the interest rates and the mortality rates with two Hull and White models correlated to each other, meaning that we relax the traditional assumption of independence between mortality risk and interest rate risk. We investigate the impact of the inclusion of correlation on the best estimate of usual life insurance contracts and study in which cases the non taking into account of correlation can lead to a severe underestimation of the best estimate.

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Return to programme

Fully-dynamic risk measures: horizon risk, time-consistency, and relations with BSDEs and BSVIEs

Emanuela Rosazza Gianin
University of Milano-Bicocca

In a dynamic framework, we identify a new concept associated with the risk of assessing the nancial exposure by a measure that is not adequate to the actual time horizon of the position. This will be called horizon risk. We clarify that dynamic risk measures are subject to horizon risk, so we propose to use the fully-dynamic version. To quantify horizon risk, we introduce h-longevity as an indicator. We investigate these notions together with other properties of risk measures as normalization, restriction property, and different formulations of timeconsistency. We also consider these concepts for fully-dynamic risk measures generated by backward stochastic differential equations (BSDEs), backward stochastic Volterra integral equations (BSVIEs), and families of these. Within this study, we provide new results for BSVIEs such as a converse comparison theorem and the dual representation of the associated risk measures.

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Return to programme

On the microstructure of green bonds
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The idea of this paper is to investigate the differences between brown and green bond markets from the lens of the trading activity. Our research exploits the idea that positive and negative jumps in the price dynamics have a specific memory nature that can be modelled through a self-exciting or a self-inhibiting process.
We investigate the microscopic structure and properties of high-frequency series of green and brown bonds using Hawkes type processes where the kernel is a CARMA(p,q) model.
Empirical results suggest that the bid-ask spread of green bonds on average is larger. Moreover, we observe that the intensities respectively of positive and negative jumps in the price dynamics are not stationary through time. Except for the case of the bullet brown bond, a classical bivariate Hawkes model seems not be the best fitting model in our dataset.

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Return to programme

Mortality Models with Jumps: Have They Foreseen the COVID-19 Pandemic?
Şule Şahin
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Population events such as natural disasters, pandemics, extreme weather, and wars might cause jumps that have an immediate impact on mortality rates. The recent COVID-19 pandemic has proved that these events should not be treated as nonrepetitive exogenous interventions. Therefore, mortality models incorporating jump effects are particularly important to capture the adverse mortality shocks. The mortality models with jumps we consider in this study differ in terms of the duration of the jumps - transitory or permanent, frequency of the jumps - modelled by Poisson or renewal process, and size of the jumps - modelled by normal or exponential distribution. We discuss the performance of the models by analysing their ability to capture the mortality deterioration caused by COVID-19. We use data from different countries to simulate the mortality rates for the pandemic years and examine their accuracy in forecasting the mortality jumps due to the pandemic. Moreover, we investigate the stability of the models by using data with and without COVID-19 mortality rates. We also analyse the impact of the pandemic mortality on the catastrophe bond prices.

Return to programme

Climate Stress Testing and Sovereign Risk
Kaveh Salehzadeh Nobari
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We consider the projection of sovereign ratings along selected NGFS climate scenarios for a large panel of countries to quantify the impact of climate risk on sovereign bond portfolios. We first identify
macro variables driving probabilities of default (PDs) and then project such variables along relevant climate pathways by using an econometric approach and an equilibrium model. We generate term structures of PDs and ratings along each climate scenario, by allowing for both transition and physical climatic risks. The results are used to quantify the impact of climate risk scenarios on sovereign bond portfolios and to document the importance of counterfactuals in designing and implementing climate stress tests.

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Return to programme

Guaranteed Minimum Maturity Benefit under self-exciting mortality.
Aasmund Hausken Sande
University of Oslo

The Guaranteed Minimum Maturity Benefit is quite a popular feature embedded in several unit-linked policies offered by insurance companies. In the present paper we assume for the mortality dynamics a self-exciting behaviour, described by a Hawkes-type process with exponential kernel, which allows to keep both the Markov and the affine features, but introduces jumps with a stochastic intensity. This type of dynamics, exhibiting a jump clustering property, is quite convenient in order to describe mortality in some critical situations, like epidemics, when contagions phenomena make the probability of jumps arrivals higher when a jump is already occurred. By assuming a diffusion type dynamics for both the fund and the interest rates and introducing all the possible correlations among the diffusion processes necessary in order to get a realistic dynamics, we take advantage of the affine features of the model proposed and compute in a semi-explicit form the GMMB.

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Return to programme

To merge or not to merge? On the impacts of pension plan consolidation.
Barbara Sanders
Simon Fraser University

We investigate the benefits and drawbacks of pension plan consolidation by quantifying the impact of mergers. To do so, we propose an exhaustive framework that combines all the relevant components of pension plan operation. Specifically, we include a realistic economic scenario generator, a stochastic mortality model that captures differences among subpopulations, a cost model with economies of scale, and an asset allocation methodology based on utility maximization.Three groups of measures are constructed from this framework to quantify mergers' solvency and welfare impacts: plan-related risk measures assessing profits from an economic capital perspective, consumption-based metrics to understand members' benefits, and contribution risk measures capturing the risk from the sponsor's viewpoint. We apply the framework to two hypothetical mergers and find that the merger is favourable for small plans in both cases.

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Return to programme

Likelihood-based estimation for multistate models subject to IBNR- and RBNS effects.
Oliver Sandqvist
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Life and health insurance policies generate longitudinal biometric data in the form of records on the occurrence and timing of certain events. Complete observation of the true event history is typically rendered impossible due to the presence of incurred-but-not-reported (IBNR) and reported-but-not-settled (RBNS) claims in addition to right-censoring and left-truncation. While such mechanisms have received some attention in the non-life insurance literature under recurrent event models e.g. Norberg (1991) and Badescu et. al. (2016), the corresponding problem in life insurance is largely unexplored.
In this talk, we discuss how to accommodate these mechanisms in the estimation of a general multistate model using thinning-based methods to accommodate IBNR (reporting delays) and missing-data techniques to accommodate RBNS (incomplete event adjudication). We are motivated by the need for predictive models in pricing and reserving that capture trends in a timely fashion. The practical relevance is illustrated via a numerical study.

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Return to programme

Generalizations of Optimal Transport in Quantitative Risk Management and Applications to Insurance and Finance

David Saunders
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The optimal transport problem of minimizing or maximizing the expectation of a function on a product space over all joint measures with given marginals is a well-studied problem with several applications in finance and insurance. We will discuss generalizations of this problem, both in terms of modified the objective function (for example to a spectral risk measure), and in terms of modifying the constraints (working with Choquet capacities rather than measures). Illustrative applications of the resulting optimization problems to insurance and finance will also be discussed.

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Return to programme

On the optimal collaboration in a two-dimensional risk model with penalty function

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University of Cologne

Collaboration between insurance lines is an important task. We consider a simple model where capital can be transmitted between insurance lines. For an allocation of capital, we define a loss like in Vierkötter (2016) and Vierkötter and Schmidli (2017). This could be interpreted as real costs, for example because of measures from the regulator or missing investment opportunities through low capital, or a loss an immaterial loss as through reputational risk. The loss function is a convex and in each variable decreasing function. The goal is then to minimize the discounted loss. We show how to solve the problem and also discuss some variants of the problem like internal reinsurance.

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Return to programme

Quantifying and Hedging Moral Hazard Risk
Annika Schneider
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Moral hazard risk in insurance describes the possibility of fraudulent policy holder behaviour, resulting in losses which are hard to predict and quantify. For disability income insurance (DII), moral hazard is one possible explanation of its often-times poor performance and is suspected to be motivated by rising unemployment. In our project, we approach this issue via the following steps. First, using weighted regression on UK data from 2004 to 2016, we quantify the extent of moral hazard risk and find that in times of rising unemployment, the number of new claims increases and the number of DII recoveries falls. Second, we build economic tracking portfolios to mimic the unemployment rate and third, we use the results of our statistical models and portfolio construction to develop a partial hedge for DII loss. As final step, we illustrate potential benefits of our hedging strategy by means of a simulation study.

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Return to programme

Quantile Mortality Modelling of Multiple Populations via Neural Networks
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Quantiles of the mortality rates are relevant in life insurance to control longevity risk properly. Recently, [1] introduced a stochastic model with the same canonical form as the popular LC model [2] for describing the quantile mortality rates. We propose a neural network- approach for jointly estimating the parameters of the individual quantile models related to multiple populations. The idea consists of exploiting the mortality experiences of all populations to obtain a more robust estimation of the single-population models. We show that the quantile LC parameters can be expressed as functions of a smaller set of parameters, including population-specific and cross-population parameters. Numerical experiments performed on all the countries of the Human Mortality Database validate our approach. The forecasts obtained considering the median level appear more accurate than those obtained with the mean models; moreover, those at the tail quantile levels capture the future mortality of the populations well.

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Return to programme

Tontines on the Blockchain
Arnold Shapiro
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At IME 2018, I presented a talk on blockchains, which dealt with what they are and how they worked. The primary goal of that presentation was to convey the notion that a blockchain was a decentralized transaction and data management technology, which featured a distributed, immutable digital record system that was shared among many independent parties and could be updated only by their consensus.
This presentation extends that discussion by exploring the implementation of tontines on blockchains. We begin with a brief overview of tontines. The topics discussed include tontine flowcharts and hierarchy charts, and intuitive justification of essential tontine equations. We then turn to the central theme of this presentation, the role of blockchains and smart contracts in the development of secure and transparent tontines. We conclude with a commentary on tontine applications of blockchain.

Return to programme

Evolution of Elderly in Institutionalised Long-Term Care Based on Multiple Health Factors
Aleksandr Shemendyuk
University of Lausanne

Advanced medicine and improved longevity entail increased demand in long-term care (LTC) provision for elderly individuals. As the most financially and managerially exposed branch of LTC, the institutionalised care is well studied, and the understanding of the related costs is achieved. However, many studies only account for a single initial assessment of the person's health status when entering the institution. In this work, we aim to investigate the evolution of institutionalised care intensity that an individual requires during their stay in a nursing home. We use novel longitudinal data from nursing homes on about 21'000 individuals covering the period from 1996 to 2018. We show that, in general, individual's condition deteriorates across all health profiles, resulting in a consistent increase of the care intensity during their stay. Our findings are relevant for the management of nursing homes, and for insurance companies to properly price their LTC products.

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Return to programme

Bowley Optimal Premium Principle under Exponential Utility
Benxuan Shi
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In the literature on optimal (re)insurance, the fundamental problem is to solve optimal indemnities for a given premium principle (e.g., the expected-value premium principle, the mean-variance premium principle, Wang's premium principle, etc.). In this paper, we take one step back and investigate which family of premium principles is optimal in the Bowley sense, by considering the welfare of both policyholder and insurer. Within convex premium principles, we find that the expected-value premium principle with constant loading is optimal for proportional contracts, and deductible contracts when claim size has decreasing mean-excess loss. Our results provide novel theoretical justification to the optimality of the expected-value premium principle for a large class of indemnities and loss distributions.

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Return to programme

A Sensitivity Approach for Understanding Mortality and Interest Rate Risks of Annuities
Jianjie Shi
Monash University

Demographic and financial factors are two key risk drivers for annuity pricing. This paper analyses the dependency of annuity cost on its mortality and interest rate risks. Unlike traditional formulation in the continuous-time framework, we will focus on the discrete version of annuities in the presence of stochastic mortality rates and discount factors. We then employ both the local infinitesimal perturbation analysis and global sensitivity analysis tools to understand the impact of the parametric assumptions behind the modelling of stochastic mortality rates and discounting factors. For local analysis, risk factors are ranked according to the Differential Importance Measure. In the global analysis, both variance-based and distribution-based sensitivity measure are used to account for parameter uncertainty. Especially, we suggest replacing the subjective distributions by the Bayesian posterior distributions of model parameters. We conclude the paper with an empirical study using the US mortality data and the US treasury yield curve data.

Return to programme

Leveraging Weather Dynamics in Insurance Claims Triage Using Deep Learning
Peng Shi
University of Wisconsin-Madison

In property insurance claims triage, insurers often use static information to assess the severity of a claim and to identify the subsequent actions. We hypothesize that the pattern of weather conditions throughout the course of a loss event is predictive of the insured losses, and hence appropriate use of weather dynamics improves the operation of insurers' claim management. To test this hypothesis, we propose a deep learning method to incorporate dynamic weather information in the predictive modeling of the insured losses for reported claims. In the empirical analysis, we examine a portfolio of hail damage property insurance claims obtained from a major U.S. insurance carrier. When supplemented by the dynamic weather information, the deep learning method exhibits substantial improvement in the hold-out predictive performance. We also demonstrate that leveraging weather dynamics in claims triage could lead to a substantial reduction in operational cost.

Return to programme

Securitization and Financial Sustainability of the HECM Program
Tianxiang Shi
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Reverse mortgages, as an important means to provide financial resources to elderly homeowners, have received lots of attentions to academics, practitioners, and policymakers. The role of a secondary market, however, has been largely overlooked in the literature. In this paper, we investigate a secondary market instrument - HECM mortgaged-backed securities (HMBS). We discuss its innovative design and examine the cashflow patterns and financial performance of the FHA, HMBS issuers, and investors. We find that the FHA is in general better off when it insures a portfolio of fixed-rate HECMs compared to adjustable-rate loans, when it comes to the risk/return relationship, probability of loss, ruin probability, and risk-based capital. However, the issuers and investors may have a preference over assets backed by adjustable-rate HECMs, which helps explain the dominance of HECMs with adjustable rates on the market. Our results have policy implications to the FHA regarding premium setting and capital requirement.

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Return to programme

Hidden semi-Markov models for rainfall-related insurance claims
Yue Shi
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We apply a non-Gaussian hidden semi-Markov model to a novel insurance dataset about rainfall-related home insurance claims in Norway. Through comparing a wide range of candidate distributions in terms of both goodness-of-fit and commonly used risk measures, we identify a proper model for modeling insurance losses caused by rainfall-induced damage. In addition, weather-related insurance claims often involve time dynamics that must be considered seriously and modeled appropriately, and the hidden semi-Markov model proposed in this study captures this feature very well. The model estimates suggest that the risks associated with heavy rain in home insurance appear to have been increasing during the period 2004-2020, which is consistent with a changing climate. The findings offer useful insights to insurance companies for accurate modelling in the face of climate changes.

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Return to programme

Retrocession: A Double-edged Sword to Reinsurers
Seva Shneer
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The current reinsurance market is extremely concentrated. The interconnections among reinsurers can be intertwined due to retrocession (i.e., reinsurance on reinsurance), causing reinsurance spirals. In this paper, we aim at a quantitative understanding of the role of retrocession in the health of reinsurers. To this end, we construct a static insurance–reinsurance network in which insurers purchase reinsurance and reinsurers also purchase reinsurance from each other. Through an asymptotic study of the number of defaulted reinsurers for the case of heavy-tailed primary losses, we discover that retrocession is a double-edged sword to the health of reinsurers.

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Return to programme

The Risk contagion of COVID-19 to oil prices and the impact on the insurance industry.
Nida Siddiqui
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The COVID-19 pandemic and its impact on crude oil prices created additional risks throughout the insurance industry. To contribute to the ongoing debates, this paper empirically examined the risk contagion of COVID-19 to oil prices by incorporating a Markov switching framework and the BEKK-MGARCH model. Further, we used principal component analysis (PCA) to find principal factors explaining the overall variability of the global economic indicators that contribute to the risk. Finally, to support the risk transmission effects between COVID-19 and oil prices, we conducted fixed effect panel regressions, while controlling for the factors extracted from the PCA method. The empirical findings could be used as a starting point for insurers to create innovative insurance products, particularly in energy and marine, to address the fundamental challenges in oil-related risk exposures, while also providing added commercial incentives to close the oil-risk protection gap.

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Return to programme

Telematics in motor insurance
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With the emergence of telematics, a huge amount of data have become available for the insurers. These new pieces of information reflect more accurately the behavior of the policyholder on the road, rising up a new question for the insurers:
"How to integrate this information into the motor insurance pricing ?"
From telematics literature, Guillen (2021) and Sun (2022) introduced near-claims events, representing dangerous events, which could have triggered a claim. These events are typically harsh deceleration, acceleration or cornering events. Based on a MTPL portfolio of a belgian insurance company, we highlighted that deceleration events were the most appropriate events for characterizing near-claims events. Then, we proposed to integrate these events in the a posteriori pricing structure aside policyholder's claim history by means of a bivariate Poisson-lognormal model.

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Return to programme

Bayesian nonlinear expectation for time series modelling and its application to Bitcoin
Tak Kuen Siu
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A two-stage approach to parametric nonlinear time series modelling in discrete time is proposed with the objective of incorporating uncertainty in the conditional mean and volatility. At the first stage, a reference time series model is specified and estimated. At the second stage, Bayesian nonlinear expectations are introduced to incorporate model uncertainty in prediction via specifying a family of alternative models. The construction of Bayesian nonlinear expectations for prediction is based on closed-form Bayesian credible intervals evaluated using conjugate priors and residuals of the estimated reference model. Using real Bitcoin data including some periods of Covid 19, the proposed method is applied to forecast Bitcoin returns and evaluate Bitcoin risks under three major parametric nonlinear time series models, namely the self-exciting threshold autoregressive model, the generalized autoregressive conditional heteroscedasticity model, and the stochastic volatility model.
This paper has been published in Empirical Economics (2023) 64, 505-537
https://doi.org/10.1007/s00181-022-02255-z

Return to programme

A Machine Learning Approach to Forecasting Italian Honey Production with Tree-Based Methods
Elia Smaniotto
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The Italian apiculture sector, one of the largest honey producers in Europe, has suffered considerable damage in recent years. Adverse weather conditions, occurring more frequently as climate change progresses, can be high-impact and cause the environment to be unfavourable to the bees' activity [1]. In this paper, we aim to study the effect of climatic and meteorological events on honey production. The database covers several hives, mainly located in northern Italy, and contains temperature, precipitations, geographical and meteorological measurements. We adopt random forest and gradient boosting algorithms, powerful and flexible tree-based methods to predict the honey production variation. Then, a feature importance analysis is performed to discover the main driver of honey production within the covered area. This study, which lies within the existing literature [2,3], seeks to establish the links between weather conditions and honey production, aiming to protect bees' activity better and assess potential losses for beekeepers.

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Return to programme

Optimal consumption, investment, and insurance under state-dependent risk aversion
Julie Bjørner Søe
Copenhagen University

We formalize a consumption–investment–insurance problem with the distinction of a state-dependent relative risk aversion. The state dependence refers to the state of the finite state Markov chain that also formalizes insurable risks such as health and lifetime uncertainty. We derive and analyze the implicit solution to the problem, compare it with special cases in the literature, and illustrate the range of results in a disability model where the relative risk aversion is preserved, decreases, or increases upon disability.

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Return to programme

Pandemic Impact on Pension Redistribution
Zuochen Song
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During the COVID-19 outbreak, mortality levels have increased at different levels in countries around the world. While basic mortality models like the Lee-Carter model have flaws in modelling mortality during catastrophic events like the Coronavirus, this paper uses mortality models from Chen and Cox(2009) to simulate the pandemic with mortality jumps in different cohorts and analysing the pandemic effect on pension redistribution between genders. Recovery period under different scenarios after the mortality jump is also included in our mortality forecasts. Our results show that, in several countries in Europe like Spain and France, the pandemic causes around 20% of increase of death numbers and different levels of decrease in life expectancy in different cohorts. Furthermore, we prove that the gender differences in pension distribution will be enlarged after the outbreak of the pandemic.

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Return to programme

Ultimate old-age mortality methods: a comparative study
Lukas Stake
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Determining the shape of the mortality curve at advanced ages is important for actuaries, demographers, and gerontologists alike. Due to lack of reliable deaths data at ages above 90 years, there is still no conclusive answer to the question, whether ultimate old-age mortality rates decelerate, accelerate or continue to increase uniformly. In our comparative analysis, we make use of high-quality Canadian and Swedish data and pit the method of Smooth Threshold Life Tables (Huang et al. 2020) which use a Generalised Pareto distribution derived from Extreme Value Theory, against the Gamma-Makeham distribution popular among demographers, also known as the Makeham-Beard mortality law to actuaries. We compare both results to the method of Hermite splines (Richards 2020), which possesses the additional benefit of ensuring mortality convergence at the ultimate ages.

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Return to programme

Co-jumps and recursive preferences in portfolio choices under ambiguity
Ilaria Stefani
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In this work, investigate a dynamic, continuous-time optimal consumption and portfolio allocation problem when the investor faces recursive utilities, both in the presence and absence of ambiguity. The economy we are considering is described through both
diffusion and discontinuities in the dynamics. Moreover, we consider a complete market setting in which there are several stochastic processes namely, the risk-free asset, the stock, the state variable, and derivatives. We consider the precision process to describe the market
diffusion feature, as in Chacko and Viceira [2005].
By exploiting standard dynamic programming techniques we derive an approximated closed-form solution to optimal rules. In an ambiguity-free framework, we obtain
dynamic optimal exposures, inversely proportional to volatility. By including ambiguity, we want to investigate whether the results obtained continue to hold, as in Faria and da Silva [2016], Chen and Escobar Anel [2021] and Jin et al. [2021], by assuming discontinuities in the dynamics.

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Return to programme

Epidemiological Modeling in Life Insurance
Mogens Steffensen
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The coronavirus pandemic has created a new awareness of epidemics, and insurance companies have been reminded to consider the risk related to infectious diseases. This talk extends the traditional multi-state models to include epidemic effects. The main idea is to specify the transition intensities in a Markov model such that the impact of contagion is explicitly present in the same way as in epidemiological models. Since we can study the Markov model with contagious effects at an individual level, we consider individual risk and reserves relating to insurance products, conforming with the standard multi-state approach in life insurance mathematics. We compare our notions with other but related notions in the literature and perform numerical illustrations.

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Return to programme

Limiting sequential decompositions and applications in finance
Hauke Stier
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The sequential updating (SU) decomposition is a well-known technique to obtain a profit and loss (P&L) attribution, e.g. of a bond portfolio, by dividing the time horizon into n subintervals and only vary one risk factor, e.g. FX, IR, CS or calendar time, in each subinterval. We show that the SU decomposition converges for large n if the P&L attribution can be expressed by a smooth function of the risk factors. We consider the average SU decomposition, which does not depend on the order or labeling of the risk factors. Sufficient conditions are given to reduce the computational complexity significantly when calculating the average SU decomposition.

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Return to programme

Bayesian and neural network modelling for health insurance related risk – inequalities, Covid-19 impact and future projections
George Streftaris
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Modelling health risk trends and variation is important for insurance purposes and can impact pricing and reserving in areas such as critical illness insurance and care provision. We investigate cancer rates using UK general population data and respiratory admission rates in a US insured population. We account for heterogeneity and uncertainty by employing Bayesian methodology in a generalised linear model-type framework. Aiming at improved predictions, traditional methods are combined with artificial neural network (ANN) deep learning, by adopting a hybrid approach that embeds regression models in ANN settings. The analysis reveals considerable socioeconomic inequalities in some of the most prevalent types of cancer, and that the rates gap among deprivation groups in the UK has widened over time for certain cancers. Our research also found that delays in the average age of diagnosis, relating to those under Covid-19, can result in significant increase in cancer mortality, also exhibiting regional variation.

Return to programme

Geometric Compound Hawkes Process and its Applications in Finance
Anatoliy Swishchuk
University of Calgary

We introduce a new model for a stock price, namely, geometric compound Hawkes process, and show how this model can be applied to solving many problems in finance, including option pricing (European and American) and Merton portfolio optimization problems. This model is a generalization of some well-known models in finance, such as Cox-Ross_Rubinstein model (1976, [1]) (geometric binomial process), Aase model (1988, [2]) (geometric compound Poisson process) and geometric Markov renewal model (2013, [3]). We note, that this new model is different from general compound Hawkes process, which was introduced in Swishchuk (2017, [4]) to model risk process in insurance, and was studied in Swishchuk (2018, [5]) and Swishchuk (2021, [6]). We will show some differences between those two models, and also present a numerical example based on real data.

Return to programme

Quantum Computing for Insurance Industry
Muhsin Tamturk
Antares

Current problems and emerging technologies encourage us to focus on quantum computers. In this research, how quantum technologies can be used in the insurance industry is being investigated. After the fundamental properties of quantum mechanics, and advantages and drawbacks of today's quantum computers are summarised, a developed and implemented quantum computing approach to predict the insurance capital by using a superconducting type IBM quantum computer is discussed.

Return to programme

Can price collars increase insurance loss coverage?
Pradip Tapadar
University of Kent

Loss coverage, defined as expected population losses compensated by insurance, is a public policy criterion for comparing different risk classification regimes. Using a model with two risk-groups (high and low) and iso-elastic demand, we compare loss coverage under three alternative regulatory regimes: (i) full risk-classification (ii) pooling (iii) a price collar, whereby each insurer is permitted to set any premiums, subject to a maximum ratio of its highest and lowest prices for different risks. Outcomes depend on the comparative demand elasticities of low and high risks. If low-risk elasticity is sufficiently low compared with high-risk elasticity, pooling is optimal; and if it is sufficiently high, full risk classification is optimal. For an intermediate region where the elasticities are not too far apart, a price collar is optimal, but only if both elasticities are greater than one. We give extensions of these results for more than two risk-groups.

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Return to programme

Impact of the choice of risk assessment time horizons on defined benefit pension schemes
Pradip Tapadar
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We examine the impact of asset allocation and contribution rates on the risk of defined benefit (DB) pension schemes, using both a run-off and a shorter 3-year time horizon. Using the 3-year horizon, which is typically preferred by regulators, a high bond allocation reduces the spread of the distribution of surplus. However, this result is reversed when examined on a run-off basis. Furthermore, under both the 3-year horizon and the run-off, the higher bond allocation reduces the median level of surplus. Pressure on the affordability of DB schemes has led to widespread implementation of the so-called de-risking strategies, such as moving away from predominantly equity investments to greater bond investments. If the incentives produced by shorter term risk assessments are contributing to this shift, they might be harming the long-term financial health of the schemes. Contribution rates have relatively lower impact on the risk.

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Return to programme

Saving for retirement: the role of long-term trends
Claudio Tebaldi
Università Bocconi

A comparison of the performances of pension products that ignores long-term trends might signi cantly overestimate the long-term impact of volatility risks while underestimating the impact of persistent, low frequency trends. This paper proposes a comparison making use of projection models based on the long-term risk-return tradeoff proposed by Campbell and Viceira (2005) to explicitly take into account slow moving economic trends. In order to illustrate the approach and its implications, we discuss the capital protection provided by life-cycle target-date fund strategies and minimum guarantee strategies.

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Return to programme

Analytical Pricing Formula Under Three-State Regime-Switching Model: An application to GMMB
Özge Tekin
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Economic and financial data display diverse behaviour at different time intervals due to their dynamics and stochastic nature. To build explanatory models, different time periods with similar characteristics can be grouped under a single regime. This study focuses on the valuation of European options within a three-state regime-switching framework in the context of an economy following a homogeneous first-order continuous-time finite-state hidden Markov chain process. The study employs the joint density function of the occupation time of the Markov chain to find an analytical solution and presents the calculations for the Greeks. To the best of our knowledge, the option pricing formula by considering this approach has not been presented in the literature under the three-state regime-switching framework. Additionally, the research considers the regime-switching guaranteed minimum maturity benefit valuation and proposes formulae for two different models with numerical examples to demonstrate its implications.

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Return to programme

Practical Aspects of a Mean-Field LMM
Stefan Thonhauser
Graz University of Technology

In this talk we will present practical aspects of a mean-field extension of the classical LIBOR Market model and discuss its adaption to cover so-called backward-looking rates. The primary intention of the mean-field formulation is to defuse the "blow-up or explosion problem" which frequently appears when valuing long term insurance products by means of Monte Carlo simulations. The calibration of such general models can be done in an iterative way - mimicking its existence proof. Fortunately, if the involved SDE coefficients only depend of the solution's distribution via its moments, things simplify and the model with its benefits can be applied in a straightforward way. Since classical LIBOR rates do not exist anymore - EURIBOR still does, we need to extend our approach for dealing with current needs.

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Return to programme

Insurers' Vulnerability to Interest Rate and Market Risks
Zhiwei Tong
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Life insurers and pension funds are faced with long-term liabilities that are sensitive to changes in interest rates. To mitigate this risk, they may employ various strategies, including holding a mix of short-term and long-term bonds, investing in the stock market, and taking a fixed-leg position in interest rate swaps. However, these strategies which worked well in the past may not be effective in adverse economic conditions where interest rates are high and the stock market is bearish. We build and estimate a model for insurers' decision making in such situations and to assess their vulnerability.

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Return to programme

Lateral and Differential Auditor Switching among U.S. Property-Liability Insurers
Carol Troy
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In a quality-differentiated audit market, insurers face the same three-way choice each year: continue with the incumbent, hire a new auditor of the same quality (lateral switch), or hire a new one of a different quality (differential switch). An insurer may switch auditors for practical reasons (e.g., seeking a level of service more appropriate to its needs) or opportunistic reasons (e.g., opinion shopping or earnings management). Using a sample of 7,327 property-liability firm-years over the 2005-2010 period, we develop two bivariate probit models with self-selection, one describing the auditor decision among Big 4 clients, the other among Non-Big 4 clients. We find that self-selection impacts switching behavior among Big 4 clients, but not Non-Big 4 clients. The decision outcome depends on three independent variables (insurer financial health, auditor tenure, the audit fee) and numerous firm characteristics. However, the determinants of switching differ, depending on the size of the incumbent auditor.

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Return to programme

Managed Retreat of Settlements Exposed to Risks from Sea Level Rise - A Financial Engineering Approach
Stefan Trueck
Macquarie Business School

Climate change and repeated extreme events have the potential to create toxic property assets, a constant reliance on recovery payments and support services, and socio-economic inequality for at-risk communities. Managed retreat is an alternative adaptation strategy allowing to plan for large-scale climate-related displacements of houses or infrastructure under risk from sea level rise. In this study we apply techniques from financial engineering to create structured products that can facilitate an urban development-led managed retreat system. In our framework investors into at-risk properties obtain so-called transferable development rights, allowing them to build dwellings in new development areas or increase the density of dwellings in existing areas. To determine dependent risks across a pool of at-risk properties we apply copula models in combination with a simulation approach for the risk of sea level rise. Our framework illustrates the potential to incentivize private sector investment, thereby reducing the burden on local or state governments.

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Return to programme

Autocalibration by balance correction in non-life insurance pricing

Julien Trufin
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By exploiting massive amounts of data, machine learning techniques provide actuaries with predictors exhibiting high correlation with claim frequencies and severities. However, these predictors generally fail to achieve financial equilibrium and thus do not qualify as pure premiums. Autocalibration effectively addresses this issue since it ensures that every group of policyholders paying the same premium is on average self-financing, as demonstrated by Denuit et al. (2021), Ciatto et al. (2022), Lindholm et al. (2022) and Wüthrich (2022). The present talk further studies the effect of balance correction on resulting pure premiums. It is shown that this method is also beneficial in terms of out-of-sample Tweedie deviance, Bregman divergence and concentration curves. We derive conditions ensuring that the initial predictor and its balance-corrected version are ordered in Lorenz order. Finally, criteria are proposed to rank the balance-corrected versions of two competing predictors in the convex order.

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Return to programme

Optimal investment timing for flood risk adaptation in presence of trend, seasonality and stochastic interest

Chi Truong
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This paper deals with 'investment timing', or how to make decisions on long-term investments to mitigate catastrophic risk where the risk is driven by trends and seasonality, and interest rates vary stochastically over time. Our model combines real options theory, extreme value theory and risk pricing theory to provide a useful decision-support system for catastrophic risk management. Using a case study of flood risk management for New York City, we show that ignoring seasonality, trend or risk aversion can lead to underestimation of the investment values and also unnecessary delay in the project investment. We also show that consideration of stochastic interest rates can provide substantial benefits when investment is optimally timed and accelerate the process of climate change adaptation.

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Return to programme

What is Fair? Proxy Discrimination vs. Demographic Disparities in Insurance Pricing

Andreas Tsanakas
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Indirect discrimination and fairness are major concerns in algorithmic models. This is particularly true in insurance, where protected policyholder attributes are not allowed to be used for insurance pricing. Simply disregarding protected policyholder attributes is not an appropriate solution, as this still allows for the possibility of inferring the protected attributes from non-protected covariates. This inference leads to so-called proxy or indirect discrimination. Though proxy discrimination is qualitatively different from the group fairness concepts in the machine learning literature, these group fairness concepts have been proposed to control the impact of protected attributes on the calculation of insurance prices. The purpose of this paper is to discuss the differences between direct and indirect discrimination in insurance and the most popular group fairness axioms. In particular, we show that one does not imply the other, as these concepts are materially different. Furthermore, we discuss input data pre-processing methods and model post-processing methods that achieve both discrimination-free insurance prices and demographic parity group fairness.

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Return to programme

A Posteriori Risk Classification and Ratemaking with Random Effects in the Mixture-of-Experts Model

Spark Tseung
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A well-designed framework for risk classification and ratemaking in automobile insurance is key to insurers' profitability and risk management, while also ensuring that policyholders are charged a fair premium according to their risk profile. In this paper, we propose to adapt a flexible regression model, called the Mixed LRMoE, to the problem of a posteriori risk classification and ratemaking, where policyholder-level random effects are incorporated to better infer their risk profile reflected by the claim history. We also develop a stochastic variational Expectation-Conditional-Maximization algorithm for estimating model parameters and inferring the posterior distribution of random effects, which is numerically efficient and scalable to large insurance portfolios. We then apply the Mixed LRMoE model to a real, multiyear automobile insurance dataset, where the proposed framework is shown to offer better fit to data and produce posterior premium which accurately reflects policyholders' claim history.

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Return to programme

Extreme Drivers Detection with User Based Insurance
Yu-Ying Tzeng
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Actuarial fairness establishes a fundamental pricing concept to associate risk exposure with adequate and fair premiums. Fixed-premium automobile insurance is generally considered actuarial unfair. The rating variables to classify risk exposure levels are objective, like gender and age. Telematics data preserve drivers' risk characteristics on the road, revealing their risk exposure which actuaries could not access for years. The latest telematics pricing research is limited to use subjective risk factors such as pre-defined acceleration and braking intervals (Guillen et al., 2021). It does not take into account the correlation of different risk factors. Several deep learning and machine learning techniques such as transfer learning, and principal components algorithm are used to extract drivers' hidden risk representation. Finally, we expect to propose a new algorithm that could fractionate telematics data into tactical components for pricing and the incentive of good driver behaviors.

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Return to programme

EM Estimation for Bivariate Mixed Poisson INAR(1) Claim Count Regression Models with Correlated Random Effects
George Tzougas
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This article considers bivariate mixed Poisson INAR(1) regression models with correlated random effects for modelling correlations of different signs and magnitude among time series of different types of claim counts. This is the first time that the proposed family of INAR(1) models is used in a statistical or actuarial context. For expository purposes, the bivariate mixed Poisson INAR(1) claim count regression models with correlated Lognormal and Gamma random effects paired via a Gaussian copula are presented as competitive alternatives to the classical bivariate Negative Binomial INAR(1) claim count regression model which only allows for positive dependence between the time series of claim count responses. Our main achievement is that we develop novel alternative Expectation-Maximization type algorithms for maximum likelihood estimation of the parameters of the models which are demonstrated to perform satisfactory when the models are fitted to Local Government Property Insurance Fund data from the state of Wisconsin.

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Return to programme

A Matter of Life and Death: Shedding Light on Swiss Medical Expenses During the Last Year of Life
Andrey Ugarte Montero
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Medical expenses tend to increase as individuals grow older. Specifically, in case of illness, the last year before death may represent a particularly costly period as the need for medical attention intensifies. By using a novel private insurance dataset containing over a million records of claims filed by individuals during the last year of their life to their health insurer, our research seeks to shed light on the medical costs before dying in Switzerland. In our work, we document how medical expense patterns change with proximity to death. Moreover, with the help of machine learning algorithms, we identify and quantify the main effects that drive a person's medical expenses in this critical period. Our findings provide a better understanding of the costs linked to hospitalization before death, the role played by age, and the differences in costs based on services, including care, required by individuals, among other factors.

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Return to programme

Portfolio Construction with Hierarchical Momentum
Urban Ulrych
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This paper presents a portfolio construction approach that combines the hierarchical clustering of a large asset universe with the stock price momentum. On the one hand, investing in high-momentum stocks enhances returns by capturing the momentum premium. On the other hand, hierarchical clustering of a high-dimensional asset universe ensures sparse diversification, stabilizes the portfolio across economic regimes, and mitigates the problem of increased drawdowns typically present in momentum portfolios. Moreover, the proposed portfolio construction approach avoids the covariance matrix inversion. An out-of-sample backtest on a non-survivorship-biased dataset of international stocks shows that, compared to the model-based and model-free benchmarks, hierarchical momentum portfolios achieve improved cumulative and risk-adjusted portfolio returns as well as decreased portfolio drawdowns net of transaction costs. Furthermore, our study indicates that the unique characteristics of the hierarchical momentum portfolios arise due to both dimensionality reduction via clustering and momentum-based stock selection.

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Return to programme

An augmented variable model for the analysis of grouped dependent lifetimes
Francesco Ungolo
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Insurance and annuity products issued on multiple lives require the use of statistical models which account for lifetime dependence. This work presents a Dirichlet Process Mixture-based approach which allows to model dependent lifetimes, such as married couples, accounting for individual and couple-specific covariates. The approach allows to account for right censoring and left truncation as typical of survival analysis. The model is analysed in a fully Bayesian setting and illustrated to the analysis of the joint and last survivor annuity dataset dataset of Frees et. al. (1996).

Return to programme

Improving Business Insurance Loss Models by Leveraging InsurTech Innovation
Emiliano Valdez
University of Connecticut

Recent transformative and disruptive developments in the insurance industry embrace various InsurTech innovations. In particular, with the rapid advances in data science and computational infrastructure, InsurTech is able to incorporate multiple emerging sources of data and reveal implications for value creation on business insurance by enhancing current insurance operations. In this paper, we unprecedentedly combine real-life proprietary insurance claims information and its InsurTech empowered risk factors describing insured businesses to create enhanced tree-based loss models. An empirical study in this paper shows that the supplemental data sources created by InsurTech innovation significantly help improve the underlying insurance company's internal or in-house pricing models. The results of our work demonstrate how InsurTech proliferates firm-level value creation and how it can affect insurance product development, pricing, underwriting, claim management, and administration practice.

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Return to programme

Optimal Savings and Portfolio Choice with Risky Labor Income and Reference-Dependent Preferences

Servaas van Bilsen
University of Amsterdam

This paper explores the joint impact of reference-dependent preferences and risky labor income on optimal savings and portfolio decisions. We develop a non-trivial solution procedure to determine the optimal policies. Our results reveal that the impact of permanent labor income shocks on both the optimal savings rate and the optimal portfolio share is more pronounced under reference-dependent preferences than under CRRA preferences. In particular, we find that in case of adverse labor income shocks, reference-dependent individuals often wish to withdraw financial wealth already before retirement. Furthermore, we show that the optimal response of the savings rate and the portfolio share to a fall in labor income exhibits large heterogeneity across the ratio of consumption to the reference level. Finally, we find that the optimal investment strategy is more conservative compared to the case with risk-less labor income and CRRA preferences.

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Return to programme

Green economy with efficient public incentives.

Emanuele Vannucci
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There is a general interest among institutions and economic agents for a reduction of the environmental impact of the production system. An important role seems to be played by the ability of public institutions to push the transition towards a green economy also through the application of fiscal policies that envisage a system of rewards and penalties, respectively, for those companies which adopt green strategies and those which don't.
It is clear that readjusting older production systems to new pollution regulations can lead in the short term to profitability reductions for the companies implementing them.
In our article we propose a dynamic model where the public administrations use pollution penalties as a control variable in order to push a production sector towards better performances as far as two targets are considered, pollution level and profitability. To this end we consider the effects of competitiveness among firms and technology innovation.

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Return to programme

Constrained Optimal Consumption and Investment for General Preferences
Michel Vellekoop
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To determine optimal strategies for consumption and investment under uncertainty [1] for a general class of utility functions, we extend an existing method to solve optimal investment problems [2] to the case which includes consumption. We first restrict utility functions to a particular class of functions and obtain that exact solutions can be found in the case where there are no constraints on investment and consumption. This class can then be used to define sequences of approximating preferences and corresponding discretization schemes for the stochastic dynamics of the risky assets. For such sequences of solutions we prove converge to the viscosity solution of the Hamilton-Jacobi-Bellman equations for the original problem. We then analyze the case where linear constraints are introduced for both the investment and consumption strategies.

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Return to programme

On the Pricing of Capped Volatility Swaps using Machine Learning Techniques
Eva Verschueren
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A capped volatility swap is a forward contract on an asset's capped, annualized realized volatility, over a predetermined period of time. The volatility swap allows investors to get a pure exposure to the volatility of the underlying asset, making the product an interesting instrument for both hedging and speculative purposes. In this presentation, we develop data-driven machine learning techniques in the context of pricing capped volatility swaps. To this purpose, we construct unique data sets comprising both the delivery price of contracts at initiation and the daily observed prices of running contracts. In order to predict future realized volatility, we explore distributional information on the underlying asset, specifically by extracting information from the forward implied volatilities and market-implied moments of the asset. The pricing performance of tree-based machine learning models and a Gaussian process regression model is presented in a tailored validation setting.

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Return to programme

Non-Crossing Dual Neural Network: Joint Value at Risk and Conditional Tail Expectation regression with non-crossing conditions

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For response variables with long conditional tails, algorithms based on Quantile Regression have been widely used to assess extreme quantile behaviors. The state-of-the-art methodologies to estimate Value at Risk (VaR) and Conditional Tail Expectation (CTE) controlled by covariates are mainly based on linear Quantile Regression, and usually do not consider non-crossing conditions across VaRs and their associated CTEs. We implement a non-crossing neural network that estimates both statistics simultaneously, for several quantile levels while ensuring that VaR and CTE at different levels fulfill the ordering by definition. We illustrate our method with a household energy consumption dataset from 2015 for quantile levels 0.9 to 0.99, and compare our method with a monotone composite quantile regression neural network approximation for the CTE specification. Computational time and an improvement in precision for large quantile levels is also analyzed.

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Return to programme

Optimal additional voluntary contribution in DC pension schemes to manage inadequacy risk

Elena Vigna
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In defined contribution pension schemes the member bears the investment risk and her main concern is obtaining an inadequate fund at retirement. To address inadequacy risk, flexibility is often given to the member to pay additional voluntary contributions (AVC) into the fund. In Anglophone European countries the AVC schemes allow members of the workplace pension plan to increase the amount of retirement benefits by paying extra contributions. In this paper we define a target-based optimization problem where the member of an AVC scheme can choose at any time the investment strategy and the additional voluntary contributions to the fund. In setting the problem, the member faces a trade-off between the importance given to the stability of payments during the accumulation phase and the achievement of the desired annuity at retirement. We derive closed-form solutions, run numerical simulations and perform sensitivity analysis to check controls' robustness and consider different member's preferences

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Return to programme

On the decomposition of mortality models into causes of death

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Decomposition methods are a standard tool used by demographers to understand and communicate the contribution of different factors to the evolution of demographic metrics. Despite their widespread use in demography, decomposition methods are less commonly used by actuaries. In this paper we develop a new approach for decomposing mortality improvement rate assumptions into the contribution of different causes of death. In particular, we show how we can decompose a Generalized Age-Period-Cohort mortality improvement rate model into the additive contribution of different causes of death. The methods introduced in this paper are useful for the communication of mortality improvement assumptions to users and decision makers and for shedding light into understanding the drivers of mortality change. We illustrate the decomposition methods using U.S. mortality data by cause of death for the period 1959-2019.

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Return to programme

Joint mortality models based on subordinated linear hypercubes

Fabio Viviano
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This work proposes a continuous-time joint mortality model for actuarial valuations and risk analyses of life insurance liabilities. The framework follows the idea described in Zhang and Brockett (2020) and uses a common subordinator for the marginal survivor processes, thus introducing a non-trivial dependence structure. Unlike Zhang and Brockett (2020), we model the underlying processes using Linear Hypercubes, a new class of Itô processes whose properties are discussed in Ackerer and Filipović (2020). As they belong to the class of polynomial processes, which extend the well-known and successful affine models, Linear Hypercubes display richer dynamics while maintaining analytical tractability. This feature enables us to derive closed-form solutions (up to the computation of a matrix exponential) for standard actuarial measures. The model shows a good fit to real data from a Canadian insurer and can be used to evaluate different insurance products issued to multiple lives, as shown through numerical applications.

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Return to programme

Building Resilience in Complex Cyber Systems – A Stylized Approach based on Network Science and Epidemic Contagion

Alexander Voß
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Systemic cyber risks like the 2017 WannaCry and NotPetya incidents pose a major threat to societies, governments, and businesses worldwide. For regulatory institutions, preventing cyber pandemics is thus a top-priority issue. Moreover, dealing with systemic accumulation risks is also challenging for insurance companies since risk pooling does not apply to these incidents.
Based on classical contagion models from network science and mathematical biology, we capture the spread of systemic cyber risks in a stylized fashion and identify two types of suitable controls: security- and topology-based interventions. In particular, topology-based measures are necessary to control the cyber pandemic risk exposure in large-scale systems with a more heterogeneous – and thus realistic - arrangement of network nodes. Further, we briefly discuss the implications of our findings on selected real-world cybersecurity measures currently applied in the insurance and regulation practice or which are under discussion for future cyber risk control.

Return to programme

4/2 rough and smooth

Ling Wang
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The controversial opinions on rough volatility stimulate us to propose a convex mixture of the rough Heston (rough 1/2) and the smooth 3/2 models to form a novel 4/2 rough and smooth (4/2RS) model in this study. This parsimonious two-factor model captures many stylized facts from empirical studies and flexibly displays the level of roughness and dependence of volatility. For instance, it makes the volatility get away from zero, generates the elasticity of variance of the variance process around 1, captures volatility roughness from short-term options, and offers a semi-closed form solution to the characteristic function for option pricing. Even for a very small weight on the rough 1/2 component, the 4/2RS model still manages to produce roughness like that of the pure rough 1/2 model. The adjustable weight between the rough 1/2 and the smooth 3/2 provides a flexible implied volatility curve with uncorrelated level and slope.

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Return to programme

On the Marketability of Registered Index-Linked Annuities
Yumin Wang
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Registered index-linked annuities (RILAs) are increasingly popular equity-linked insurance products which combine features of fixed-index annuities and traditional variable annuities (TVA). In this paper, we provide theoretical justification to the popularity of RILAs. Under a stochastic optimal stopping framework, we compare an investor's utility of holding RILAs to that of holding TVAs. We demonstrate that RILAs are preferable to TVAs, which explains their increasing popularity. Contract design suggestions for RILAs will also be discussed.

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Return to programme

On the area in the red of Lévy risk processes and related quantities
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In this paper, we study the expected areas in the red (below level 0) up to the recovery time, Poissonian and continuous first passage times for spectrally negative Lévy processes (SNLPs). Our results improve the existing literature in which only expected areas for the Brownian motion and the Cramér-Lundberg risk process with exponential jumps are known. Our approach is more probabilistic in nature, and our results involve only the scale function and the Laplace exponent of the underlying risk process, hence allowing the study of other area-related quantities.

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Return to programme

Counterparty Credit Risk Valuation with Replacement Closeout: Theory and Algorithms
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In this paper, we show how to address the nonlinearity attributed to the replacement closeout in the theoretical and computational analysis of counterparty credit risk valuation. In the theoretical part, we prove the unique solvability of the nonlinear valuation system and study the impact of the replacement closeout on the credit valuation adjustment. In the computational part, we propose a neural network-based algorithm for solving the (high dimensional) nonlinear valuation system and effectively alleviating the curse of dimensionality. We numerically compare the computational cost for the valuations with risk-free and replacement closeouts. The numerical tests confirm both the accuracy and the computational efficiency of our proposed algorithm for the valuation of the replacement closeout.

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Return to programme

Linear Risk Sharing in Intergenerational Pension
Morten Wilke
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We introduce and analyze a novel collective defined contributions plan (CDC) which guarantees upon retirement at least a target benefit as a lump sum. The guarantee is provided by the remaining working generations under a pre-determined linear intergenerational risk sharing (IRS) rule. Through a simulation-based study, we show that the CDC scheme consistently outperforms the comparable individual DC scheme in terms of risk-adjusted performance. An extensive sensitivity analysis indicates that this outperformance is robust, especially in a 'double-hit' scenario where the underlying market dynamics and the demographics are worse than assumed. Our work indicates that guaranteed retirement benefits can be organized via a CDC scheme with IRS in a way that is, first, beneficial for all generations and, second, resilient.

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Return to programme

Irreversible consumption habit under ambiguity: Singular control and optimal G-stopping time
Hoi Ying Wong
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Consider a robust utility maximization with irreversible consumption habit, where an ambiguity-averse agent does not tolerate any decline of her consumption and faces a disutility from consumption increase, simultaneously. This consumption habit induces a singular control while the ambiguity is referred to a set of non-dominated probability measures. We develop a duality theory connecting the singular controls in the optimization and optimal G-stopping times in a dual G-expectation space. Our connection can be seen as the robust analogue of the classical connection between singular controls and optimal stopping times. The robust consumption strategy is given through a running maximum of stochastic boundary characterized by the free boundary arising from the optimal G-stopping times. The duality, described through G-BSDEs and reflected G-BSDEs, is attained through verifying the first-order optimality conditions for the singular control, the budget constraint equation for the robust strategies, and the worst-case realization under the non-dominated measures.

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Return to programme

Risk-adjusted Kelly strategy
Kwok Chuen Wong
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Kelly strategy has long been utilized in various practical applications, especially in the themes of portfolio management and gambling. Despite many successful examples of investment management using Kelly-style strategies, it has been pointed out that the Kelly criterion is inherently a very risky investment. A possible way to address this criticism is to incorporate risk management practices into portfolio choice. Therefore, we embed downside risk measures into logarithm utility maximization to control the investment risk. We shall obtain the risk-adjusted Kelly strategy in terms of the solution to a system of equations. The performance of the risk-adjusted Kelly strategy will be assessed through a comparison with fractional Kelly strategies. Under most encountered market values of different model parameters, it is astonishing to observe that the additional adjustment using risk measures can significantly reduce the investment risk of the conventional Kelly criterion with an asymmetrically tiny loss in utility.

Return to programme

Joint life annuity derivative valuation in a linear-rational Wishart mortality model
Patrick Wong
University of New South Wales

This study proposes a linear-rational joint life mortality model based on the Wishart process. The Wishart process, which is a stochastic continuous matrix affine process, allows for a general dependency between the mortality intensities that are positive by construction. Using the linear-rational framework along with the Wishart process as state variable, we derive a closed-form expression for the joint life annuity contract as well as a derivative written on that contract. We explicit the distribution of the mortality intensities and their dependency. We also develop some polynomial expansions for the underlying state variable that lead to fast and accurate derivative price approximations. These polynomial expansions also significantly simplify the implementation and estimation of the model. Overall, the linear-rational Wishart model provides a flexible and unified framework for modelling and managing joint mortality risk.

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Return to programme

What is the average surplus before ruin?
Jae-Kyung Woo
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Our goal is to study the moments of the average surplus before ruin in a renewal risk process with a general interclaim time distribution. The average surplus before ruin is calculated as the area under the sample path divided by the ruin time, which provides a new ruin quantity of interest. However, the traditional approach of conditioning on the first claim event is no longer feasible because the ruin time appears in the denominator. To circumvent this, we show that the moments of the average surplus can be obtained by integrating the discounted moments of the area under the sample path with respect to the force of interest. These discounted moments can then be determined using a moment-based discounted density similar to the one in Cheung (2013). We also provide explicit formulas for the case where the claim amounts are a combination of exponentials.

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Return to programme

Asymmetric volatility connectedness among the US Treasury futures
Chih-Chiang Wu
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This paper examines the dynamic and asymmetric mechanism of realized volatility connectedness throughout the full maturity spectrum of US Treasury futures. By discomposing realize variance into semi-variances and employing the network connectedness framework proposed by Diebold and Yılmaz (2014), we document the chief volatility transmission function of the intermediate tenors as well as the net volatility receiver of the 2-year maturity throughout our sample period. However, this mechanism underwent structural change between the 2-year and 10-year maturities during the COVID-19 pandemic shock era. Regarding asymmetries, positive volatility connectedness dominates the negative connectedness, but negative connectedness only associates with the QE of GFC, whilst QE of COVID-19 shock is characterized by positive connectedness. This indicates the potential normalization of unconventional monetary in volatility connectedness among Treasury futures and the role of quantitative tightening post-GFC on these changes.

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Return to programme

Multivariate Poisson model adjusting for unidirectional covariate misrepresentation
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Insurance fraud has been a long-lasting issue in actuarial modelling. Policyholders are prone to hide their true status in their best interest when disclosing their information for insurance pricing purposes. However, from the insurers' point of view, it is either time-consuming or laborious to verify the true status of such risk factors. There is thus a strong incentive to build models accounting for potential misrepresentation, which contributes to a more robust ratemaking system. In this paper, we consider the misrepresentation problem in a multivariate Poisson model. As for inference, we develop a generalized expectation–maximization (EM) algorithm to estimate the parameters. Our model is then applied to the data from the Australian Health Survey. We demonstrate that the model considering misrepresentation is much superior to the one without considering it.

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Return to programme

Climate risk, health risks, and the roles of public insurance in poverty alleviation (POSTER ONLY)
Yang-Che Wu
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Poverty and climate change are common problem faced by all countries. “No Poverty” is the first one of the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015. Climate action failure and extreme weather are the top two global risk by severity are listed in the Global Risks Reports issued by World Economic Forum in 2022. Medical Expenses are always among top five causes of family bankruptcies in the U.S., the most developed country. Consequently, this research plan develops a theoretic framework for poverty trap to study how insurance can help to escape poverty traps under considering four factors: climate risk, health risks, economic cycle and human capital endowment. Comparative static analysis will demonstrate how insurance influences the probability of falling in to poverty trap. The contributions of this research will make the policymakers understand the importance of insurance in poverty alleviation.

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The ultimate drawdown insurance and its state-dependent premium structure
Duo Xu
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In this paper, we focus on the insurance contract against the drawdown risk, in particular where a claim is incurred when the ultimate drawdown occurs. The ultimate drawdown is triggered either when the drawdown process stays below the soft barrier for a long time (i.e., the Parisian drawdown) or by a significant large drawdown size exceeding the hard barrier.
For the L\'evy insurance process, we analyze the fair market premium under the proposed state-dependent structure (rather than the constant premium). We further examine the optimal terminations for the policyholder when a cancellation feature is allowed in the insurance contract, and make the comparison between the two premium structures. It turns out that the optimal stopping time is the first-passage time with some optimal stopping barrier.
Numerical examples are then presented for illustration purpose. The occupation time under distress is discussed as well.

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Return to programme

Modeling province-specific mortality in China
Mengyi Xu
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A rapidly aging population in China puts pressure on the social security system, which has expanded substantially in the past few decades. Since China's social security system is managed at the provincial level with different treatments for urban and rural residents, understanding regional differences in mortality is essential to the continuing development of the system that helps to address vast social inequality. We extend the state-space formulation of the Lee-Carter model to include a clustering method and fit the model using the Markov chain Monte Carlo methods. Such an approach offers a possible solution to the data sparsity problem of Chinese mortality data by borrowing information from countries with higher-quality data. The results of mortality trends by province and urban-rural areas will help build a more sustainable centralized social security system in China.

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Return to programme

Optimal singular dividend control with capital injection and affine penalty payment at ruin
Ran Xu
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In this paper, we extend the optimal dividend and capital injection problem with affine penalty at ruin in (Xu, R. and Woo, J.K. Insurance: Mathematics and Economics 92:1 16 (2020)) to the case with singular dividend payments. The asymptotic relationships between
our value function to the one with bounded dividend density are studied, which also help to verify that our value function is a viscosity solution to the associated Hamilton Jacob Bellman Quasi Variational Inequality (HJBQVI). We also show that the value function is the smallest viscosity supersolution within certain functional class. A modified comparison principle is proved to guarantee the uniqueness of the value function as the viscosity solution within the same functional class. Finally, a band type dividend and capital
injection strategy is constructed based on four crucial sets; and the optimality of such band type strategy is proved by using fixed point argument. Numerical examples of the optimal band type strategies are provided at the end w hen the claim size follows exponential and gamma distribution respectively.

Return to programme

Borrowing Information across Space and Time: Pricing Flood Risk with Physics-Based Hierarchical Machine Learning Models

Yanbin Xu
Nanyang Technological University

This paper aims to propose a physics-based hierarchical machine learning (ML) framework to improve the interpretability of the ML models in risk estimation and resolves the difficulty of flood risk prediction due to anthropogenic effects. Using the Mississippi river as a laboratory, we embed high-resolution climate and hydraulic data into the model and demonstrate that the proposed models perform better than conventional ML model benchmarks in risk estimation. Moreover, we applied the model-generated risk factors to the national flood insurance program (NFIP) policy & claim dataset to create an index insurance program and an indemnity insurance program. While the risk factor generated using the proposed model improves the index insurance in terms of reducing the basis risk, it also lowers the capital requirement of the indemnity insurance under different premium principles. The proposed model outperforms the benchmarks because our global optimization allows the model to borrow spatial and temporal information.

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Return to programme

Taylor's Law of Fluctuation Scaling for Semivariances and Higher Moments of Heavy-tailed Data

Phillip Yam
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We introduce Taylor's law and its generalization for variance of light-tailed distributions to many sample statistics of heavy-tailed distributions with infinite mean, namely, as sample size increases, the sample upper and lower semivariances, sample higher moments, skewness, and kurtosis of a random sample from the law increase asymptotically in direct proportion to a power of sample mean. These and additional scaling laws characterize the asymptotic behavior of commonly used measures of the risk-adjusted performance of investments, such as Sortino and Sharpe ratios, when returns follow heavy-tailed nonnegative distributions. Such power-law scaling relationships are known in ecology as Taylor's law and in physics as fluctuation scaling. We find the asymptotic distribution and moments of number of observations exceeding the sample mean, and finally propose estimators of tail index based on these scaling laws and the number of observations exceeding the sample mean and compare these estimators with some prior estimators.

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Return to programme

Benchmark-driven investment for DC Pension Plans
Li Yang
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We investigate whether risk-taking for resurrection type of risk preference (non-constant risk aversion) can increase the probability of achieving inflation-indexed benchmark at retirement, especially when the value of the starting asset is below the expected value of this desired benefits. Our model incorporates a lower bound to guarantee the fund's minimum value at retirement. By maximizing the expected utility of the ratio of wealth at retirement to this inflation-indexed benchmark, we find that this non-constant risk aversion type of utility gives a high degree of certainty about achieving a certain percentage of this desired benchmark. The CRRA utility is too risk averse to achieve the benchmark.

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Return to programme

Optimal Consumption and Investment Problem Incorporating Household's Subjective Beliefs
Shang-Yin Yang
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The household's subjective beliefs affect their views on labor income, mortality, and price changes in the capital market. This study investigates the effects of household's subjective beliefs on the household financial decisions in a stochastic financial market. Using the data collected from government departments in Taiwan, this study calibrates the model parameters and analyzes the effect of insurance demand and bequest motivation on the household financial decisions. The results show that households with a pessimistic outlook tend to have a lower savings rate and higher consumption compared than households with an optimistic outlook, suggesting household beliefs play a significant role in shaping household finance.

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Return to programme

Pricing Tenure Payment Reverse Mortgages Integrating Long Term Care Insurances with Optimal Exercised Prepayment Options under House Price, Interest Rate, and Mortality Risk

Sharon Yang
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A reverse mortgage (abbreviated as a RM) allows an elder homeowner to pledge her house for retirement income without selling or moving out of her house. We consider the RM contract will be terminated only when the borrower can't take care of himself or die. A borrower's health conditions can be enumerated as health, self-care inability and death.To find optimal exercise policies that maximize option premiums and establish the most conservative annuity rates, we propose a three-dimensional tree for modeling stochastic house prices, interest rates, and mortality risks. Fair annuity rates are evaluated to ensure that expected insurer losses (i.e., loan balances exceeding house values) equal gains (i.e., insurance premiums plus house values exceeding loan balances). We find that such non-optimal exercise policies undervalue option premiums and overestimate fair annuity rates. Increasing upfront premiums, insurance premium rates, and early redemption charges reduce prepayment incentives and increase fair annuity rates.

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Return to programme

Learning about Shifts in a Financial Market under Uncertainty

Yunshen Yang
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When trading in a financial market, participants need to cope with unexpected shocks and dangerous situations. To elicit participants' behaviour under uncertainty, we consider a financial market with both short-lasting aberrations and long-lasting regime shifts. Participants need to forecast shifts in a series of trials and gradually learn the pattern under different types of uncertainty such as structural uncertainty, distributional uncertainty, and parametric uncertainty. In consideration of the potential risk-aversion and ambiguity-aversion of participants, we construct behavioural models under various learning rules including experience-weighted-attraction learning, reinforcement learning, and Bayesian learning, and we fit each model with laboratory data. Our study reveals how people adopt different behavioural strategies under different types of uncertainty and sheds light on the impact of uncertainty on financial performance in the real world.

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Return to programme

The threshold effect of climate risk and the nonlinear role of climate policy uncertainty on insurance demand: evidence from OECD countries

JING YAO
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This paper investigates whether climate risk and climate policy uncertainty have a traditional linear or complicated non-linear impact on insurance demand. Based on a sample of 28 OECD countries from 2006 to 2019, we find evidence showing that both phenomena exist. We first conduct traditional linear regressions, which show a positive effect of climate risk and a negative effect of climate policy uncertainty on insurance demand. Note that climate risk and climate policy uncertainty are interdependent. We then employ non-linear analysis demonstrating that climate policy uncertainty plays the role of a threshold. In particular, climate risk has a U-shaped relationship with demand for life insurance and an inverse S-shaped relationship with non-life insurance. We hope this study can provide practical guidance and understanding for insurance companies on how insurance demand fluctuates against climate risk and climate policy uncertainty.

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Return to programme

LIFE INSURANCE VALUATION UNDER PANDEMIC RISKS: COVID-19

Cem Yavrum
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The Covid-19 pandemic has changed the world, affecting almost every industry, including the insurance sector. Since health and life products considering epidemic risk will gain prominence in the future, insurance companies need to consider pandemic dynamics on their products to minimize the effect of the epidemic. From a life insurance perspective, traditional actuarial models and mortality tables lack the flexibility to model infectious diseases which are significantly different from natural cases of death. In this study, the implementation of epidemiological models on the valuation of life insurance premiums is considered. Covid-19 cases are utilized to illustrate the efficiency of a modified risk scheme based on an epidemic cause. Subsequently, the reserve of some life insurance products is examined. The expected outcome of the study is to determine how costly the pandemic risk is on life insurance.

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Return to programme

Bivariate phase-type distributions for experience rating in disability insurance
Jorge Yslas
University of Liverpool

We consider experience rating in the classic Markov chain life insurance setting. To this end, we first study multivariate mixed Poisson models under different mixing distributions, including independent Gamma, Hierarchical Gamma, and multivariate phase-type. In all cases, we show how maximum likelihood estimation of the proposed models can be carried out via EM algorithms. Then, we provide a link between mixed Poisson distributions and the problem of pricing group disability insurance contracts subject to heterogeneity. In particular, we consider shrinkage estimation of disability and recovery rates subject to, among other things, right-censoring. Finally, the applicability of these shrinkage estimators is illustrated with a simulated data example which shows that, by allowing for dependence between latent group effects, the estimation of the recovery rate can borrow strength from the estimation of the disability rate and vice versa, leading to improvements in predictive performance.

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Return to programme

Computing the tail conditional allocation under the multivariate truncated normal distributions
Chong Yu
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The multivariate normal distributions have been widely advocated as an elegant yet flexible model, which uses a simple covariance matrix parameter to capture the intricate dependence involved in high-dimensional data. However, insurance loss random variables are often assumed to be non-negative. Thereby, the multivariate normal distributions must be properly truncated to be adopted in insurance applications. In this presentation, we propose an efficient numeric scheme to compute the tail conditional allocation for the multivariate truncated normal distributions, which hinges on the holonomic gradient method for computing the probability content of a simplex structure.

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Return to programme

Asymptotic Dissimilarity
Zhongyi Yuan
The Pennsylvania State University

Probability distance has been widely used to measure dissimilarities between probability distributions and has seen extensive applications in various fields such as statistical learning, information theory, and risk management.
In risk management, it is important to be able to distinguish tail risks and, to this end, we study the dissimilarities between distributions in their tails. We employ extreme value theory and asymptotic analysis to characterize the dissimilarities for heavy-tailed distributions based on their Wasserstein distance and φ-divergence. Our characterization is fine enough to capture the dissimilarities between similar tails that have the same tail index.
We also use real-world data to demonstrate how a tail risk conscious asset manager could use the results for portfolio management.

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Return to programme

Life Insurance and Annuity Pricing During the Financial Crisis, Revisited
George Zanjani
University of Alabama

We reexamine insurance and annuity pricing during the 2008 financial crisis. We find that the existing narrative---of insurers selling policies at significant economic loss to gain statutory accounting benefits---is false. Instead, we show that the pricing was set to produce unusually high rates of return on capital and thus was consistent with standard theories of pricing in the presence of financial frictions. Moreover, we show that experience in 2008 was not extraordinary but 1) mirrored earlier episodes where corporate borrowing rates rose quickly, and 2) produced, as in earlier and subsequent episodes of bond market stress, an inversion of the expected relationship between price and default risk.

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Return to programme

The Ignorance of Crowds: Understanding Loss Reserving Errors in the Liability Catastrophe of 1997-2001

George Zanjani
University of Alabama

We estimate first-report company-level ultimate loss ratios by accident year and line using Chain Ladder and Bornhuetter-Ferguson techniques. We find that posted first report loss ratios track closely with Bornhuetter-Ferguson estimates, and that these estimates are more precise than Chain Ladder estimates at the company level. However, when the estimates are rolled up to the industry level, the Chain Ladder rollups are significantly more accurate than both the Bornhuetter-Ferguson rollups and the rollups of the results actually posted. We interpret this as a failure of information aggregation, driven by the reliance of companies on reserving methods that are essentially Bayesian updates keyed to highly correlated priors. We show further that the Bayesian priors appear to be relatively unresponsive to new information, which allows accident year errors to persist over time.

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Return to programme

On pricing some complex life insurance products

Raghid Zeineddine
University of Liverpool

I would like to speak in my talk about pricing some complex life insurance products called variable annuities that represent three features: a minimum accumulation benefit to be paid at the maturity of the life insurance contract, a death benefit and a surrender benefit. Considering a model for this last benefit is very important for insurance companies especially after the covid-19 pandemic. The setup is based on a hybrid model for the financial market and uses time-inhomogeneous Levy processes as risk drivers.

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Return to programme

Is accumulation risk in cyber systematically underestimated?
Gabriela Zeller
Technical University of Munich

Recently, many insurers have started to underwrite cyber and developed their first actuarial models for this new risk type. On the portfolio level, two major challenges are the adequate modelling of the dependence structure among cyber losses and the lack of suitable data to calibrate the model. This presentation highlights the importance of taking a holistic approach to cyber, in particular, that actuarial modelling should be viewed as an integral part of an interconnected value chain with processes such as cyber-risk assessment and cyber-claims settlement.
We mathematically illustrate that otherwise, i.e. if these data-collection processes are not aligned with the actuarial (dependence) model, naïve data collection necessarily leads to a dangerous underestimation of accumulation risk. We analyze the detrimental effects on the assessment of the dependence structure and portfolio risk using a simple mathematical model for dependence through common vulnerabilities. The presentation concludes by highlighting the practical implications for insurers.

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Return to programme

Navigating Uncertainty in ESG Investing: A Reinforcement Learning Approach to ESG-Related Portfolio using Mean-Variance Utility
JIAYUE ZHANG
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To create a portfolio that is optimized for both financial returns and sustainability, this paper incorporates ESG scores in the reward function of Reinforcement Learning in order to analyze the effect of various ESG rating agencies on the coherence of investment strategies more robustly. Uncertainty induced by ESG rating agencies is treated in the model as a source of ambiguity and four ESG ensemble strategies are proposed to cater to investors' different risk and ambiguity preference profiles. Additionally, the paper uses a Double-Mean-Variance model to combine the objectives of financial returns and ESG scores theoretically, defines three types of investors, analyzes the optimal portfolio weights for these investors, and constructs novel ESG-modified Capital Asset Pricing Models to evaluate the performance of the resulting optimized portfolio. Lastly, the paper also extends the Fama-French three-factor model to examine the contribution of each separate component of the three pillars of ESG.

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* (It is very sad that Ken Seng has left us forever. This is the project we have worked on together in 2022.)

Return to programme

Integrated Design for Index Insurance
Jinggong Zhang
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Weather index insurance (WII) is a promising tool for agricultural risk mitigation, but its popularity is often hindered by challenges of product design, such as basis risk, weather index selection and product complexity issues. In this paper we develop machine learning methodologies to design the statistically optimal WII to address those critical concerns in the literature and practice. The idea from tree-based models is exploited to simultaneously achieve weather variable selection and payout function determination, leading to effective basis risk reduction. The proposed framework is applied to an empirical study where high-dimensional weather variables are adopted to hedge soybean production losses in Iowa. Our numerical results show that the designed insurance policies are potentially viable with much lower government subsidy, and therefore can enhance social welfare.

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Return to programme

Bayesian CART for insurance pricing
Yaojun Zhang
University of Leeds

An insurance portfolio offers protection against a specified type of risk to a collection of policy-holders with various risk profiles. Insurance companies use risk factors to group policyholders with similar risk profiles in tariff classes. Premiums are set to be equal for policyholders within the same tariff class which should reflect the inherent riskiness of each class. tree-based methods, like the classification and regression tree (CART), have gained popularity as they can in some cases give good performance and be easily interpretable. In this talk, we discuss a Bayesian approach applied to CART models. The idea is to have the prior induce a posterior distribution that will guide the stochastic search using MCMC towards more promising trees. We shall introduce different Bayesian CART models for the insurance claims data, which include the frequency-severity model and the (zero-inflated) compound Poisson model. Some simulation and real data examples will be discussed.

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Return to programme

Robust Mean-Variance Portfolio Optimization: Mean-Variance-Variance criterion v.s. Mean-Variance-Standard Deviation criterion

Yuanyuan Zhang
University of Waterloo

We study a dynamic robust portfolio optimization problem under the mean-variance-variance (M-V-V) criterion proposed by Maccheroni et al. (2013). It is an analogue of the Arrow-Pratt approximation to the well-known smooth ambiguity model. Under the standard Black-Scholes framework, fully explicit equilibrium investment strategies are derived which exhibit clear separation of risk aversion, ambiguity aversion, and level of ambiguity. We find the time horizon appears inconsistently in the objective function of the M-V-V criterion which causes the equilibrium strategies to be non-monotonic with respect to risk aversion. In response, we introduce a new mean-variance-standard deviation (M-V-SD) criterion to address this issue. Equilibrium strategies under the M-V-SD criterion exhibit an appealing feature of limited stock market participation which provides a theoretical justification to the empirical evidence that a significant portion of households does not invest in the stock market.

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Return to programme

Efficient and proper GLM modelling with power link functions

Feng Zhou
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Generalised linear modelling is a flexible predictive model for observational data that is widely used in practice. Such predictive model requires a careful choice of the link function, and estimation is then achieved by maximum likelihood estimation for which an optimisation algorithm is required. The computational efficiency is not well-understood, and we raised awareness of importance of choosing the right link function so the goodness of fit tests and other model adequacy tests are meaningful. Our main contributions are as follows: 1) formalise the concept of proper Generalised linear modelling so that a Generalised Linear Model is more reliable, 2) raise awareness of the consequences of choosing an improper link function, 3) provide novel algorithms that are computationally stable. The latter two contributions are illustrated through a comprehensive comparison with all available off-the-shelf existing packages implemented in MATLAB, Python and R.

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Return to programme

Testing gender disparity in mortality improvement trends in Asia-Pacific countries: Implications on the life insurance industry

Kenneth Zhou
Arizona State University

In this project, we study the issue of gender disparity in mortality improvement trends. We first develop a statistical test to examine the extent of such disparity for different age groups, and then apply the proposed test to mortality data from various Asia-Pacific countries. Our preliminary results indicate that there exists a significant long-term divergence in mortality improvement trends between genders, and the extent of such a divergence depends on age and geographical location. For example, in Japan gender disparity is more significant at retirement ages, but in China working age groups are experiencing stronger gender disparity. We further develop an adapted Lee-Carter model that captures the gender disparity found in the statistical test. The proposed model is then used to investigate the impact of gender disparity in mortality improvement trends on life insurers in the region, particularly that concerning gender-neutral pricing of life insurance and annuity products.

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Return to programme

Equilibria and Efficiency in a Reinsurance Market: Heterogeneous Beliefs and Choquet Pricing

Michael Zhu
University of Waterloo

We study equilibria in a reinsurance market with multiple reinsurers, where preferences are given by distortion risk measures. We construct a model in the form of a sequential economic game, where the reinsurers have the first-mover advantage over the insurer, as in the Stackelberg setting. However, unlike the Stackelberg setting which assumes a single monopolistic reinsurer, our model accounts for strategic price competition between reinsurers. We argue that the notion of a Subgame Perfect Nash Equilibrium (SPNE) is the appropriate solution concept, and we characterize SPNEs with sufficient conditions. We then examine ex post efficiency properties of SPNE contracts, and show that these contracts result in Pareto-efficient allocations. Additionally, we show that under mild conditions, the insurer realizes a strict welfare gain, addressing the concerns of Boonen and Ghossoub [1] with the Stackelberg model and ultimately reflects the benefit to the insurer of competition on the supply side.

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Return to programme

Mortality Risks, Subjective Well-Being and Polygenic Scores: Evidence from the Health and Retirement Study

Nan Zhu
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The relationship between an individual's subjective well-being and their future mortality prospects has been well documented. Using data from the Health and Retirement Study combined with genetic information, we present empirical evidence of how this relationship operates through various channels. Our findings reveal that both the genetic and environmental factors contributing to subjective well-being have a significant impact not only on the objective mortality of participants in our study, but also on the bias in their survival estimation—measured as the disparity between individuals' subjective and objective survival probabilities. Our gender-specific analyses further reveal diverging observations for females and males in terms of explaining the bias in survival estimation.

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Return to programme

Machine Learning in Long-term Mortality Forecasting

Wenjun Zhu
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We propose a new machine learning-based framework for long-term mortality forecasting. Based on ideas of neighbouring prediction, model ensembling, and tree boosting, this framework can significantly improve the prediction accuracy of long-term mortality. In addition, the proposed framework addresses the challenge of a shrinking pattern in long-term forecasting with information from neighbouring ages and cohorts. An extensive empirical analysis is conducted using various countries and regions in the Human Mortality Database. Results show that this framework reduces the mean absolute percentage error (MAPE) of the 20-year forecasting by almost 50\% compared to classic stochastic mortality models, and it also outperforms deep learning-based benchmarks. Moreover, including mortality data from multiple populations can further enhance the long-term prediction performance of this framework.

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A Bayesian generalized additive model approach to forecasting mortality improvement with expert judgment

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Mortality modeling is facing new challenges as historical mortality experiences are insufficient to foresee the future impact of the COVID-19 pandemic. Experts' opinion has become one important source of information that provides additional insights into the pandemic's possible future courses. In this paper, we develop a Bayesian generalized additive model where expert elicitation is seamlessly integrated into the projections of future mortality improvement rates. A collection of spline functions over age, period, and cohort dimension is utilized to construct a smooth transition of mortality improvement trends from recent mortality shocks to long-term rates. Our approach is able to reflect the diversity of expert opinions and incorporate multiple types of elicited data in a probabilistic and coherent manner. We illustrate the application of the proposed model with predictive imputation on populations with insufficient mortality data.

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Innovative Combo Product Design Embedding Variable Annuity and Long-term Care Insurance Contracts

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This paper presents a novel combo insurance product design consisting of a variable annuity contract embedded with guaranteed minimum income benefit and long-term care insurance riders. This product provides leveraged benefit when the policyholder is functionally disabled. We model mortality and morbidity risks by a 4-state Markov chain disability transition model calibrated to the latest available data from the University of Michigan Health and Retirement Study. The Hamiltonian Monte Carlo (HMC) simulation technique is utilised for numerically pricing the combo product. HMC is a proven computational technique for simulating high-dimensional distributions. Its convergence speed is fast, and the sample shows very-low autocorrelation. Cost efficiency analyses relative to long-term care annuities (long-term care insurance combined with fixed annuities) reveal that the combo product is attractive to policyholders and providers. Sensitivity analysis with respect to various model parameters provides a comprehensive analysis of the pricing and risk management of the product.

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