The 25th International Congress on Insurance: Mathematics and Economics

July 12th–15th 2022
Online

Conference Organizers

中山大學嶺南學院 LINGNAN COLLEGE SUN YAT-SEN UNIVERSITY

MACQUARIE University SYDNEY·AUSTRALIA

Co-Organizer

中山大学金融工程与风险管理研究中心
Sun Yat-Sen,Center for Financial Engineering and Risk Management
广东省人文社会科学重点研究基地

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Scientific Committee

Chair:

Zhongfei Li, Southern University of Science and Technology

Members:

Hansjörg Albrecher, University of Lausanne
Bingzheng Chen, Tsinghua University
Jan Dhaene, KU Leuven
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Junyi Guo, Nankai University
Taizhong Hu, University of Science and Technology of China
Zhuo Jin, Macquarie University
Roger Laeven, University of Amsterdam
Zongxia Liang, Tsinghua University
Sheldon Lin, University of Toronto
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Ken Siu, Macquarie University
Qihe Tang, University of New South Wales
Rongming Wang, East China Normal University
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Organizing Committee

Chair:

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Jianwei Hu, Sun Yat-sen University
Jiwook Jang, Macquarie University
Junqing Kang, Sun Yat-sen University
Danping Li, East China Normal University
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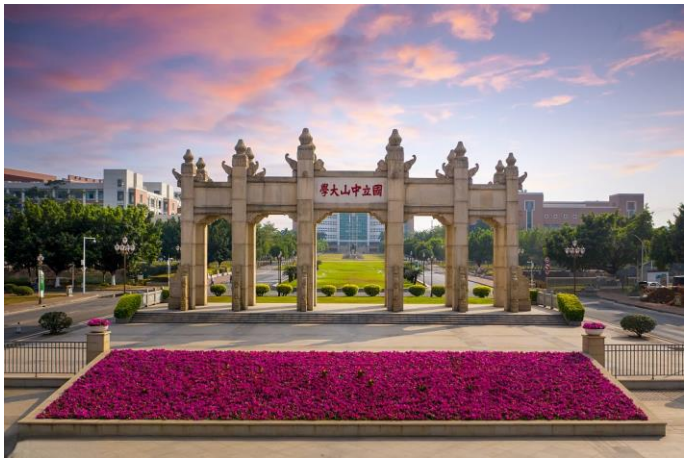
Yu Liu, Sun Yat-sen University
Haoran Peng, Sun Yat-sen University
Linyi Qian, East China Normal University
Hanlin Shang, Macquarie University
Shuguang Shen, Sun Yat-sen University
Yanlin Shi, Macquarie University
Shibin Song, Sun Yat-sen University
Ling Sun, Sun Yat-sen University
Chong It Tan, Macquarie University
Zhiwei Tong, The University of Iowa
Chi Truong, Macquarie University
Wenyuan Wang, Xiamen University
Yuantao Xie, University of International Business and Economics
Wenguang Yu, Shandong University of Finance and Economics
Xudong Zeng, Shanghai University of Finance and Economics
Colin Zhang, Macquarie University
Yong Zhang, Sun Yat-sen University
Zhimin Zhang, Chongqing University

Conference Organizers

Lingnan College, Sun Yat-sen University

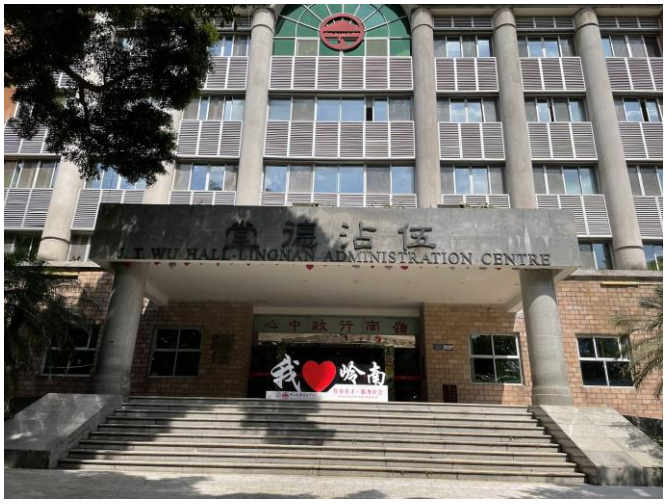
About Sun Yat-sen University



Founded by Dr. Sun Yat-sen and with an educational tradition spanning over 100 years, Sun Yat-sen University is a preeminent research, academic and cultural center and the premier location for talent development in South China. SYSU is under the direct leadership of the MoE and has the "985", "211" and "Double First-Class" marks. With five campuses in the three cities of Guangzhou, Zhuhai and Shenzhen, and ten affiliated hospitals, the University is striving to become a world-class university and global center of learning.Ranked among the top 1% of universities in the world, Macquarie University enjoys an enviable reputation for research excellence – 100 per cent of the research is ranked at world standard or above. Looking to the future, Macquarie has developed five research priorities – Healthy People, Resilient Societies, Prosperous Economies, Secure Planet and Innovative Technologies – that provide a focal point for the cross-disciplinary research approach that's at the heart of Macquarie's ethos.

With about 61,786 students and 17,614 employees the university contributes significantly to the research landscape of China. Built on a solid multidisciplinary foundation of humanities, social sciences, natural sciences, medical sciences, and engineering, Sun Yat-sen University is propelled forward by the continuous pursuit of academic innovation. The University is equipped with a globally aware outlook, and has dedicated itself to being an institution that is "comprehensive, innovative, and open". The goal of talent cultivation is to nurture students who have both ability and moral integrity, able to cultivate charisma and eager to serve their country. The guiding philosophy is to be oriented toward academic frontiers, oriented toward national major strategic needs, and oriented toward national and regional economic and social development. The basic approach is through the construction of big research teams, big platforms and big projects. The University is pushing forward the transformation from external development to internal development, the transformation from routine development to active development, and the transformation from advantages in humanities, social sciences, natural sciences and medical sciences to a university where humanities, social sciences, natural sciences, medical sciences and engineering can integrate and develop while retaining their distinctive characteristics. Now, standing at a new starting point, Sun Yat-sen University strives to foster an academic environment where all disciplines develop distinctively yet systematically, thus blossoming into an institution with influence and impact on a global scale.

About Lingnan College



Lingnan is a school of economics that provides programmes in economics and finance. Currently, the College offers programmes ranging from undergraduate to the Master's and PhD levels. It also provides specialized master's programme in finance, international business and insurance. All those programmes are among the most competitive programmes in China and are considered the best ones in South China. In 2018, Master of Finance programme ranked No. 60 globally. the Global Three Programme (collaborated with the McIntire School of Commerce at the University of Virginia (USA) and ESADE Business School (Spain) to offer a postgraduate program) was ranked No. 1 in Asia Pacific in most recent QS and FT Rankings.

The College currently has about 100 full-time faculty members and continuously strives for academic excellence. The faculty members carry out rigorous and original research with particular focus on China's ongoing economic development by publishing in first tier international and national research journals. To build up a high-quality education brand and forge Lingnan's international reputation, the College is committed to building up a world-caliber faculty team and forging a platform for career development.

Lingnan is triple-crowned in AACSB, EQUIS and AMBA. Lingnan has also established an extensive network of partnerships with over 40 leading universities around the globe. International cooperation focuses on student exchange, faculty exchange, dual degree programmes, joint research, and etc. This global partnership network has provided students and faculty alike with a platform for international exchanges that enhances teaching, learning and research collaboration.

Macquarie Business School, Macquarie University

About Macquarie University

Macquarie University is a public research university based in Sydney, Australia. Uniquely located in the heart of Australia's largest high-tech precinct, Macquarie brings together more than 44,000 students and 3000 staff in one thriving hub of discovery. Since its foundation in 1964, Macquarie has aspired to be a different type of university: one unbound by ivory towers and sandstone walls. Built to break from traditions and work in tandem with industry, Macquarie strives for the extraordinary by challenging convention and embracing different views.

Ranked among the top 1% of universities in the world, Macquarie University enjoys an enviable reputation for research excellence – 100 per cent of the research is ranked at world standard or above. Looking to the future, Macquarie has developed five research priorities – Healthy People, Resilient Societies, Prosperous Economies, Secure Planet and Innovative Technologies – that provide a focal point for the cross-disciplinary research approach that's at the heart of Macquarie's ethos.

With more than 300 leading companies located in the Macquarie Park Innovation District around the Macquarie campus, Macquarie students are able to tap into industry connections that give them an edge in their future careers, while Macquarie staff have access to outstanding research and innovation opportunities with some of the world's leading organisations.

About Macquarie Business School

MACQUARIE University BUSINESS SCHOOL SYDNEY·AUSTRALIA

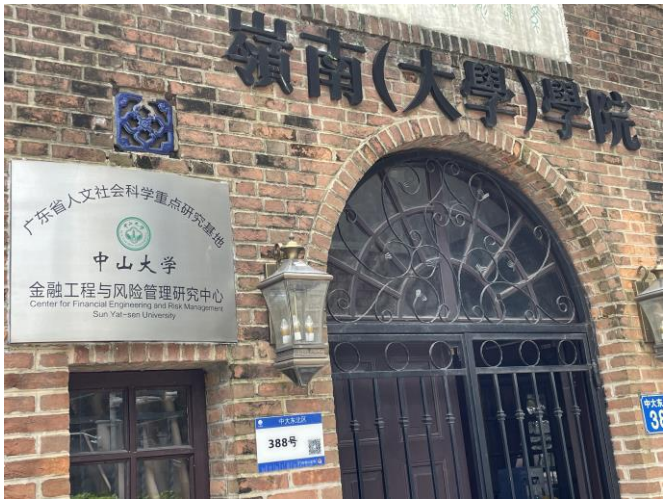
Macquarie University has been a leading provider of actuarial education for over 50 years. As the first university to be accredited with a professional actuarial body in the world, Macquarie University has consistently delivered a first-class experience to our students. In addition to being accredited with the Actuaries Institute, Macquarie University is also recognised as a Center of Actuarial Excellence by the Society of Actuaries.

Macquarie Business School was established in 2019 and is the home for all business, management and economics research and education at Macquarie University. Macquarie Business School is an AACSB accredited and highly engaged business school. Working with our corporate partners, students, and alumni, we create and communicate insights through research that addresses business and societal challenges. Our purpose is to provide inspiring and engaging business education and research that is useful to students throughout their careers and for solving society's biggest problems.

Being one of the six departments in the Macquarie Business School, Department of Actuarial Studies and Busines Analytics is the home for a group of leading actuarial scholars who have produced world-class research at the forefront of the discipline. Our research programs focus on the practical application of advanced quantitative approaches for innovation in insurance and business. Macquarie Business School is ranked fifth globally among business schools in the UNL Global Research Rankings of Actuarial Science and Risk Management & Insurance for the period of 2016-2020.

Co-Organizer

The Center for Financial Engineering and Risk Management of Sun Yat-sen University



The Center for Financial Engineering and Risk Management of Sun Yat-sen University (hereinafter referred to as the Center) is a scientific research institution directly affiliated to Sun Yat-sen University. In June of 2003, the Center was officially established with the approval of Sun Yat-sen University. With the strong support of Sun Yat-sen University, Lingnan College and other sister universities, the Center was authorized as the key research base of Humanities and Social Sciences in Guangdong Province in July of 2010. In 2012, it was rated as an advanced team of the "Thousand-Hundred-Ten Projects" of colleges and universities in Guangdong Province. In 2013, it was rated as outstanding of all key research bases of Humanities and Social Sciences in Guangdong Province.

At present, the Center has 1 Ministry of Education Yangtze River scholar professor, 1 Ministry of Education Young Yangtze River scholar professor, 2 winners of National Science Fund for Distinguished Young Scholars, 1 winner of National Science Fund for Excellent Young Scholars, 2 winners of The 100th excellent doctor degree dissertation in China and 2 Guangdong province universities and colleges Young Peal River scholars. The Center also has a group of outstanding researchers, experts and scholars from academia, politics and industry both domestically and internationally.

The Center is oriented towards the world's scientific and technological frontier, the main economic battlefield, the major needs of the country, and the people's life and health. With the purpose of building a high-level and open research platform for financial engineering and risk management, the center comprehensively applies the theories, methods and technologies of finance, economics, management, mathematics, engineering, behavior and other disciplines in studying and creatively resolving major theoretical and practical problems encountered in financial development. The Center works hard to promote the construction of large projects, teams and platforms, and strives to build a national key research base, a key laboratory and a high-end think tank in the fields of economy, finance and management. Specifically, it conducts academic research on cutting-edge scientific issues in important directions such as digital finance, inclusive finance, digital insurance, supply chain finance, pension finance, real estate finance and risk management. The Centre carries out policy research on major practical issues of national strategies such as financial supply-side structural reform, aging, digital China, financial security, and financial support for the elderly.

Closely centering on the main work of scientific research and policy research, the Center has made full use of its advantages at the forefront of reform and opening up, and established a long-term and extensive academic exchange relationship with internationally renowned universities and academic

institutions. The Center has hosted "Sun Yat-sen University Financial Engineering and Risk Management Seminars Series" and "Quantitative Finance and Insurance Branch of Chinese Society of Optimization, Overall Planning and Economic Mathematics Academic Annual Conference" for many years, and has undertaken a large number of major and key national projects, produced plenty of high-caliber treatises, and offered decision-making advisory services for economic and financial realities. Our achievements effectively promote discipline construction and talent training, and play an increasingly important role in scientific research and social services.

Members of the Center have won more than ten important projects, including the Creative Research Groups project, major project and key project of the National Natural Science Foundation of China, major project of the National Social Science Fund of China, major project of the Ministry of Education, National Natural Science Foundation of China/RGC Joint Research Scheme, and research team project of Guangdong Natural Science Foundation. We have published a series of papers in UTD/FT/ domestic top journals, and won more than 20 first or second prizes at the ministerial and provincial levels. Our works have been approved by the premier, the chairman and other central leaders more than 20 times.

The Center is working to enhance its capacity to support local, regional, and national economic and social development. Members of the Center actively offer decision-making consulting services for governments at all levels, enterprises and institutions by undertaking horizontal topics. Members of the center give full play to the role of "think tanks" and "brain trust" by serving as consultants of governments at all levels, enterprises and institutions, and leaders of various academic groups.

Compact Schedule

IME 2022

Schedule

ORGANIZERS:

25th International Congress on Insurance: Mathematics and Economics

Guangzhou & Sydney, UTC+8, Tue-Fri, July 12–15, 2022

Tuesday, July 12

20:30 Opening Ceremony

21:00 Keynote Speech

21:50 *Break*

22:15 Parallel Sessions (Eight)

23:55

Wednesday, July 13

15:00 Parallel Sessions (Eight)

16:40 *Break*

17:00 Parallel Sessions (Eight)

18:40 *Break*

20:30 IME Editorial Board Meeting

22:00 *Break*

22:15 Parallel Sessions (Eight)

23:55

Thursday, July 14

15:00 Parallel Sessions (Eight)

16:40 *Break*

17:00 Parallel Sessions (Eight)

18:40 *Break*

21:00 Keynote Speech

21:50 *Break*

22:15 Parallel Sessions (Eight)

23:55

Friday, July 15

15:00 Parallel Sessions (Eight)

16:40 *Break*

21:00 Keynote Speech

21:50 *Break*

22:00 Closing Ceremony

23:00

Biographies of Keynote Speakers

Hazel Bateman

Professor, Deputy Director of the ARC Centre of Excellence in Population Ageing Research (CEPAR)
School of Risk & Actuarial Studies, UNSW Sydney

Hazel Bateman is a Professor in the School of Risk & Actuarial Studies, UNSW Sydney, and Deputy Director of the ARC Centre of Excellence in Population Ageing Research (CEPAR). Hazel's research focusses on consumer financial decision making especially as it relates to retirement accumulation and decumulation with an emphasis on interventions to facilitate better financial decisions. She also works on design of and demand for retirement products including annuities, long-term care insurance and home equity release products. Hazel has consulted on retirement income issues to international organisations including the OECD, the World Bank, the Social Insurance Administration (China) and the Korean Institute of Health and Social Affairs. She is the Chair of Netspar's Scientific Council and President of the International Pension Research Association (IPRA) and serves on the UniSuper Consultative Committee and the Advisory Boards of the Mercer CFA Institute Global Pension Index, the Conexus Institute and MyHomeStream.

Daniel Bauer

Professor, Chairman of the Department of Risk and Insurance, and Hickman-Larson Chair in Actuarial Science
Wisconsin School of Business, University of Wisconsin-Madison

Dani is a Professor of Risk and Insurance and the Hickman-Larson Chair in Actuarial Science at the Wisconsin School of Business at the University of Wisconsin-Madison. He currently serves as the chairman of the Department of Risk and Insurance at UW.

Dani grew up in Germany and received his PhD in Applied Mathematics from Ulm University. He also holds a Master's in Statistics from San Diego State University, where he studied as a Fulbright scholar. Dani was on the faculty at other US Business Schools before joining UW in 2018.

He has published his research in leading journals in insurance, statistics, economics, finance, and management, and he teaches classes in actuarial science, data science, quantitative finance, and quantitative risk management. He currently serves as a senior editor at the Journal of Risk and Insurance, as a co-editor of the North American Actuarial Journal, and as an Associate Editor at several other actuarial journals including Insurance: Mathematics and Economics.

Ka Chun Cheung

Professor, Director of the Actuarial Science Programme
Department of Statistics and Actuarial Science, HKU

Ka Chun Cheung received his Bachelor degree in Actuarial Science and PhD degree from The University of Hong Kong. He rejoined HKU as an Associate Professor in 2008 after being an Assistant Professor at the University of Calgary for four years. He is now a full professor at Department of Statistics and Actuarial Science, HKU, and is the Director of the Actuarial Science Programme. He is an Associate of the Society of Actuaries and an elected member of the International Statistical Institute. He served as the Vice President of the Hong Kong Statistical Society from 2017 to 2019, and is currently an Honourary Advisory Board Member of the Actuarial Society of Hong Kong. His research interests include various topics in actuarial science, including optimal reinsurance, credibility theory, stochastic orders, dependence structures, and extreme value theory.

Short Program

East Asia Time (UTC+8, Beijing, Hong Kong, Singapore, Manila)

Date: Tuesday, 12/Jul/2022								
20:00-20:30	IT Drop-in Session (Optional)							
Opening Ceremony Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402								
	Chair: **Zhuo Jin**							
20:30-20:40	**Conference Chair's Speech by Zhongfei Li**							
20:40-21:00	**SYSU Dean's Speech by Shanmin Li** **MQ Deans' Speeches by Eric Knight & Leonie Tickle**							
Keynote Speech 1 Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402								
	Chair: **Zhongfei Li**							
21:00-21:50	**Keynote Speech by Daniel Bauer, University of Wisconsin-Madison**							
21:50-22:15	**Break**							
Tuesday Parallel Sessions 1								
	TUE1-01: Data science and statistical modelling 1	TUE1-02: Financial modelling 1	TUE1-03: Optimal control in insurance and finance 1	TUE1-04: Risk measures 1	TUE1-05: Ruin theory and related topics 1	TUE1-06: Insurance economics 1	TUE1-07: Life and non-life insurance 1	TUE1-08: Insurance risk models 1
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Jianxi Su**	**Yongzeng Lai**	**Bin Zou**	**Fangda Liu**	**Stephane Loisel**	**Zhiwei Tong**	**Ze Chen**	**Qian Zhao**
22:15-22:40	Jianxi Su	Yongzeng Lai	Bin Zou	Fangda Liu	Stephane Loisel	Zhiwei Tong	Jamaal Ahmad	Qian Zhao
22:40-23:05	Zhiyu Quan	Alexandru Badescu	Nora Muler	Yiqing Chen	Barbara Pacchiarotti	Tatjana Miljkovic	Alaric Jules Antoine Müller	Emma Kroell
23:05-23:30	Xing Wang	Haibo Liu	Tsz Hin Ng	Etienne Marceau	Vaios Dermitzakis	Tim Brasch	Aleksandr Shemendyuk	Christopher Blier-Wong
23:30-23:55	Kenneth Zhou	Yang Liu	Tak Wa Ng	Silvana M. Pesenti	José Miguel Flores-Contró	Raviar S. Karim	Nicolaus Grochola	Thai Nguyen
Date: Wednesday, 13/Jul/2022								
14:30-15:00	IT Drop-in Session (Optional)							

Wednesday Parallel Sessions 1								
	WED1-01: Data science and statistical modelling 2	WED1-02: Financial modelling 2	WED1-03: Optimal control in insurance and finance 2	WED1-04: Risk measures 2	WED1-05: Reinsurance and other risk-sharing arrangements 1	WED1-06: Insurance economics 2	WED1-07: Life and non-life insurance 2	WED1-08: Insurance risk models 2
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Zhengxiao Li**	**Phillip Yam**	**Shuaiqi Zhang**	**Jinzhu Li**	**Benjamin Avanzi**	**Jiyuan Wang**	**Yichun Chi**	**Peter Vekas**
15:00-15:25	Zhengxiao Li	Phillip Yam	Shuaiqi Zhang	Jinzhu Li	Benjamin Avanzi	Jiyuan Wang	Liang Yang	Naidan Deng
15:25-15:50	Yen-Chih Chen	Yang Zhao	Marina Di Giacinto	Linhai Zhao	Alexandra Bugalho de Moura	Thomas Dudek	Hafidh Afif Ardhi	Yaumil Rizki
15:50-16:15	Jiamin Yu	Hervé Andres	Matteo Brachetta	Yiying Zhang	Niko Ardita	Wenjing Han	Xi Xin	Yifan Hu
16:15-16:40	Chi Truong	Tin Long Ho	Fan Wu	Zinoviy Landsman	Gabriela Zeller	Wanting He	Arif Agung Riyadi	Mustafa Asim Ozalp
16:40-17:00	**Break**							
Wednesday Parallel Sessions 2								
	WED2-01: Data science and statistical modelling 3	WED2-02: Financial modelling 3	WED2-03: Optimal control in insurance and finance 3	WED2-04: Risk measures 3	WED2-05: Reinsurance and other risk-sharing arrangements 2	WED2-06: Mortality modelling 1	WED2-07: Pension and pension mathematics 1	WED2-08: Predictive insurance analytics 1
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Alexandra Dias**	**Michèle Vanmaele**	**Pavel Shevchenko**	**Sebastian Schlütter**	**Hoi Ying Wong**	**Chong It Tan**	**Ling Zhang**	**Guangyuan Gao**
17:00-17:25	Alexandra Dias	Michèle Vanmaele	Pavel Shevchenko	Sebastian Schlütter	Hoi Ying Wong	Qingxiao Ma	Ling Zhang	Guangyuan Gao
17:25-17:50	Peter Vekas	Morten Wilke	Yang Shen	Qingyao Xie	Hui-Min Wang	Torsten Kleinow	Danping Li	Jaeyoun Ahn
17:50-18:15	Wenyan Hao	Bilgi Yilmaz	Guo Liu	Tolulope Fadina	Yan Liu	Onofre Alves Simões	Zheng Chen	Yaodi Yong

18:15-18:40	Jorge Yslas	Biwen Ling	Ming Qiu	Fangyuan Zhang	Li Xun	Piotr Sliwka	Zhaojie Ren	Yaojun Zhang
18:40-20:30	**Break**							
20:30-22:00	**IME Editorial Board Meeting**							
22:00-22:15	**Break**							
Wednesday Parallel Sessions 3								
	WED3-01: Data science and statistical modelling 4	WED3-02: Financial modelling 4	WED3-03: Optimal control in insurance and finance 4	WED3-04: Risk measures 4	WED3-05: Insurance products linked to equity 1	WED3-06: Reinsurance and other risk-sharing arrangements 3	WED3-07: Climate change 1	WED3-08: Decentralized insurance and financial technology 1
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Torsten Kleinow**	**Arnold F. Shapiro**	**Marina Di Giacinto**	**Yiqing Chen**	**Dongchen Li**	**Jiandong Ren**	**Qi Zhou**	**Runhuan Feng**
22:15-22:40	Ruiting Sun	Arnold F. Shapiro	Shihao Zhu	Corina Birghila	Dongchen Li	Jiandong Ren	Qi Zhou	Runhuan Feng
22:40-23:05	Salvatore Scognamiglio	Anatoliy Swishchuk	Lina Palmborg	Zhanyi Jiao	Zhiyi Shen	Ruodu Wang	Chengxiu Ling	Ze Chen
23:05-23:30	Meng Sun	Zhenzhen Huang	Thijs Kamma	Liyuan Lin	Rosario Maggistro	Haiyan Liu	Ming Chen	Jingchao Li
23:30-23:55	Hong Beng Lim	Sebastian Felipe Calcetero	Feng Zhou	Qiuqi Wang	Peter Hieber	Mingren Yin	Fuwei Freeman Zhang	Yixing Zhao
Date: Thursday, 14/Jul/2022								
14:30-15:00	IT Drop-in Session (Optional)							
Thursday Parallel Sessions 1								
	THUR1-01: Data science and statistical modelling 5	THUR1-02: Financial modelling 5	THUR1-03: Optimal control in insurance and finance 5	THUR1-04: Risk measures 5	THUR1-05: Ruin theory and related topics 2	THUR1-06: Longevity risk 1	THUR1-07: Retirement planning 1	THUR1-08: Insurance economics 3
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Zhimin Zhang**	**Tak Kuen Siu**	**Michel Vellekoop**	**Sujin Zheng**	**Jae-Kyung Woo**	**Yanlin Shi**	**Colin Zhang**	**Wei Zhu**

15:00-15:25	Martin Bladt	Tak Kuen Siu	Michel Vellekoop	Sujin Zheng	Jae-Kyung Woo	Yung-Tsung Lee	Huiling Wu	Wei Zhu
15:25-15:50	Zahra Barzegar	Chun-Yang Liu	Wuyuan Jiang	Wanrong Mu	Eric Cheung	Selin Özen	Katja Hanewald	Yuantao Xie
15:50-16:15	Hong Sun	Kai Ding	Xiaoqing Liang	Guosen Yang	M.A. Lkabous	Giovanna Apicella	Kyunghyun Park	Guiyun You
16:15-16:40	Bowen Jia	Gaeun Lee	Zhaoyang Liu	Qinyu Wu	Bükre Yıldırım Külekci	Doreen Kabuche		
16:40-17:00	**Break**							
Thursday Parallel Sessions 2								
	THUR2-01: Data science and statistical modelling 6	THUR2-02: Financial modelling 6	THUR2-03: Optimal control in insurance and finance 6	THUR2-04: Risk measures 6	THUR2-05: Reinsurance and other risk-sharing arrangements 4	THUR2-06: Asset and liability management 1	THUR2-07: Mortality modelling 2	THUR2-08: Insurance risk models 3
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Wenyuan Wang**	**Guiyuan Ma**	**Yang Shen**	**Carole Bernard**	**Zuoquan Xu**	**Tingjin Yan**	**Hanlin Shang**	**Yuantao Xie**
17:00-17:25	Xiaoyu Zhang	Guiyuan Ma	Jinhui Han	Carole Bernard	Zuoquan Xu	Tingjin Yan	Hanlin Shang	Yousra Cherkaoui Tangi
17:25-17:50	Rui Xu	Minha Lee	William Lim	Andrea Perchiazzo	Wing Fung Chong	Rui Ma	Len Patrick Dominic Garces	Philipp Aigner
17:50-18:15	Mustafa Asim Ozalp	Giovani Gracianti	Fudong Wang	Jinghui Chen	Chi Feng	Sheng Wang	Ho Yan Joey Yung	Yutaro Takagami
18:15-18:40	Felix Zhu	Qiguan Chen		Peng Liu	Ling Wang	Di Ma	Apostolos Bozikas	Jiaen Xu
18:40-21:00	**Break**							
Keynote Speech 2 Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402								
	Chair: **Yan Zeng**							
21:00-21:50	**Keynote Speech by Hazel Bateman, University of New South Wales**							
21:50-22:15	**Break**							
Thursday Parallel Sessions 3								

	THUR3-01: Valuation of emerging risks 1	THUR3-02: Asset and liability management 2	THUR3-03: Ruin theory and related topics 3	THUR3-04: Pension and pension mathematics 2	THUR3-05: Climate change and others 2	THUR3-06: Loss reserve methods 1	THUR3-07: Life and non-life insurance 3	THUR3-08: Insurance risk models 4
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Petar Jevtic**	**Xing Wang**	**Ruodu Wang**	**Ruilin Tian**	**Zhiyu Quan**	**Haiyan Liu**	**Danping Li**	**Yiying Zhang**
22:15-22:40	Petar Jevtic	Minhua He	Zhengjun Jiang	Ruilin Tian	Lili Zheng	Xusheng Deng	Isabel Maria Cordeiro	Raluca Vernic
22:40-23:05	Cheng Tao	Tingting Yang	Ye Teng	Xiaobai Zhu	Ezgi Nevruz	Pengfei Cai	Wei Zhong	Muhsin Tamturk
23:05-23:30	Saeid Safarveisi	Shuai Liu	Zijia Wang	Wenyuan Li	Wenchu Li	Xenxo Vidal-Llana	Nii Okine	Tachfine El Alami
23:30-23:55	Linfeng Zhang	Qi Guo	Mario Sikic	Servaas van Bilsen	Ali Raisolsadat	Jun-Hee An		Hirbod Assa
Date: Friday, 15/Jul/2022								
14:30-15:00	IT Drop-in Session (Optional)							
Friday Parallel Sessions 1								
	FRI1-01: Data science and statistical modelling 7	FRI1-02: Financial modelling 7	FRI1-03: Optimal control in insurance and finance 7	FRI1-04: Valuation of emerging risks 2	FRI1-05: Reinsurance and other risk-sharing arrangements 5	FRI1-06: Catastrophe modelling 1	FRI1-07: Health insurance 1	FRI1-08: Ruin theory and related topics 4
Zoom	Meeting ID: 836 7795 1605 Passcode: 194402	Meeting ID: 891 8739 0955 Passcode: 499695	Meeting ID: 830 7941 4558 Passcode: 744891	Meeting ID: 896 1348 8008 Passcode: 631164	Meeting ID: 835 3269 4794 Passcode: 684635	Meeting ID: 881 0326 2533 Passcode: 377864	Meeting ID: 879 4168 9738 Passcode: 863503	Meeting ID: 817 9899 0334 Passcode: 980248
Chair	**Jingchao Li**	**Zheng Chen**	**Xudong Zeng**	**Jiwook Jang**	**Vali Asimit**	**Chi Truong**	**Chunli Cheng**	**Kazutoshi Yamazaki**
15:00-15:25	Andzar Syafa'atur Rahman	Ozan Evkaya	Pin Wang	Jaehun Cho	Vali Asimit	Chi Truong	Jiyuan Wang	Kazutoshi Yamazaki
15:25-15:50	Singgih Aji Nugroho	Churui Li	Yi Xia	Yunshen Yang	Yinzhi Wang	Yunxian Li	Xiangwen Zheng	Oscar Peralta
15:50-16:15	Gamar Aseffa	Sudan Kumar Oli	Shiqi Yan	Yuhao Liu	Zhaoxia Wu	Jiajun Liu	M. Ivan Ariful Fathoni	José Miguel Flores-Contró

16:15-16:40	Muhammed Taher Al-Mudafer	Gongyue Jiang	Guanxia Zhu	Fera Rusanti	Yuxia Huang	Yanbin Xu	Kyu Hyung Park	Yanfeng Li
16:40-21:00	**Break**							
Keynote Speech 3 Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402								
	Chair: **Zhuo Jin**							
21:00-21:50	**Keynote Speech by Ka Chun Cheung, The University of Hong Kong**							
21:50-22:00	**Break**							
Closing Ceremony Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402								
	Chair: **Yan Zeng**							
22:00-23:00	**IME Editor's Speech & Heriot-Watt's IME2023 Announcement**							

Program Agenda

East Asia Time (UTC+8, Beijing, Hong Kong, Singapore, Manila)

Date: Tuesday, 12/Jul/2022		
20:00-20:30	IT Drop-in Session (Optional)	
Opening Ceremony Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402		
	Chair: **Zhuo Jin**	
20:30-20:40	**Conference Chair's Speech by Zhongfei Li**	
20:40-21:00	**SYSU Dean's Speech by Shanmin Li** **MQ Deans' Speeches by Eric Knight & Leonie Tickle**	
Keynote Speech 1 Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402		
	Chair: **Zhongfei Li**	
21:00-21:50	**Keynote Speech by Daniel Bauer, University of Wisconsin-Madison** **Title: Calculation of Enterprise Capital via Least-Squares Monte Carlo -- Regress Now or Later?**	
21:50-22:15	**Break**	
22:15-23:55	**Tuesday Parallel Sessions 1**	
22:15-23:55	**TUE1-01: Data science and statistical modelling 1** Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	**Chair: Jianxi Su**
	TUE1-02: Financial modelling 1 Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695	**Chair: Yongzeng Lai**
	TUE1-03: Optimal control in insurance and finance 1 Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891	**Chair: Bin Zou**
	TUE1-04: Risk measures 1 Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164	**Chair: Fangda Liu**
	TUE1-05: Ruin theory and related topics 1 Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635	**Chair: Stephane Loisel**
	TUE1-06: Insurance economics 1 Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864	**Chair: Zhiwei Tong**
	TUE1-07: Life and non-life insurance 1 Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503	**Chair: Ze Chen**
	TUE1-08: Insurance risk models 1 Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248	**Chair: Qian Zhao**
Date: Wednesday, 13/Jul/2022		
14:30-15:00	IT Drop-in Session (Optional)	
15:00-16:40	**Wednesday Parallel Sessions 1**	
15:00-16:40	**WED1-01: Data science and statistical modelling 2** Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	**Chair: Zhengxiao Li**
	WED1-02: Financial modelling 2 Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695	**Chair: Phillip Yam**

	WED1-03: Optimal control in insurance and finance 2 Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891	**Chair: Shuaiqi Zhang**
	WED1-04: Risk measures 2 Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164	**Chair: Jinzhu Li**
	WED1-05: Reinsurance and other risk-sharing arrangements 1 Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635	**Chair: Benjamin Avanzi**
	WED1-06: Insurance economics 2 Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864	**Chair: Jiyuan Wang**
	WED1-07: Life and non-life insurance 2 Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503	**Chair: Yichun Chi**
	WED1-08: Insurance risk models 2 Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248	**Chair: Peter Vekas**
16:40-17:00	**Break**	
17:00-18:40	**Wednesday Parallel Sessions 2**	
17:00-18:40	**WED2-01: Data science and statistical modelling 3** Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	**Chair: Alexandra Dias**
	WED2-02: Financial modelling 3 Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695	**Chair: Michèle Vanmaele**
	WED2-03: Optimal control in insurance and finance 3 Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891	**Chair: Pavel Shevchenko**
	WED2-04: Risk measures 3 Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164	**Chair: Sebastian Schlütter**
	WED2-05: Reinsurance and other risk-sharing arrangements 2 Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635	**Chair: Hoi Ying Wong**
	WED2-06: Mortality modelling 1 Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864	**Chair: Chong It Tan**
	WED2-07: Pension and pension mathematics 1 Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503	**Chair: Ling Zhang**
	WED2-08: Predictive insurance analytics 1 Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248	**Chair: Guangyuan Gao**
18:40-20:30	**Break**	
20:30-22:00	**IME Editorial Board Meeting**	
22:00-22:15	**Break**	
22:15-23:55	**Wednesday Parallel Sessions 3**	
22:15-23:55	**WED3-01: Data science and statistical modelling 4** Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	**Chair: Torsten Kleinow**
	WED3-02: Financial modelling 4 Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695	**Chair: Arnold F. Shapiro**
	WED3-03: Optimal control in insurance and finance 4 Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891	**Chair: Marina Di Giacinto**
	WED3-04: Risk measures 4 Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164	**Chair: Yiqing Chen**
	WED3-05: Insurance products linked to equity 1	**Chair: Dongchen Li**

	Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635	
	WED3-06: Reinsurance and other risk-sharing arrangements 3	**Chair: Jiandong Ren**
	Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864	
	WED3-07: Climate change 1	**Chair: Qi Zhou**
	Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503	
	WED3-08: Decentralized insurance and financial technology 1	**Chair: Runhuan Feng**
	Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248	
Date: Thursday, 14/Jul/2022		
14:30-15:00	IT Drop-in Session (Optional)	
15:00-16:40	**Thursday Parallel Sessions 1**	
15:00-16:40	**THUR1-01: Data science and statistical modelling 5**	**Chair: Zhimin Zhang**
	Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	
	THUR1-02: Financial modelling 5	**Chair: Tak Kuen Siu**
	Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695	
	THUR1-03: Optimal control in insurance and finance 5	**Chair: Michel Vellekoop**
	Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891	
	THUR1-04: Risk measures 5	**Chair: Sujin Zheng**
	Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164	
	THUR1-05: Ruin theory and related topics 2	**Chair: Jae-Kyung Woo**
	Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635	
	THUR1-06: Longevity risk 1	**Chair: Yanlin Shi**
	Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864	
	THUR1-07: Retirement planning 1	**Chair: Colin Zhang**
	Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503	
	THUR1-08: Insurance economics 3	**Chair: Wei Zhu**
	Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248	
16:40-17:00	**Break**	
17:00-18:40	**Thursday Parallel Sessions 2**	
17:00-18:40	**THUR2-01: Data science and statistical modelling 6**	**Chair: Wenyuan Wang**
	Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	
	THUR2-02: Financial modelling 6	**Chair: Guiyuan Ma**
	Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695	
	THUR2-03: Optimal control in insurance and finance 6	**Chair: Yang Shen**
	Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891	
	THUR2-04: Risk measures 6	**Chair: Carole Bernard**
	Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164	
	THUR2-05: Reinsurance and other risk-sharing arrangements 4	**Chair: Zuoquan Xu**
	Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635	
	THUR2-06: Asset and liability management 1	**Chair: Tingjin Yan**
	Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864	
	THUR2-07: Mortality modelling 2	**Chair: Hanlin Shang**
	Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503	
	THUR2-08: Insurance risk models 3	**Chair: Yuantao Xie**
	Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248	

18:40-21:00	**Break**
Keynote Speech 2 Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	
	Chair: **Yan Zeng**
21:00-21:50	**Keynote Speech by Hazel Bateman, University of New South Wales** **Title: Why Don't Retirees Spend Their Savings? Behavioural Explanations and Demand-Side Solutions**
21:50-22:15	**Break**
22:15-23:55	**Thursday Parallel Sessions 3**
22:15-23:55	**THUR3-01: Valuation of emerging risks 1** **Chair: Petar Jevtic** Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402
	THUR3-02: Asset and liability management 2 **Chair: Xing Wang** Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695
	THUR3-03: Ruin theory and related topics 3 **Chair: Ruodu Wang** Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891
	THUR3-04: Pension and pension mathematics 2 **Chair: Ruilin Tian** Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
	THUR3-05: Climate change and others 2 **Chair: Zhiyu Quan** Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
	THUR3-06: Loss reserve methods 1 **Chair: Haiyan Liu** Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864
	THUR3-07: Life and non-life insurance 3 **Chair: Danping Li** Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503
	THUR3-08: Insurance risk models 4 **Chair: Yiying Zhang** Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248
Date: Friday, 15/Jul/2022	
14:30-15:00	IT Drop-in Session (Optional)
15:00-16:40	**Friday Parallel Sessions 1**
15:00-16:40	**FRI1-01: Data science and statistical modelling 7** **Chair: Jingchao Li** Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402
	FRI1-02: Financial modelling 7 **Chair: Zheng Chen** Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695
	FRI1-03: Optimal control in insurance and finance 7 **Chair: Xudong Zeng** Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891
	FRI1-04: Valuation of emerging risks 2 **Chair: Jiwook Jang** Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
	FRI1-05: Reinsurance and other risk-sharing arrangements 5 **Chair: Vali Asimit** Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
	FRI1-06: Catastrophe modelling 1 **Chair: Chi Truong** Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864
	FRI1-07: Health insurance 1 **Chair: Chunli Cheng** Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503
	FRI1-08: Ruin theory and related topics 4 **Chair: Kazutoshi Yamazaki**

	Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248
16:40-21:00	**Break**
Keynote Speech 3 Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	
	Chair: **Zhuo Jin**
21:00-21:50	**Keynote Speech by Ka Chun Cheung, The University of Hong Kong** **Title: Optimal Design of Reinsurance Contracts Under Adverse Selection with a Continuum of Types**
21:50-22:00	**Break**
Closing Ceremony Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402	
	Chair: **Yan Zeng**
22:00-23:00	**IME Editor's Speech & Heriot-Watt's IME2023 Announcement**

Detailed Program

East Asia Time (UTC+8, Beijing, Hong Kong, Singapore, Manila)

Tuesday parallel sessions 1

TUE1-01: Data science and statistical modelling 1

Time: Tuesday, 12/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402

Chair: Jianxi Su

Inference for the Tail Conditional Allocation: Large Sample Properties and Insurance Risk Assessment

Authors: **Nadezhda Gribkova, Jianxi Su** (Purdue University)**, Ricardas Zitikis**

Improving Business Insurance Loss Models by Leveraging InsurTech Innovation

Authors: **Zhiyu Quan** (University of Illinois at Urbana-Champaign)

Statistical Inference for Bifurcating Autoregression Models

Authors: **Xing Wang** (Illinois State University)

A Bayesian Generalized Additive Model Approach to Forecasting Mortality Improvement with Expert Judgment

Authors: **Xiaobai Zhu, Kenneth Zhou** (Arizona State University)

TUE1-02: Financial modelling 1

Time: Tuesday, 12/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695

Chair: Yongzeng Lai

Asset Price Modeling and Options Pricing with Asymmetric Exponential Power Distribution

Authors: **Yongzeng Lai** (Wilfrid Laurier University)

Long Memory in Option Pricing: A Fractional Discrete-Time Approach

Authors: **Maciej Augustyniak, Alexandru Badescu** (University of Calgary)**, Jean-François Bégin, Sarath Kumar Jayaraman**

Pricing Defaultable Bonds and Credit Derivatives in the Presence of Shock Risk and Unpredictable Recovery

Authors: **Haibo Liu** (Purdue University)**, Qihe Tang**

Uncertainty Aversion and Equity Improvement

Authors: **Yang Liu** (University of Waterloo)**, Tiantian Mao, Ruodu Wang**

TUE1-03: Optimal control in insurance and finance 1

Time: Tuesday, 12/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891

Chair: Bin Zou

Stackelberg Differential Game for Insurance Under Model Ambiguity

Authors: **Bin Zou** (University of Connecticut)**, Jingyi Cao, Dongchen Li, Virginia Young**

Optimal Dividends Under a Drawdown Constraint and a Curious Square-Root Rule
Authors: **Hansjoerg Albrecher, Pablo Azcue, Nora Muler** (Universidad Torcuato di Tella)

Optimal Asset Allocations in DC Pension Funds Under Forward Utility Preferences
Authors: **Tsz Hin Ng** (University of Illinois at Urbana-Champaign)**, Wing Fung Chong**

Portfolio Performance Under Benchmarking Relative Loss and Portfolio Insurance: From Omega Ratio to Loss Aversion
Authors: **Tak Wa Ng** (Laval University)**, Thai Nguyen**

TUE1-04: Risk measures 1
Time: Tuesday, 12/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
Chair: Fangda Liu

Inf-Convolution and Optimal Allocations for Tail Risk Measures
Authors: **Fangda Liu** (University of Waterloo)**, Tiantian Mao, Linxiao Wei, Ruodu Wang**

An Asymptotic Study of Systemic Expected Shortfall and Marginal Expected Shortfall
Authors: **Yiqing Chen** (Drake University)**, Jiajun Liu**

Collective Risk Models with FGM Dependence
Authors: **Etienne Marceau** (Laval University)

Sensitivity Measures Based on Scoring Functions
Authors: **Silvana M. Pesenti** (University of Toronto)**, Tobias Fissler**

TUE1-05: Ruin theory and related topics 1
Time: Tuesday, 12/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
Chair: Stephane Loisel

Optimal Prevention Strategies in Risk Theory
Authors: **Stephane Loisel** (Université Claude Bernard Lyon 1)

Large Deviations and Ruin Problems for Grey Gaussian Processes
Authors: **Barbara Pacchiarotti** (Università degli Studi di Roma Tor Vergata)

Monotonicity Properties for Solutions of Renewal Equations with Applications to Ruin Theory
Authors: **Vaios Dermitzakis** (University of Liverpool)**, Konstadinos Politis**

On a Risk Process with Deterministic Investment and Multiplicative Jumps - An Application to Poverty Trapping
Authors: **Kira Henshaw, José Miguel Flores-Contró** (University of Lausanne)**, Sooie-Hoe Loke, Corina Constantinescu, Séverine Arnold, Jorge Mario Rámirez Osorio**

TUE1-06: Insurance economics 1
Time: Tuesday, 12/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864

Chair: Zhiwei Tong

An Integrated Study of Cyber Risk and Cyber Security

Authors: **Yang Feng, Zhiwei Tong** (The University of Iowa)

Modeling Economic Cost of Obesity in the United States- State Level Analysis

Authors: **Tatjana Miljkovic** (Miami University)

Determinants and Value of Corporate Social Responsibility Management: Empirical Evidence from the Insurance Industry

Authors: **Tim Brasch** (Coburg University of Applied Sciences and Arts)**, Christian Eckert**

Exact and Asymptotic Analysis of Multivariate Hawkes Population Processes

Authors: **Raviar S. Karim** (University of Amsterdam)**, Roger J.A. Laeven, Michel R.H. Mandjes**

TUE1-07: Life and non-life insurance 1

Time: Tuesday, 12/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503

Chair: Ze Chen

Estimating Absorption-Time Distributions of Markov Jump Processes with Piecewise Constant Transition Rates

Authors: **Jamaal Ahmad** (University of Copenhagen)**, Martin Bladt, Mogens Bladt**

Joint Lifetime Modeling with mIPH Distributions

Authors: **Hansjörg Albrecher, Martin Bladt, Alaric Jules Antoine Müller** (University of Lausanne)

Study of Institutionalized Elderly Profiles Derived from Multiple Health Factors

Authors: **Aleksandr Shemendyuk** (University of Lausanne)**, Joël Wagner**

The Influence of Negative Interest Rates on Life Insurance Companies

Authors: **Nicolaus Grochola** (Goethe University Frankfurt)

TUE1-08: Insurance risk models 1

Time: Tuesday, 12/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248

Chair: Qian Zhao

Robust Credibility Based on Censored Data

Authors: **Qian Zhao** (Robert Morris University)**, Chudamani Poudyal**

Reverse Sensitivity Testing for Compound Poisson Processes

Authors: **Emma Kroell** (University of Toronto)**, Silvana M. Pesenti, Sebastian Jaimungal**

Risk Aggregation with FGM Copulas

Authors: **Christopher Blier-Wong** (Université Laval)**, Hélène Cossette, Etienne Marceau**

Risk Management Under Weighted Limited Expected Loss

Authors: **Thai Nguyen** (Université Laval)**, An Chen**

Wednesday parallel sessions 1

WED1-01: Data science and statistical modelling 2

Time: Wednesday, 13/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402

Chair: Zhengxiao Li

A New Class of Composite GBII Regressions with Varying Threshold for Modelling Heavy-Tailed Data

Authors: **Zhengxiao Li** (University of International Business and Economics)**, Fei Wang, Zhengtang Zhao**

Cyber Risk Content Analysis Using Topic Modelling Approach

Authors: **Yin-Yee Leong, Yen-Chih Chen** (Feng-Chia University)

Will Claim Histories Become Deprecated Rating Factors? An Optimal Design Method on Real-Time Road Risk Model

Authors: **Jiamin Yu** (Shanghai Lixin University of Accounting and Finance)

Pricing Renewable Energy Investment in Presence of Trend, Seasonality, Mean Reversion and Price Spikes

Authors: **Chi Truong** (Macquarie University)

WED1-02: Financial modelling 2

Time: Wednesday, 13/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695

Chair: Phillip Yam

Universal Poisson Approximations for Wiener Functionals Arisen in Financial and Insurance Models

Authors: **Jinhui Han, Nicolas Privault, Phillip Yam** (The Chinese University of Hong Kong)

A Volatility Model Based on Adaptive Expectations: An Improvement on the Rational Expectations Model

Authors: **Yang Zhao** (Henan University)**, Yuan Yao, Lei Huang**

Signature-Based Validation for Real World Economic Scenarios

Authors: **Alexandre Boumezoued, Benjamin Jourdain, Hervé Andres** (Ecole des Ponts ParisTech)

Optimal Use of Housing Wealth in Retirement: A Simulation Study Comparing Home Equity Release and Downsizing

Authors: **Katja Hanewald, Hazel Bateman, Tin Long Ho** (UNSW Sydney)

WED1-03: Optimal control in insurance and finance 2

Time: Wednesday, 13/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891

Chair: Shuaiqi Zhang

Stochastic Control for Sub-Diffusions and Its Applications in Finance

Authors: **Shuaiqi Zhang** (China University of Mining and Technology)

Optimal Order Execution Under Price Impact: A Hybrid Model
Authors: **Marina Di Giacinto** (Università degli studi di Cassino e del Lazio Meridionale)**, Claudio Tebaldi, Tai-Ho Wang**

Optimal Reinsurance via BSDEs in a Partially Observable Contagion Model
Authors: **Matteo Brachetta** (Politecnico of Milan)

Optimal Reinsurance-Investment Problem for a General Insurance Company of a Contagion Risk Model
Authors: **Fan Wu** (Southeast University)**, Xin Zhang, Zhibin Liang**

WED1-04: Risk measures 2
Time: Wednesday, 13/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
Chair: Jinzhu Li

Asymptotic Results of Tail Moment and Tail Central Moment for Dependent Risks
Authors: **Jinzhu Li** (Nankai University)

The Identification of Systemically Important Banks Based on Tsallis Entropy with Application to Chinese Banks
Authors: **Linhai Zhao** (Huaqiao University)**, Yajun Wang**

Distortion Risk Contribution Ratio Measures: Definitions and Comparisons
Authors: **Yiying Zhang** (Southern University of Science and Technology)

The Location of a Minimum Variance Squared Distance Risk Functional
Authors: **Zinoviy Landsman** (University of Haifa)**, Tomer Shushi**

WED1-05: Reinsurance and other risk-sharing arrangements 1
Time: Wednesday, 13/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
Chair: Benjamin Avanzi

Optimal Reinsurance Under Terminal Value Constraints
Authors: **Benjamin Avanzi** (University of Melbourne)**, Hayden Lau, Mogens Steffensen**

Reinsurance Treaty Minimizing the Ruin Probability Using a Diffusion Approximation
Authors: **Alexandra Bugalho de Moura** (Univesity of Lisbon)**, Carlos Oliveira, Adrialina Botnariuc**

Calculation of Return Period for Earthquake Events for Catastrophe Reinsurance Coverage in the Java Island Region
Authors: **Niko Ardita** (University of Indonesia)

Optimal Price Structure of Cyber Insurance Policies with Risk Mitigation Services
Authors: **Gabriela Zeller** (Technical University of Munich)**, Matthias Scherer**

WED1-06: Insurance economics 2
Time: Wednesday, 13/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864

Chair: Jiyuan Wang

The Value of Outside Information: Identifying Asymmetric Information Across Markets Using Evidence from China

Authors: **Jiyuan Wang** (Central University of Finance and Economics)**, Ya Gao, Shouyang Wang, Daiyuan Li**

Demand for Multi-Year Catastrophe Insurance Contracts: Experimental Evidence for Mitigating the Insurance Gap

Authors: **Thomas Dudek** (Victoria University of Wellington)**, Eric Ulm, Ilan Noy**

Study on the Spatial Spillover Effect of Insurance Agglomeration on Regional Economic Growth——Empirical Research from the Yangtze River Economic Belt

Authors: **Wenjing Han** (University of International Business and Economics)**, Guiyun You**

Division or Unification? An Analysis of the Potential Structural Change of the Digital Broker on the Supply Side of the Insurance Market

Authors: **Wanting He** (The University of Hong Kong; Southern University of Science and Technology)**, He Wang, Gene Lai, Hailiang Yang**

WED1-07: Life and non-life insurance 2

Time: Wednesday, 13/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503

Chair: Yichun Chi

A Modified Classification Tree Method for Imbalanced Insurance Loss Data

Authors: **Liang Yang** (Southwestern University of Finance and Economics)**, Xiang Shu Wu**

Analysis of Crop Insurance Claims Reserve Estimates with Chain Ladder and Bornhuetter-Ferguson Method

Authors: **Hafidh Afif Ardhi** (University of Indonesia)**, Lenny Suardi**

Anti-Discrimination Insurance Pricing: Regulations, Fairness Criteria, and Models

Authors: **Xi Xin** (UNSW Sydney)**, Fei Huang**

Estimation of Reserves for Credit Insurance Claims Using the Munich Chain Ladder & Bornhutter-Ferguson Method

Authors: **Arif Agung Riyadi** (Universitas Indonesia)**, Lenny Suardi**

WED1-08: Insurance risk models 2

Time: Wednesday, 13/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248

Chair: Peter Vekas

The Perturbed Dual Risk Model with Proportional Investment

Authors: **Naidan Deng** (Henan University of Science and Technology)**, Chuanwei Wang**

Application of Multiple Decrement Tables: Analysis of Pension Security Claims Under Competing Risks

Authors: **Yogo Purwono, Yaumil Rizki** (University of Indonesia)

Modelling Heavy-Tailed Data with Two-Stage Mixture Regression Models
Authors: **Yifan Hu** (University of International Business and Economics)

Aggregate Claims Process Based on the Hidden Markov Model
Authors: **Mustafa Asim Ozalp** (Hacettepe University)**, Sule Sahin, Kasirga Yildirak**

Wednesday parallel sessions 2

WED2-01: Data science and statistical modelling 3
Time: Wednesday, 13/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402
Chair: Alexandra Dias

On the Finite Sample Properties of the Pseudo-Likelihood Estimator for Copula Model Parameters
Authors: **Alexandra Dias** (University of York)

AI in Longevity Risk Management: Improved Long-Term Projections by Machine Learning
Authors: **Peter Vekas** (Corvinus University of Budapest)**, Ronald Richman, Laszlo Kovacs**

Factor Structure of Cryptocurrencies
Authors: **Wenyan Hao** (University of Leicester)

Phase-Type Mixture-of-Experts Regression for Loss Severities
Authors: **Jorge Yslas** (Institute for Financial and Actuarial Mathematics)**, Martin Bladt**

WED2-02: Financial modelling 3
Time: Wednesday, 13/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695
Chair: Michèle Vanmaele

Mortality/Longevity Risk-Minimization with or without Securitization
Authors: **Tahir Choulli, Catherine Daveloose, Michèle Vanmaele** (Ghent University)

Novel Executive Stock Options and Their Implications
Authors: **Morten Wilke** (Ulm University)**, An Chen, Steven Vanduffel**

Option Pricing in Emerging Markets Using Pure Jump Processes: Explicit Calibration
Authors: **Bilgi Yilmaz** (TU Kaiserslautern)**, Ali Alper Hekimogulu**

A Note on Dependence and Volatility in P and Q
Authors: **Jan Dhaene, Daniel Linders, Biwen Ling** (KU Leuven)**, Qian Wang**

WED2-03: Optimal control in insurance and finance 3
Time: Wednesday, 13/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891
Chair: Pavel Shevchenko

A Bias-Corrected Least-Squares Monte Carlo for Utility Based Optimal Decisions in Retirement
Authors: **Pavel Shevchenko** (Macquarie University)**, Johan Andréasson**

Robust Life-Cycle Model with Background Stochastic Mortality Risk
Authors: **Yang Shen** (UNSW Sydney)

Optimal Dividend Policy Under a Contagious Market Until Bankruptcy
Authors: **Guo Liu** (University of Melbourne)

Optimal Dividend Strategies with Reinsurance Under Contagious Systemic Risk
Authors: **Ming Qiu** (University of Melbourne)**, Zhuo Jin, Shuanming Li**

WED2-04: Risk measures 3
Time: Wednesday, 13/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
Chair: Sebastian Schlütter

Tail Correlations of Sub-Portfolios
Authors: **Joachim Paulusch, Sebastian Schlütter** (Mainz University of Applied Sciences)

Study on Rice Income Insurance Pricing Model and Risk Dispersion Mechanism
Authors: **Qingyao Xie** (Southwestern University of Finance and Economics)

A Framework for Measures of Risk Under Uncertainty
Authors: **Tolulope Fadina** (University of Essex)**, Yang Liu, Ruodu Wang**

On the Equivalence Between Value-at-Risk- and Expected Shortfall-Based Risk Measures in Non-Concave Optimization
Authors: **Fangyuan Zhang** (EURECOM)**, An Chen, Mitja Stadje**

WED2-05: Reinsurance and other risk-sharing arrangements 2
Time: Wednesday, 13/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
Chair: Hoi Ying Wong

Irreversible Reinsurance: A Singular Control Approach
Authors: **Tingjin Yan , Kyunghyun Park, Hoi Ying Wong** (The Chinese University of Hong Kong)

Measurement of Crop Revenue Insurance on Small Areas: Under China's Insurance Plus Futures
Authors: **Hui-Min Wang** (Shandong University)**, Yang Xiao, Xiao-Dong Yan, Dian-Jiang Yu**

Heterogeneous Reinsurance Premiums Under a Trilateral Stochastic Differential Reinsurance and Investment Game
Authors: **Xiufang Li, Yan Liu** (Nankai University)**, Xiaowei Chen**

Portfolio Risk Analysis of Excess of Loss Reinsurance
Authors: **Qihe Tang, Zhiwei Tong, Li Xun** (Changchun University of Technology)

WED2-06: Mortality modelling 1

Time: Wednesday, 13/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864

Chair: Chong It Tan

Longevity Risk and the Consumer Price Index

Authors: **Qingxiao Ma** (University of Amsterdam)**, Tim Boonen**

Projecting Life Expectancy Using Cause-of-Death-Specific Mortality Scenarios

Authors: **Torsten Kleinow** (Heriot-Watt University)**, Alexander Yiu, George Streftaris**

Mortality in the United States' Border Regions: A Closer Look at the U.S.-Mexico and U.S.-Canada Borders

Authors: **Onofre Alves Simões** (ISEG-ULisboa)**, Melanie Jean Joerger**

Modeling the Mortality Rates μ(x,t) Using Stochastic, Non-Gaussian Linear Scalar Filter Models with Switches.

Authors: **Piotr Sliwka** (Cardinal S.Wyszynski University, Warsaw)

WED2-07: Pension and pension mathematics 1

Time: Wednesday, 13/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503

Chair: Ling Zhang

Equilibrium Investment Strategy for a DC Pension Plan with the Return of Premiums Clause and Mispricing Under Imperfect Information

Authors: **Pei Wang, Ling Zhang** (Guangdong University of Finance)**, Yongzeng Lai**

Robust Optimal Investment and Consumption Strategies for Pooled Annuity with Partial Information and Exit Penalty

Authors: **Lin Xie, Lv Chen, Linyi Qian, Danping Li** (East China Normal University)**, Zhinxin Yang**

Dynamic Derivative-Based Pension Investment with Stochastic Volatility: A Behavioral Perspective

Authors: **Zheng Chen** (Guangdong University of Technology)**, Zhongfei Li, Yan Zeng**

Optimal Mix Among PAYGO, EET and Individual Savings

Authors: **Zhaojie Ren** (Tsinghua University)**, Zongxia Liang, Lin He, Yilun Song**

WED2-08: Predictive insurance analytics 1

Time: Wednesday, 13/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248

Chair: Guangyuan Gao

Double Boosting of Mean and Dispersion in Tweedie's Compound Poisson Model for Insurance Loss Prediction

Authors: **Guangyuan Gao** (Renmin University of China)

The Neural Ratemaking System in Insurance and the Bias

Authors: **Kyongwon Kim, Rosy Oh, Jaeyoun Ahn** (Ewha Womans University)

Credibility Theory for Mean-Variance Premium Principles
Authors: **Yaodi Yong** (The University of Hong Kong)**, Yiying Zhang**

Insurance Claim Frequency Analysis Using Bayesian CART Model
Authors: **Yaojun Zhang** (University of Leeds)**, Lanpeng Ji, Georgios Aivaliotis, Charles Taylor**

Wednesday parallel sessions 3

WED3-01: Data science and statistical modelling 4
Time: Wednesday, 13/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402
Chair: Torsten Kleinow

Research on the Impact of Earthquake Disaster Insurance Literacy on Public Service Satisfaction
Authors: **Qinglu Yuan, Ruiting Sun** (Institute of Disaster Prevention)

Robust Classification via Support Vector Machines
Authors: **Salvatore Scognamiglio** (University of Naples "Parthenope")**, Vali Asimit, Ioannis Kyriakou, Simone Santoni, Rui Zhu**

Statistical Modeling of Data Breaches and Its Application in Cyber Insurance
Authors: **Meng Sun** (Simon Fraser University)**, Yi Lu**

Mortality Forecasting with Neural Tangent Kernel Regression
Authors: **Hong Beng Lim** (The University of Iowa)**, Siyang Tao, Nariankadu Datatreya Shyamalkumar**

WED3-02: Financial modelling 4
Time: Wednesday, 13/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695
Chair: Arnold F. Shapiro

Modeling Life Annuities as Fuzzy Random Variables
Authors: **Arnold F. Shapiro** (The Pennsylvania State University)**, Dabuxilatu . Wang**

Applications of Hawkes Processes in Insurance
Authors: **Anatoliy Swishchuk** (University of Calgary)

Statistical Classification Methods for the Combining Portfolio Strategy
Authors: **Zhenzhen Huang** (University of Waterloo)**, Pengyu Wei, Chengguo Weng**

An Efficient Approach for Computation and Interpretation of Bayesian Credibility Models for Experience Rating
Authors: **Sebastian Felipe Calcetero** (University of Toronto)**, Andrei Badescu, Sheldon Lin**

WED3-03: Optimal control in insurance and finance 4
Time: Wednesday, 13/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891

Chair: Marina Di Giacinto

Optimal Consumption, Portfolio and Best Time for Health Investment

Authors: **Shihao Zhu** (Bielefeld University)**, Giorgio Ferrari**

Premium Control with Reinforcement Learning

Authors: **Lina Palmborg** (Stockholm University)

Dual Formulation of the Optimal Consumption Problem with Multiplicative Habit Formation

Authors: **Thijs Kamma** (Maastricht University)**, Antoon Pelsser**

Risk Sharing via Risk Budgeting

Authors: **Feng Zhou** (Bayes Business School)**, Vali Asimit, Wing Fung Chong, Radu Tunaru**

WED3-04: Risk measures 4

Time: Wednesday, 13/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164

Chair: Yiqing Chen

Robusts Model in Band Ambiguity

Authors: **Corina Birghila** (University of Waterloo)

A Reverse Expected Shortfall Optimization Formula

Authors: **Zhanyi Jiao** (University of Waterloo)**, Ruodu Wang, Yuanying Guan**

Calibrating Probability Equivalent Level of VaR-ES

Authors: **Liyuan Lin** (University of Waterloo)

E-Backtesting Risk Measures

Authors: **Qiuqi Wang** (University of Waterloo)**, Ruodu Wang, Johanna Ziegel**

WED3-05: Insurance products linked to equity 1

Time: Wednesday, 13/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635

Chair: Dongchen Li

Equilibrium Pricing of Variable Annuities with Discount Rate Uncertainty

Authors: **Min Dai, Bin Li, Dongchen Li** (Brock University)**, Yumin Wang**

Out-of-Model Adjustments of Variable Annuities

Authors: **Zhiyi Shen** (Morgan Stanley)

A Dynamic Programming Approach to Price VAs Within a Stochastic Mortality Framework

Authors: **Anna Rita Bacinello, Rosario Maggistro** (University of Trieste)**, Ivan Zoccolan**

Randomization and the Valuation of Guaranteed Minimum Death Benefits

Authors: **Peter Hieber** (Université de Lausanne)**, Griselda Deelstra**

WED3-06: Reinsurance and other risk-sharing arrangements 3

Time: Wednesday, 13/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864

Chair: Jiandong Ren

Evaluating the Tail Risks of Multivariate Aggregate Losses

Authors: **Wenjun jiang, Jiandong Ren** (Western University)

An Axiomatization of Conditional Mean Risk Sharing

Authors: **Ruodu Wang** (University of Waterloo)

Distributionally Robust Reinsurance with Value-at-Risk and Conditional Value-at-Risk

Authors: **Haiyan Liu** (Michigan State University)**, Tiantian Mao**

Optimal Reinsurance Design with Model Uncertainty

Authors: **Mingren Yin** (University of Waterloo)**, Jun Cai, Fangda Liu**

WED3-07: Climate change 1

Time: Wednesday, 13/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503

Chair: Qi Zhou

Carbon Footprint and Carbon Risk Exposure of China's Social Security Fund

Authors: **Qi Zhou** (South China University of Technology)

Extreme Analysis of Flood Disaster Risks in China with Insurance and Financial Management

Authors: **Chengxiu Ling** (Xi'an Jiaotong-Liverpool University)**, Yixuan Liu, Zhiyan Cai, Jiayi Li**

The Impacts of Carbon Tax on Economy in Production Networks Model

Authors: **Ming Chen** (Sun Yat-sen University)

ESG Green Insurance Action from Underwriting - world's First E-6S (re)Insurance U/W Model

Authors: **Fuwei Freeman Zhang** (Thames Investment Limited)

WED3-08: Decentralized insurance and financial technology 1

Time: Wednesday, 13/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248

Chair: Runhuan Feng

Distributed Insurance

Authors: **Runhuan Feng** (University of Illinois at Urbana-Champaign)**, Mao Li**

Optimal Risk Pooling for Peer-to-Peer Insurance

Authors: **Ze Chen** (Renmin University of China)

Optimal Design for Network Mutual Aid

Authors: **Jingchao Li** (Shenzhen University)

Impact of Insurance on Capital-Constrained Supply Chain Finance Under Asymmetric Information

Authors: **Yixing Zhao** (Guangdong University of Foreign Studies)**, Yan Zeng**

Thursday Parallel Sessions 1

THUR1-01: Data science and statistical modelling 5

Time: Thursday, 14/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402

Chair: Zhimin Zhang

Randomization and Informed Censoring for Loss Estimation

Authors: **Martin Bladt** (University of Lausanne)**, Hansjoerg Albrecher**

Anomality Detection in Health Insurance Data Based on Outlingness Function

Authors: **Zahra Barzegar** (Saman Insurance Company)**, Sakineh Dehghan, Shima Ara**

A Multivariate Frequency-Severity Framework for Healthcare Data Breaches

Authors: **Hong Sun** (Lanzhou University)

Machine Learning of Surrender Charge: Optimality and Humanity

Authors: **Bowen Jia** (The Chinese University of Hong Kong)**, Ling Wang, Hoi Ying Wong**

THUR1-02: Financial modelling 5

Time: Thursday, 14/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695

Chair: Tak Kuen Siu

European Option Pricing with Market Frictions, Regime Switches and Model Uncertainty

Authors: **Tak Kuen Siu** (Macquarie University)

Pricing Double-Barrier Parisian Options

Authors: **Chun-Yang Liu** (Liaoning University)**, Song-Ping Zhu**

Pricing Inflation-Indexed Swaps and Swaptions with Markov Regime-Switching Jump-Diffusion Models

Authors: **Kai Ding** (Southeast University)**, Xin Zhang**

Insurance Guaranty Premium via Exchange Options

Authors: **Hangsuck Lee, Seongjoo Song, Gaeun Lee** (Sungkyunkwan University)

THUR1-03: Optimal control in insurance and finance 5

Time: Thursday, 14/Jul/2022: 15:00-16:40

Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891

Chair: Michel Vellekoop

Optimal Consumption and Investment for General Preferences

Authors: **Michel Vellekoop** (University of Amsterdam)**, Marcellino Gaudenzi**

Optimal Robust Reinsurance Contracts with Investment Strategy Under Variance Premium Principle

Authors: **Wuyuan Jiang** (Hunan Institute of Science and Technology)**, Zhaojun Yang**

A Simple and Nearly Optimal Investment Strategy for Minimizing the Probability of Lifetime Ruin
Authors: **Xiaoqing Liang** (Hebei University of Technology)**, Virginia R. R. Young**

Policy Iteration Algorithm for Optimal Dividend Problem in Cramer-Lundberg Risk Model with Transaction Costs
Authors: **Guoxin Liu, Yuying Liu, Zhaoyang Liu** (Nankai University)

THUR1-04: Risk measures 5
Time: Thursday, 14/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
Chair: Sujin Zheng

Research on the Contagion and Impact of Reputational Risk --A Case Study of the Zhang Naidan Incident of China Life Insurance
Authors: **Sujin Zheng** (Central University of Finance and Economics)**, Hairuo Guo, Haitao Hu, Shuning Song**

CDS Index Tranches Pricing Under Thinning-Dependence Structure with Regime Switching
Authors: **Wanrong Mu** (Soochow University)

Spectral Risk Measures and Portfolio Selection with Additive and Multiplicative Background Risks
Authors: **Yongjun Liu, Guosen Yang** (School of Business Administration)**, Weiguo Zhang**

Model Aggregation for Risk Evaluation and Robust Optimization
Authors: **Qinyu Wu** (University of Science and Technology of China)**, Tiantian Mao, Ruodu Wang**

THUR1-05: Ruin theory and related topics 2
Time: Thursday, 14/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
Chair: Jae-Kyung Woo

A Bivariate Laguerre Series for Joint Ruin Probabilities in a Two-Dimensional Risk Process
Authors: **Hansjoerg Albrecher, Eric Cheung, Haibo Liu, Jae-Kyung Woo** (UNSW Sydney)

Finite-Time Ruin Probabilities Using Bivariate Laguerre Series
Authors: **Eric Cheung** (UNSW Sydney)**, Hayden Lau, Gordon Willmot, Jae-Kyung Woo**

On the Speed of Recovery of a Lévy Risk Process
Authors: **M.A. Lkabous** (University of Southampton)**, Ronnie Loeffen, Z. Palmowski**

Optimal Dynamic Ruin Probabilities for Heavy-Tailed Losses Under Reinsurance Strategies
Authors: **Bükre Yıldırım Külekci** (TU Kaiserslautern)**, Ralf Korn, Sevtap Selcuk-Kestel**

THUR1-06: Longevity risk 1
Time: Thursday, 14/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864
Chair: Yanlin Shi

An Innovation of Reverse Mortgages in Taiwan: Crossover Risk Insurance, Deferred Life Annuity, and

Spouse Annuity
Authors: **Yung-Tsung Lee** (National Chiayi University)**, Meng Hsuan Tsai**

A Longevity Basis Risk Hedging Framework Under Collateralization
Authors: **Selin Özen** (Ankara University)**, Şule Şahin**

Longevity and Financial Risk-Taking
Authors: **Giovanna Apicella** (University of St. Gallen)**, Enrico De Giorgi**

Linking Annuity Benefits to Financial and Longevity Experience: A Joint Stochastic Pricing Framework
Authors: **Doreen Kabuche** (UNSW Sydney)**, Annamaria Olivieri**

THUR1-07: Retirement planning 1
Time: Thursday, 14/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503
Chair: Colin Zhang

Optimal Investment, Consumption and Time of Annuitization Post Retirement with Subjective Evaluations of Mortality Probability
Authors: **Huiling Wu** (Central University of Finance and Economics)**, Pu Liao**

Funding Retirement with Public Reverse Mortgages: An Evaluation of Australia's Home Equity Access Scheme
Authors: **Katja Hanewald** (UNSW Sydney)**, Katie Sun, Hazel Bateman**

Robust Retirement and Life Insurance with Inflation Risk and Model Ambiguity
Authors: **Kyunghyun Park** (The Chinese University of Hong Kong)**, Hoi Ying Wong, Tingjin Yan**

THUR1-08: Insurance economics 3
Time: Thursday, 14/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248
Chair: Wei Zhu

Selection of Loss Averse Consumers in Life Insurance Market
Authors: **Wei Zhu** (University of International Business and Economics)

Research on the Redistribution Effect of Social Insurance Under Information Asymmetry
Authors: **Yuantao Xie** (University of International Business and Economics)**, Yu Chen, Yue Zhang**

Research of the Effect of Directors' and Officers' Liability Insurance on Corporate Fraud
Authors: **Guiyun You** (University of International Business and Economics)**, Huidan Liu, Ying Sun**

Thursday Parallel Sessions 2

THUR2-01: Data science and statistical modelling 6
Time: Thursday, 14/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402

Chair: Wenyuan Wang

Modeling and Pricing the Cybersecurity Risks in Fog Computing Based Internet of Things Architectures
Authors: **Xiaoyu Zhang** (University of Science and Technology of China)

The Influence of Survival Expectation on the Demand of Commercial Medical Insurance for the Middle-Aged and Elderly--Based on Both Perceptual and Rational Perspectives
Authors: **Rui Xu** (Central University of Finance and Economics)**, Xiaojun Wang, Hui Meng, Ming Zhou**

Interpretable Machine Learning Algorithms for Crop Insurance: Hail Risk in Turkey
Authors: **Mustafa Asim Ozalp** (Hacettepe University)**, İsmail Gur, Kasirga Yildirak**

Economic Scenario Generator in a Data-Rich Environment
Authors: **Felix Zhu** (UNSW Sydney)**, Fei Huang**

THUR2-02: Financial modelling 6
Time: Thursday, 14/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695
Chair: Guiyuan Ma

Dynamic Mean-Variance Problem with Frictions
Authors: **Alain Bensoussan, Guiyuan Ma** (Xi'an Jiaotong University)**, Chi Chung Siu, Sheung Chi Phillip Yam**

Variable Annuities via Piecewise Linear Barrier Options
Authors: **Hangsuck Lee, Hongjun Ha, Minha Lee** (Sungkyunkwan University)

Model Risk in Pricing Wind Speed Derivatives
Authors: **Giovani Gracianti** (University of Melbourne)**, Rui Zhou, Johnny Li, Xueyuan Wu**

Optimal Investment Under Ambiguity: The G-Martingale Approach
Authors: **Qiguan Chen** (Nanjing University)**, Zengwu Wang, Zengting Yuan, Yulin Song**

THUR2-03: Optimal control in insurance and finance 6
Time: Thursday, 14/Jul/2022: 17:00-18:40
Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891
Chair: Yang Shen

A probabilistic Method for a Class of Non-Lipschitz BSDEs with Application to Fund Management
Authors: **Jinhui Han** (The Chinese University of Hong Kong)**, Sheung Chi Phillip Yam**

Generalised Option-Based Portfolio Insurance Strategy
Authors: **William Lim** (Australian National University)**, Gaurav Khemka, Catherine Donnelly**

Optimal Per-Loss Reinsurance and Investment Problem Under Negative Correlation Assumption
Authors: **Fudong Wang** (Nanjing Normal University)

THUR2-04: Risk measures 6
Time: Thursday, 14/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164

Chair: Carole Bernard

Assessing Model Uncertainty for Log-Symmetric Distributions

Authors: **Carole Bernard** (Vrije Universiteit Brussel)**, Rodrigue Kazzi, Steven Vanduffel**

Implied Value-at-Risk and Model-Free Simulation

Authors: **Carole Bernard, Andrea Perchiazzo** (Vrije Universiteit Brussel)**, Steven Vanduffel**

Coskewness Under Dependence Uncertainty

Authors: **Carole Bernard, Jinghui Chen** (Vrije Universiteit Brussel)**, Ludger Rüschendorf, Steven Vanduffel**

One Axiom to Rule Them All: A Minimalist Axiomatization of Quantiles

Authors: **Tolulope Fadina, Peng Liu** (University of Essex)**, Ruodu Wang**

THUR2-05: Reinsurance and other risk-sharing arrangements 4

Time: Thursday, 14/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635

Chair: Zuoquan Xu

Dynamic Optimal Reinsurance and Dividend-Payout in a Finite Time Horizon

Authors: **Zuoquan Xu** (The Hong Kong Polytechnic University)**, Chonghu Guan, Rui Zhou**

Pareto Optimal Risk Sharing for Multiple Policyholders

Authors: **Tim Boonen, Wing Fung Chong** (Heriot-Watt University)**, Mario Ghossoub**

The Portfolio Diversification Effect of Catastrophe Bonds

Authors: **Chi Feng** (Shanghai University of Finance and Economics)**, Xudong Zeng**

Time-Consistent Mean-Variance Reinsurance-Investment Problem with Long-Range Dependent Mortality Rate

Authors: **Ling Wang** (The Chinese University of Hong Kong)**, Mei Choi Chiu, Hoi Ying Wong**

THUR2-06: Asset and liability management 1

Time: Thursday, 14/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864

Chair: Tingjin Yan

Local Mean-Variance Asset-Liability Management with Temporary and Persistent Price Impacts

Authors: **Tingjin Yan** (East China Normal University)**, Jinhui Han, Guiyuan Ma, Chi Chung Siu**

Research on the Proportion of Subordinates and the Pricing of Asset Securitization Products in Accounts Receivable in China

Authors: **Rui Ma** (Anhui Polytechnic University)**, Chuanyu Wang, Zemin Liu**

Dynamic Optimal Adjustment Policies of Hybrid Pension Plans

Authors: **Sheng Wang** (Tsinghua University)**, Zongxia Liang, Lin He**

A New Mean-Variance Model for Uncertain Portfolio Selection with Inflation Taking Linear Uncertainty Distributions

Authors: **Xiaoxia Huang, Di Ma** (University of Science and Technology Beijing)**, Kwang-Il Choe**

THUR2-07: Mortality modelling 2

Time: Thursday, 14/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503

Chair: Hanlin Shang

Multi-Population Modelling and Forecasting Life-Table Death Counts

Authors: **Hanlin Shang** (Macquarie University)**, Ruofan Xu, Steven Haberman, Ruofan Xu**

Affine Mortality Models with Jumps: Parameter Estimation and Forecasting

Authors: **Len Patrick Dominic Garces** (UNSW Sydney)**, Jovana Kolar, Michael Sherris, Francesco Ungolo, Yuxin Zhou**

Modelling the Mortality of China's Oldest-Old

Authors: **Ho Yan Joey Yung** (UNSW Sydney)**, Katja Hanewald, Andres Villegas**

Mortality Forecasting Under the Non-Linear Credibility Regression Framework

Authors: **Apostolos Bozikas** (University of Piraeus)**, Georgios Pitselis**

THUR2-08: Insurance risk models 3

Time: Thursday, 14/Jul/2022: 17:00-18:40

Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248

Chair: Yuantao Xie

Dynamic Random Models with Internal and External Excitation for Applications in Cyber Risk Insurance

Authors: **Yousra Cherkaoui Tangi** (Crest)**, Alexandre Boumezoued, Caroline Hillairet**

How Can Insurers Identify Scenarios in Their Own Risk and Solvency Assessment?

Authors: **Philipp Aigner** (Mainz University of Applied Sciences)

Cyber Risk Assessment by Classic Insurance Model

Authors: **Yutaro Takagami** (Graduate School of Waseda)

On a Compound Poisson Risk Model with Two-Sided Jumps and Proportional Investment

Authors: **Jiaen Xu** (Henan University of Science and Technology)**, Chunwei Wang, Naidan Deng**

Thursday Parallel Sessions 3

THUR3-01: Valuation of emerging risks 1

Time: Thursday, 14/Jul/2022: 22:15-23:55

Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402

Chair: Petar Jevtic

Framework for Cyber Risk Loss Distribution of Hospital Infrastructure

Authors: **Stefano Chiaradonna, Petar Jevtic** (Arizona State University)**, Nicolas Lanchier**

Investment-Consumption with Unemployment and Reemployment Driven by Regime Switching
Authors: **Ximin Rong, Hui Zhao, Cheng Tao** (Tianjin University)

Actuarially Market Consistent Valuations of Catastrophe Bonds
Authors: **Saeid Safarveisi** (KU Leuven)**, Dixon Domfeh, Arpita Chatterjee**

Pandemic Risk Management: Resources Contingency Planning and Allocation
Authors: **Linfeng Zhang** (University of Illinois at Urbana-Champaign)**, Xiaowei Chen, Wing Fung Chong, Runhuan Feng**

THUR3-02: Asset and liability management 2
Time: Thursday, 14/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695
Chair: Xing Wang

How Financial Disintermediation Affects Commercial Bank Stability
Authors: **Minhua He** (Fudan University)

The Consistency of Mean-Risk Models with Dominance Rules: An Analysis Based on Uncertainty Theory
Authors: **Tingting Yang** (University of Science and Technology Beijing)**, Xiaoxia Huang**

Valuation of Hybrid Pension Scheme Liabilities Under Inflation
Authors: **Shuai Liu** (Anhui Polytechnic University)**, Chuanyu Wang, Juan Xue, Wang Lan**

A Hawkes Type Mean-Variance Portfolio Optimization Model with Liability in Limit Order Book
Authors: **Qi Guo** (University of Calgary)**, Anatoliy Swishchuk**

THUR3-03: Ruin theory and related topics 3
Time: Thursday, 14/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891
Chair: Ruodu Wang

Q-Scale Function and Ultimate Ruin Probability Under a Markov-Modulated Jump-Diffusion Risk Model with Hyperexponential Jumps
Authors: **Zhengjun Jiang** (BNU-HKBU United International College)

On a Time-Changed Lévy Risk Model with Capital Injections and Periodic Observation
Authors: **Ye Teng** (Chongqing University)**, Zhimin Zhang**

Bridging the First and Last Passage Times for Lévy Models
Authors: **David Landriault, Bin Li, Mohamed Amine Lkabous, Zijia Wang** (University of Waterloo)

On Corporate Demand for Insurance: A Dynamic Perspective on Property Insurance
Authors: **Andrea Bergesio, Mario Sikic** (University of Zurich)**, Pablo Koch-Medina**

THUR3-04: Pension and pension mathematics 2
Time: Thursday, 14/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
Chair: Ruilin Tian

Influence of DB Pension De-Risking on Pension Betas and Firm Value
Authors: **Ruilin Tian** (North Dakota State University)**, Jun Chen**

Raising the Normal Retirement Age Gradually
Authors: **Xiaobai Zhu** (Southwestern University of Finance and Economics)**, Jingong Zhang**

Optimal Defined-Contribution Pension Management with Financial and Mortality Risks
Authors: **Wenyuan Li** (University of Waterloo)**, Ken Seng Tan, Pengyu Wei**

Optimal Savings and Portfolio Choice with Risky Labor Income and Reference-Dependent Preferences
Authors: **Servaas van Bilsen** (University of Amsterdam)**, Roger Laeven, Theo Nijman**

THUR3-05: Climate change and others 2
Time: Thursday, 14/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
Chair: Zhiyu Quan

Inclusive Insurance and Residents' Consumption: Evidence from China
Authors: **Lili Zheng** (Central University of Finance and Economics)**, Wenxin Deng**

Sustainability of Agricultural Income Insurance Under Climate Change and Market Uncertainty
Authors: **Ezgi Nevruz** (Hacettepe University)

Sustainable Investing in Corporate Bonds: Evidence from the U.S. Life Insurance Companies
Authors: **Wenchu Li** (Temple University)

Introduction to Switching Loss Distribution for Climate Disasters: A Case Study of United States Climate Disaster Losses
Authors: **Kai Liu, Xander Wang, Ali Raisolsadat** (University of Prince Edward Island)

THUR3-06: Loss reserve methods 1
Time: Thursday, 14/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864
Chair: Haiyan Liu

Estimating the Claims Reserve Using Gaussian Process Regression with Log-Transform Data and Compound Kernel
Authors: **Xusheng Deng** (Tianjin University of Commerce)**, Zhiyi Lu**

Dependent Loss Reserving and Risk Capital Modeling with Copula Regression and Recurrent Neural Network
Authors: **Pengfei Cai** (McMaster University)**, Anas Abdallah, Pratheepa Jeganathan**

Cross-Sectional Quantile Regression for Estimating Conditional VaR During Periods of High Volatility
Authors: **Xenxo Vidal-Llana** (Universitat de Barcelona)**, Montserrat Guillen**

Optimal Annuity Demand Under the Presence of Annuity Costs and Taxes
Authors: **Jun-Hee An** (Tilburg University)

THUR3-07: Life and non-life insurance 3
Time: Thursday, 14/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503
Chair: Danping Li

Average Time Until First Income Protection Claim
Authors: **Isabel Maria Cordeiro** (Universidade do Minho)

Efficient Valuation of GMMBs in Regime Switching Jump Diffusion Models with Surrender Risk
Authors: **Wei Zhong** (Chongqing university)**, Zhenyu Cui, Zhimin Zhang**

Ratemaking in a Changing Environment
Authors: **Nii Okine** (Appalachian State University)

THUR3-08: Insurance risk models 4
Time: Thursday, 14/Jul/2022: 22:15-23:55
Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248
Chair: Yiying Zhang

On a Bivariate Sarmanov Distribution with Composite Marginals for Bivariate Auto Insurance Costs
Authors: **Raluca Vernic** (Ovidius University of Constanta)**, Catalina Bolance, Montserrat Guillen**

An Alternative Insurance Model Against New Emerging Risks
Authors: **Muhsin Tamturk** (University of Leicester)

Risk Aggregation Under IFRS 17: An Ultimate Run-Off Adaptation of Solvency 2 Elliptic Aggregation
Authors: **Tachfine El Alami** (Université Claude Bernard Lyon 1)

Pooling and Systematic Risk
Authors: **Hirbod Assa** (Kent Business School)

Friday Parallel Sessions 1

FRI1-01: Data science and statistical modelling 7
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 836 7795 1605 Passcode: 194402
Chair: Jingchao Li

Projection of Successor Excellence Branch Manager XYZ Bank Using Survival Model
Authors: **Andzar Syafa'atur Rahman** (University of Indonesia)**, Lenny Suardi**

Application of Survival Analysis Method to Find Out Time to Default Salary Based Credit Debtor at XYZ Bank
Authors: **Singgih Aji Nugroho** (Universitas Indonesia)**, Lenny Suardi**

Credit Scoring Micro Loan Using Multivariate Adaptive Regression Splines
Authors: **Gamar Aseffa** (University of Indonesia)**, Lenny Suardi**

Distributional Forecasting of Outstanding Liabilities with Neural Networks
Authors: **Muhammed Taher Al-Mudafer** (UNSW Sydney)**, Benjamin Avanzi, Greg Taylor, Bernard Wong**

FRI1-02: Financial modelling 7
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 891 8739 0955 Passcode: 499695
Chair: Zheng Chen

Modeling the Dependency in the Turkish Stock Market via the Dynamic Vine-GARCH Model
Authors: **Ozan Evkaya** (Edinburgh University)**, Gulden Poyraz, Bukre Yildirim Kulekci, Ismail Gur**

Portfolio Selection Criteria Based on Generalized Herd Behavior Index for Bespoke Basket
Authors: **Wing Fung Chong, Churui Li** (KU Leuven)**, Daniël Linders, Gertjan Verdickt**

Domestic Credit Channelization to Private Sector and Economic Growth: An Empirical Analysis
Authors: **Sudan Kumar Oli** (University of International Business and Economics)

OVX Forecasting via SVR-GARCH Method: A New Cross-Market Perspective Based on Stock Market Jumps
Authors: **Gongyue Jiang** (Southwest Jiaotong University)**, Gaoxiu Qiao, Feng Ma, Lu Wang**

FRI1-03: Optimal control in insurance and finance 7
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 830 7941 4558 Passcode: 744891
Chair: Xudong Zeng

Optimal Investment-Consumption-Insurance Problem with Default Risk
Authors: **Pin Wang** (Soochow University)**, Guojing Wang, Rui Mu**

Optimal Management of DC Pension Fund Under Relative Performance Ratio and VaR Constraint
Authors: **Yi Xia** (Tsinghua University)**, Guohui Guan, Zongxia Liang**

Optimal Strategies with Stochastic Wage and Multi-Payments Critical-Illness Insurance
Authors: **Shiqi Yan** (Central University of Finance and Economics)

The N-Player and Mean-Field Game of Optimal Reinsurance and Investment Strategy
Authors: **Guanxia Zhu** (Shanghai University of Finance and Economics)**, Xudong Zeng**

FRI1-04: Valuation of emerging risks 2
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 896 1348 8008 Passcode: 631164
Chair: Jiwook Jang

Spatial Dependency and Socio-Economic Impacts on Data Breach Risks: Nation-Wide Analysis in the U.S.
Authors: **Kwangmin Jung, Jaehun Cho** (Pohang University of Science and Technology)

High-Quality Credit Portfolios Under Multilevel Extreme Risks
Authors: **Qihe Tang, Yang Yang, Yunshen Yang** (UNSW Sydney)

Pricing Catastrophe Bonds Under Transitions of the Physical and Economic Environment
Authors: **Haibo Liu, Yuhao Liu** (UNSW Sydney)**, Qihe Tang, Jinxia Zhu**

Survival Analysis of Cardiovascular Patients Participants of National Health Insurance in Indonesia
Authors: **Fera Rusanti** (Indonesia University)**, Lenny Suardi**

FRI1-05: Reinsurance and other risk-sharing arrangements 5
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 835 3269 4794 Passcode: 684635
Chair: Vali Asimit

Portfolio Risk Mitigation via Risk Parity
Authors: **Vali Asimit** (Bayes Business School)**, Radu Tunaru, Liang Peng, Feng Zhou**

Optimal Reinsurance for Multivariate Risks
Authors: **Yinzhi Wang** (Southwestern University of Finance and Economics)

Deep Insights of Reinsurance Research: A Review of Main Streams and Development Track
Authors: **Wei Zhou, Zhaoxia Wu** (Yunnan University of Finance and Economics)

An Insurer's Optimal Strategy Towards a New Independent Business
Authors: **Yuxia Huang** (Central University of Finance and Economics)**, Yichun Chi, Ken Seng Tan**

FRI1-06: Catastrophe modelling 1
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 881 0326 2533 Passcode: 377864
Chair: Chi Truong

Flood Risk and the Option to Adapt Under Uncertainty
Authors: **Chi Truong** (Macquarie University)

Earthquake Parametric Insurance with Bayesian Spatial Quantile Regression
Authors: **Yunxian Li** (Yunnan University of Finance and Economics)

Modelling the Joint Extremes of Air Pollution Risks
Authors: **Chengxiu Ling, Jiajun Liu** (Xi'an Jiaotong-Liverpool University)**, Jingyi Xu**

Borrowing Information Across Space and Time: Pricing Flood Risk with Physics-Based Hierarchical Machine Learning Models.
Authors: **Yanbin Xu** (Nanyang Technological University)**, Ken Seng Tan, Wenjun Zhu**

FRI1-07: Health insurance 1
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 879 4168 9738 Passcode: 863503
Chair: Chunli Cheng

It Is Not Only up to You! The Effect of Retirement on Healthcare Utilization-The Role of Physician Incentives
Authors: **Jiyuan Wang** (Central University of Finance and Economics)**, Ya Gao, Jiankun Lu, Xiaomin Zhong**

The Effect of Childhood Socioeconomic Status on Private Medical Insurance Demand: Evidence from China
Authors: **Xiangwen Zheng** (Central University of Finance and Economics)

Critical Illness Insurance Model for Breast Cancer Patients After Chemotherapy
Authors: **M. Ivan Ariful Fathoni** (Universitas Gadjah Mada)**, Gunardi Gunardi, Fajar Adi Kusumo, Susanna Hilda Hutajulu**

Multi-State Modelling of Functional Disability and Health Status Using Australian Cross-Sectional Data
Authors: **Kyu Hyung Park** (The Australian Research Council (ARC) Centre of Excellence in Population Ageing Research (CEPAR))**, Michael Sherris**

FRI1-08: Ruin theory and related topics 4
Time: Friday, 15/Jul/2022: 15:00-16:40
Zoom Link: Meeting ID: 817 9899 0334 Passcode: 980248
Chair: Kazutoshi Yamazaki

Series Expansion Formula for Scale Matrices and Applications in Ruin Theory
Authors: **Kazutoshi Yamazaki** (University of Queensland)**, Jevgenijs Ivanovs**

A Multivariate Risk-Theoretic Approach to the Matrix Sequential Probability Ratio Test
Authors: **Oscar Peralta** (University of Lausanne)**, Hansjoerg Albrecher**

The Role of Direct Cash Transfers Towards Extreme Poverty Alleviation - An Omega Risk Process
Authors: **José Miguel Flores-Contró** (University of Lausanne)**, Séverine Arnold**

Ensemble Distributional Forecasting for Insurance Loss Reserving
Authors: **Benjamin Avanzi, Yanfeng Li** (UNSW Sydney)**, Bernard Wong, Alan Xian**

Abstracts of Keynote Speeches

(in alphabetical order)

Why Don't Retirees Spend Their Savings? Behavioural Explanations and Demand-Side Solutions

Hazel Bateman (University of New South Wales)

The life-cycle model predicts that people accumulate wealth during their working life and draw down their assets after retirement. Yet recent empirical studies for many countries show that many retirees hold on to their assets or even keep on saving well into old age. This presentation will draw upon recently published papers and work-in-progress to explore this phenomenon. The focus will be the identification of behavioural explanations for the reluctance to drawdown wealth accumulated during working years and the role of behavioural interventions to encourage people to drawdown their wealth in retirement.

Calculation of Enterprise Capital via Least-Squares Monte Carlo -- Regress Now or Later?

Daniel Bauer (University of Wisconsin-Madison)

There has been substantial interest in applied research and practice on the estimation of risk capital within enterprise risk models via Monte Carlo procedures. The difficulty arises from characterizing the distribution of the company's available capital, which takes the form of a conditional expected value of the firm's future cash flows given the market and company state at the risk horizon.

One prevalent approach that improves on the basic nested simulations estimator, referred to as regression-now, projects realized cash flows corresponding to a product or portfolio on a set of basis functions of the Markov states at the risk horizon. Another approach seeks to approximate the cash-flows based on functions of realizations of a class of tractable processes, and in a second step calculates the conditional expected value of the approximating functional combination at the risk horizon. This approach is referred to as regression-later. Different authors documented advantages and disadvantages to both approaches in specific situations.

This presentation discusses these approaches. We show "optimal" implementations of the different approaches, including the derivation of robust approximating functions for the regress-now and regress-later approach. We also characterize situations in which the different approaches result in a superior performance. This is based on a joint work with Hongjun Ha (St. Josephs University).

Optimal Design of Reinsurance Contracts Under Adverse Selection with a Continuum of Types

Ka Chun Cheung (The University of Hong Kong)

We use the Principal-Agent models to study a monopolistic reinsurance market under adverse selection with a continuum of types. Instead of adopting the classical expected utility paradigm, we model the risk preference of each insurer (agent) by his Value-at-Risk at his own chosen risk tolerance level. Under information asymmetry, the reinsurer (principal) aims to maximize his expected profit by designing an optimal menu of reinsurance contracts for a continuum of insurers with hidden characteristics. The optimization problem is constrained by agents' individual compatibility and rationality constraints. By making use of the notion of indirect utility functions originated from optimal transport theory, the problem is completely solved for the following commonly encountered subclasses of reinsurance indemnities: (i) stop-loss, (ii) quota-share, and (iii) change-loss. This is based on a joint work with S.C.P. Yam, K. Yuen, and Y. Zhang.

Abstracts of Contributed Talks

(in alphabetical order)

Calculation of Enterprise Capital via Least-Squares Monte Carlo -- Regress Now or Later?

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This is based on a joint work with Hongjun Ha (St. Josephs University).

Authors: Daniel Bauer

Estimating Absorption-Time Distributions of Markov Jump Processes with Piecewise Constant Transition Rates

Jamaal Ahmad (University of Copenhagen)

In this talk, we consider the problem of estimating absorption-time distributions of time-inhomogeneous Markov jump processes, which are known as inhomogeneous phase-type distributions (IPH). Since the underlying trajectory of the Markov jump process is not observed, we take an incomplete data approach and develop an EM algorithm for estimation of the transition rates based on independent observations of the absorption times. As this algorithm in general provides computational complexities that greatly increases compared to its homogeneous counterpart, we give special attention to the case where transition rates can be assumed piecewise constant over a grid of time points. In this special case, we show that a set of conditional expected sufficient statistics can be computed and used in classic Poisson GLM methods known from inference of Markov jump processes with piecewise constant transition rates. Numerical examples are provided in an example with mortality modeling based on data of Danish lifetimes.

Authors: Jamaal Ahmad, Martin Bladt, Mogens Bladt

The Neural Ratemaking System in Insurance and the Bias

Jaeyoun Ahn (Ewha Womans University)

For many of insurance product, ratemaking system consists of a priori and a posteriori processes. As a statistical forecasting system, this rate making system has special structure where a policyholder’s rate is first determined by the observable characteristics of the policyholder in the a priori risk classification process, and then adjusted by the claim history in the a posteriori risk classification process. Typically, a posteriori risk classification does not utilize the a priori information, and the a posteriori risk classification depends solely by the claim history. In this presentation, we show that any ratemaking system having a priori and a posteriori

process can possibly suffer from bias issue, so called ``double-counting problem.`` In this presentation, we show how to detour the double-counting problem in the ratemaking system, and explain how the method can be applied for the neural network method to achieve the maximum accuracy while the bias issue has been removed.

Authors: Kyongwon Kim, Rosy Oh, Jaeyoun Ahn

How Can Insurers Identify Scenarios in Their Own Risk and Solvency Assessment?

Philipp Aigner (Mainz University of Applied Sciences)

Most insurers in the European Union determine their regulatory capital requirements based on the standard formula of Solvency II. However, there is evidence that the standard formula inaccurately reflects insurers' current risk situation and provide misleading steering incentives. In order to extend the standard formula to reflect the "true" portfolio risk also including risks that are not or not adequately evaluated, this paper follows the requirements to the Own Risk and Solvency Assessment (ORSA) and identify additional stress scenarios. In especial, we employs an innovative method to identify scenarios allowing to capture situations that are not considered by the standard formula but necessary for a reliable risk evaluation. Technically, the extension of the regulatory risk calculation to include a measurement based on ORS scenarios ensures that the first and second order derivatives of the "true" risk measurement are met in a neighbourhood of an actual portfolio. Thus, it allows for an easy and reliable assessment of marginal and even non-marginal portfolio changes considered, based on a deterministic function. Our idea is numerically evaluated using an internal model from the academic literature and the Solvency Capital Requirement (SCR) calculation of the market risk module under Solvency II.

Authors: Philipp Aigner

Distributional Forecasting of Outstanding Liabilities with Neural Networks

Muhammed Taher Al-Mudafer (UNSW Sydney)

In recent years, new techniques based on artificial intelligence and machine learning in particular have been making a revolution in the work of actuaries, including in loss reserving. A particularly promising technique is that of neural networks, which have been shown to offer a versatile, flexible and accurate approach to loss reserving. However, applications of neural networks in loss reserving to date have been primarily focused on the (important) problem of fitting accurate central estimates of the outstanding claims. In practice, properties regarding the variability of outstanding claims are equally important (e.g., quantiles for regulatory purposes).In this paper we fill this gap by applying a Mixture Density Network ("MDN") to loss reserving. The approach combines a neural network architecture with a mixture Gaussian distribution to achieve simultaneously an accurate central estimate along with flexible distributional choice. Model fitting is done using a rolling-origin approach. Our approach consistently outperforms the classical over-dispersed model both for central estimates and quantiles of interest, when applied to a wide range of simulated environments of various complexity and specifications.We further extend the MDN approach by proposing two extensions. Firstly, we present a hybrid GLM-MDN approach called "ResMDN". This hybrid approach balances the tractability and ease of understanding of a traditional GLM model on one hand, with the additional accuracy and distributional flexibility provided by the MDN on the other. We show that it can successfully improve the errors of the baseline ccODP, although there is generally a loss of performance when compared to the MDN in the examples we considered. Secondly, we allow for explicit projection constraints, so that actuarial judgement can be directly incorporated into the modelling process.Throughout, we focus on aggregate loss triangles, and show that our methodologies are tractable, and that they out-perform traditional approaches even with relatively limited amounts of data. We use both simulated data—to validate properties, and real data—to illustrate and ascertain practicality of the approaches.

Authors: Muhammed Taher Al-Mudafer, Benjamin Avanzi, Greg Taylor, Bernard Wong

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Optimal Annuity Demand Under the Presence of Annuity Costs and Taxes

Jun-Hee An (Tilburg University)

Taxes are often ignored in the academic literature in the field of pension economics and finance despite their significant impact on the financial decisions of individuals. This paper investigates the welfare effect of pension tax treatments on the optimal annuity demand. We extend the well-known Merton model by incorporating pension tax rules and find the optimal investment and consumption strategies over the life-cycle. To see how the tax treatments affect optimal decisions of individuals in practice, we compare different pension tax treatments in four countries: the United States, the Netherlands, Australia, and Korea.

Authors: Jun-Hee An

Signature-Based Validation for Real World Economic Scenarios

Hervé Andres (Ecole des Ponts ParisTech)

Real world economic scenarios are widely used by insurance companies for applications requiring the simulation of realistic asset and liability cash-flows in the future. These applications cover the calculation of the Solvency Capital Requirement, strategic asset allocation analysis, or profitability studies, among others.An important process for insurers is the validation of those scenarios, that is the assessment of their consistency with respect to historical data and any additional expectation of future behavior. While current validation methods essentially consist in basic analyses of marginal distributions of the forecasts for a limited number of points in time, we propose a more general approach to validation by assessing the relevance of the pathwise properties of the generated scenarios, including core stylized facts such as autocorrelation, smoothness or clustering, that are often neglected in practice. The tool we rely on was originally introduced [2] to test whether two samples of stochastic processes paths come from the same distribution. It relies on a statistical test which is based on the concept of signature [4] and maximum mean distance [3]. The signature of a path, defined as the iterated integrals of the trajectory against itself, is essential in this method as it provides a way to represent paths in a parsimonious, hierarchical and accurate manner, that has proven to be successful in a variety of learning problems [1].Our contribution is to apply this method as a validation tool to assess the appropriateness of a given model over another, and so for a collection of use cases that are relevant to the insurance industry. We will present in particular the statistical power of this approach for stochastic models used for forecasting risk drivers such as indices, volatility, inflation or spread, among others. We will also discuss several challenges related to the numerical implementation of this approach, and highlight its domain of validity in terms of distance between models and the volume of historical data at hand.

Authors: Alexandre Boumezoued, Benjamin Jourdain, Hervé Andres

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Longevity and Financial Risk-Taking

Giovanna Apicella (University of St. Gallen)

The growing importance of funded pensions increasingly transfers the risks related to retirement saving (e.g. investment and longevity) to the individuals. Within these funded pension arrangements, planning involves making active decisions toward the desired level of retirement income, and thus more choice about savings and investment during the working years and wealth decumulation afterwards, so as to not outlive the own assets. Our research focus on the role of gender and longevity risk perception in the explanation of individuals' willingness to engage in financial risks. Indeed, financial risk tolerance underlies several household decisions relevant to retirement planning, from asset allocation to insurance purchase. We use data from the "Survey of Health, Ageing and Retirement in Europe" (SHARE) and study the relationship between a measure of longevity perception, i.e. the difference between subjective survival probabilities and their actuarial counterparts. Among the other findings, we show that individuals who are able to express a more precise estimation of their survival prospects are more likely to tolerate any financial risks, compared to all the other respondents. This is particularly relevant for women, being more prone to under-estimate their survival. Overall, our results pave the way to a better understanding of women's observed behaviour with respect to long-term investing and retirement planning.

Authors: Giovanna Apicella, Enrico De Giorgi

Analysis of Crop Insurance Claims Reserve Estimates with Chain Ladder and Bornhuetter-Ferguson Method

Hafidh Afif Ardhi (University of Indonesia)

This research aims to estimate the reserves of claims Rice Farmer Business Insurance Program (AUTP) which was implemented in 2015 to provide protection and empowerment to rice farming business farmers who have the potential to experience crop failure. The AUTP program has a short policy period (valid for 4 months) and gets an 80% subsidy for premiums from the government, so it is necessary to analyze the claim

reserves for AUTP because fail to harvest. In the AUTP claim reserve study for the period 2017 - 2021, the analysis used the concept of monthly and quarterly in the Run-Off Triangle (ROT) (Monthly 60x60 and Quarterly 20x20) because it has variations in accident year and development year periods. Furthermore, the Chain Ladder (CL) method is the most common and simple method used in general insurance because it considers Age-to-Age Factor (LDF) as well as the Bonrhuetter-Ferguson (BF) method also considers earning a premium and Estimated Ultimate Losses (EUL) from CL.The result was obtained that there was no significant difference between the value of Estimated Loss Reserve and EUL in the CL and BF. The reason was the value of the amount of LDF in ROT, no payment of claims in some periods of events & periods of delay, claim payments completed for more than 1 year. In addition, the AUTP is a new program from the government for rice farmers, so the benefits of this insurance program are still studied by prospective policyholders for the benefits to be received.

Authors: Hafidh Afif Ardhi, Lenny Suardi

Calculation of Return Period for Earthquake Events for Catastrophe Reinsurance Coverage in the Java Island Region

Niko Ardita (University of Indonesia)

Earthquake is a natural disaster that is difficult to predict when it occurs and also causes the most damage to buildings and deaths. Java Island is the island with the most population and also has the most buildings, so it is necessary to calculate non-proportional reinsurance companies to minimize losses from insurance companies due to catastrophic events. In this study, we will discuss how to determine the reinsurance premium rate for catastrophe events using the payback method. So that when it is completed it will get the results in the form of the time of occurrence of the return period of the earthquake on the island of Java and also the appropriate premium rate for catastrophe events on the island of Java.

Authors: Niko Ardita

Credit Scoring Micro Loan Using Multivariate Adaptive Regression Splines

Gamar Aseffa (University of Indonesia)

This paper aim to formulate credit scoring model for micro loan using the Multivariate Adaptive Regression Splines (MARS) method. The MARS method is a nonparametric regression approach that has the ability to model complex relationships between variables without strong model assumptions and produces a model with high accuracy that exceeds other credit scoring models and is able to process high-dimensional data. In recent years, MARS has been widely applied to modeling various data, however, no one has used it for micro loan credit scoring yet. Generally, the credit scoring methods commonly used are discriminant analysis and logistic regression. However, there are limitations to both methods, namely the need for parametric assumptions between the response variables and predictors. The results of this study indicate that the microcredit credit scoring model using MARS has a higher predictive accuracy with the smallest error rate, type I and II errors compared to the Logistics Regression Method. So the results of this study can be used as considerations for banks in applying the MARS method in credit scoring in order to control the Non-Performing Loan Risk of Micro Loan.

Authors: Gamar Aseffa, Lenny Suardi

Portfolio Risk Mitigation via Risk Parity

Vali Asimit (Bayes Business School)

We consider the problem of risk mitigation in a portfolio of (insurance or financial) risks, and therefore, risk minimisation is not the primary interest. This is achieved through risk parity where the risks are distributed via a budgeting strategy imposed by the risk manager. We provide the theoretical background of risk parity mitigation for a generic portfolio of risks, and we then explain the advantages of this strategy in the context of i) portfolio investment and ii) constructing insurance risk portfolios within an insurance group or a group of insurers that are willing to achieve risk mitigation through risk sharing. We provide multiple numerical examples for both financial and insurance risks, one of which is about social responsibility investment.

Authors: Vali Asimit, Radu Tunaru, Liang Peng, Feng Zhou

Pooling and Systematic Risk

Hirbod Assa (Kent Business School)

This paper, for the first time, gives a general formulation of the systematic risk in a risk pool as portfolio's excess loss, and studies its relation with the principle of insurance (POI), and its extension, the principle of pooling (POP). We see that the systematic risk is secure if and only if POP holds. We call this proposition the fundamental theorem of pooling. Then, we show how the systematic risk can organically be measured. We present a variety of examples within the family of typological common shock models, covering homogeneous and heterogeneous risk pools, where we can identify the systematic risk, and measure it in different situations. Then we take a fresh look at the risk valuation from the systematic risk perspective. First, we study the valuation of the ex-ante policies and see that they are not independent of the pool, and need to be adjusted according to the relative systematic safety loading. Second, as we are exposed to systematic risk, we also study the ex-post policies and see that while in finite pools the relative safety loading is contingent on the common shock, for infinite pools it vanishes. In the end, we make an assessment of our theoretical models with reference to two real-world examples. First, we look at the UK Coronavirus (Covid-19) job retention case and second we use our theory to study the agricultural catastrophe risk. This way we propose a novel way to analyze events with large economic losses.

Authors: Hirbod Assa

Optimal Reinsurance Under Terminal Value Constraints

Benjamin Avanzi (University of Melbourne)

Optimal reinsurance is a perennial problem in insurance. The problem formulation considered in this paper is closely connected to the optimal portfolio problem in finance, with some important distinctions. In particular, the surplus of an insurance company is routinely approximated by a Brownian motion, as opposed to the geometric Brownian motion used to model assets in finance. Furthermore, exposure to risk is controlled "downwards" via reinsurance, rather than "upwards" via risky investments. This leads to interesting qualitative differences in the optimal solutions. In this paper, using the martingale method, we derive the optimal proportional, non cheap reinsurance control that maximises the quadratic utility of the terminal value of the insurance surplus. We also consider a number of realistic constraints on the terminal value: a strict lower boundary, the probability (Value at Risk) constraint, and the expected shortfall (conditional Value at Risk) constraints under the P and Q measures, respectively. Comparison of the optimal strategies with the optimal solutions in finance are of particular interest. Results are illustrated.

Authors: Benjamin Avanzi, Hayden Lau, Mogens Steffensen

Long Memory in Option Pricing: A Fractional Discrete-Time Approach

Alexandru Badescu (University of Calgary)

This article studies the impact of long memory on asset return modelling and option pricing. We propose a general discrete-time pricing framework based on affine multi-component volatility models that admit ARCH(∞) representations. It not only nests a plethora of option pricing models from the literature, but also allows for the introduction of novel fractionally integrated processes for option valuation purposes. Using an infinite sum characterization of the unconditional cumulant generating function of the log-asset price, we derive semi-explicit expressions for European option prices under a volatility-dependent stochastic discount factor. We carry out an extensive empirical analysis which includes returns-only as well as return and option joint estimations of a variety of short- and long-memory models for the S&P 500 index. Our results indicate that the inclusion of long memory into return modelling substantially improves the option pricing performance. Using a set of out-of-sample option pricing errors, we show that long-memory model outperforms richer parametrized one- and two-component model with short-memory dynamics.

Authors: Maciej Augustyniak, Alexandru Badescu, Jean-François Bégin, Sarath Kumar Jayaraman

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Anomality Detection in Health Insurance Data Based on Outlingness Function

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Zahra Barzegar (Saman Insurance Company)

Anomality detection is an important and challenging task in analyzing insurance data sets. Despite the existence of various techniques, most of them become challenging with increasing data dimension and departing from Gaussianity. Specifically, many experiments in insurance are performed based on the non-Gaussian multivariate data. This paper aims to provide an affine invariant depth-based method to identify outlier observations. Depth functions by taking into account the geometry of the multivariate data provide from the deepest point a center-outward ordering of multivariate data. Since the outlingness of issues is inevitably related to data ranks, they can be therefore used to construct an algorithm for anomality detections. Here, we apply this framework to recognize anomaly group health insurance contracts of Iranian Saman Insurance Company during 2021. To this end we calculated average premium and average claim amount per insured along with loss ratio of each contract. Then we used R software for programing the method. The findings shed new light on the comparison of contracts and making decisions on renewing for next year.

Authors: Zahra Barzegar, Sakineh Dehghan, Shima Ara

Assessing Model Uncertainty for Log-Symmetric Distributions

Carole Bernard (Vrije Universiteit Brussel)

Model-based decisions are susceptible to model uncertainty that arises from the inadequacy of the adopted model. One natural way to address model uncertainty is to compare the adopted model with the worst-case and best-case models (i.e., models that yield a maximum resp. a minimum value for some chosen risk measure) that are consistent with a set of trusted assumptions. Even though it is common in actuarial and financial modeling to deal with risks whose distributions become symmetric after a log transformation, the literature (to the best of our knowledge) did not consider this assumption in assessing model uncertainty.In this talk, we present upper and lower bounds for the Value-at-Risk of log-symmetric risks under two sets of (trusted) assumptions. First, we consider the case in which the log-transformed random variable is known to have a unimodal and symmetric distribution with a known mean and a known maximum variance. The bounds, in this case, are sharp and significantly improve over those available in the literature for all probability levels lower than some extreme value. However, the practical issue of this case is that the upper bound increases dramatically at extreme probability levels.Second, we consider the case in which the random variable at hand is known to be log-symmetric and has a unimodal distribution with a known median, a known maximum mean, and a known second moment. For high probability levels, we could derive an upper bound that is sharp and stable for extreme probability levels and consequently offer a significant improvement over the bound of the first case (and the findings in the literature) for high probability levels. Indeed, this upper bound can be extended to the cases where the first moment is unknown but finite and the second moment is unknown and possibly infinite.Our approach for deriving the extreme models consists of two steps. In a first step, we use some classical results on stochastic ordering to reduce the optimization problem to a parametric one, which in a second step can be solved using standard methods.Our findings are illustrated using real-world datasets: an automobile insurance claims dataset and a general liability claims dataset (heavy-tailed).

Authors: Carole Bernard, Rodrigue Kazzi, Steven Vanduffel

Robusts Model in Band Ambiguity

Corina Birghila (University of Waterloo)

A major topic in finance and actuarial science is the identification, among all admissible models, of the most influential model for risk quantification. The set of these models is often called the ambiguity set, and it captures uncertainty concerning the data. In this regard we represent the set using the likelihood ratio with respect to a reference model P, and use this ratio to construct a band ambiguity set, introduced in Shapiro and Ahmed [2004] . The band set is parametrized by two constants that control the size of the set, or equivalently, the amount of uncertainty. We propose to find the optimal likelihood ratio that minimizes the f-divergence in the sense of Csiszar [1967], such that the general reward-risk ratio of a random return is exceeding a prescribed acceptance level β. The solution of the robust optimization problem is derived in both a continuous and a discrete state space. In the latter case, due to the connection between f-divergence and the Kullback-Leibler divergence (KL), we derive bounds for the optimal value in terms of the KL divergence. Via simulation experiments, we analyse the sensitivity of the optimal solution to the change in the band ambiguity parameters, as well as the change in acceptance level.

Authors: Corina Birghila

Randomization and Informed Censoring for Loss Estimation

Martin Bladt (University of Lausanne)

We consider the introduction of exogenous random variables into the loss modeling framework. The first aim is to show that such a setting can produce robust estimators in case of few or heterogeneous data, and in that case, the exogenous variables will be fully independent and regarded as a smoothing mechanism. The second aim is to incorporate expert information into maximum likelihood estimation through informed randomization. This mechanism allows incorporating expert guesses into a loss function even before any observation has been made, or when only partial information is present. The latter method has the potential to bridge statistical rigor with certain actuarial traditions, by casting both into the same framework and outputting a balanced result.We provide conditions for recovering the asymptotic distribution of the presented estimators, generalizing Donsker-type results for the independent case, and M- and Z- estimator-type asymptotics for the informed case. We construct and analyze realistic scenarios under which insight can be drawn, and apply the methodology to real-life insurance loss data. Potential extensions and limitations are briefly discussed. The results are not limited to actuarial applications and may be used whenever exogeneous information requires to be taken into account in statistical analysis.

Authors: Martin Bladt, Hansjoerg Albrecher

Risk Aggregation with FGM Copulas

Christopher Blier-Wong (Université Laval)

This talk presents new results on risk aggregation when the dependence structure is a Farlie-Gumbel-Morgenstern (FGM) copula. Leveraging a new stochastic representation of the FGM copula, 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 also develop allocation rules for conditional mean risk-sharing and Euler-based TVaR allocation. Finally, we present new results for the law of large numbers, the central limit theorem, a bound on the classical discrete-time ruin probability and large deviations for the FGM copula with the most positive dependence.

Authors: Christopher Blier-Wong, Hélène Cossette, Etienne Marceau

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Mortality Forecasting Under the Non-Linear Credibility Regression Framework

Apostolos Bozikas (University of Piraeus)

Empirical studies have shown that mortality rates decline over time. Based on the non-linear credibility regression framework, this work proposes a mortality forecasting approach, aiming to capture the downward trend in mortality data and lead to accurate forecasts. The parameter estimation process is described and the forecasting performance, compared to other mortality modelling approaches, is evaluated using real mortality datasets.

Authors: Apostolos Bozikas, Georgios Pitselis

Optimal Reinsurance via BSDEs in a Partially Observable Contagion Model

Matteo Brachetta (Politecnico of Milan)

We investigate the optimal reinsurance problem when the loss process exhibits jump clustering features and the insurance company has restricted information about the claims arrival intensity. We provide a rigorous model construction and introduce the problem of maximizing the expected exponential utility. We provide the equation governing the dynamics of the (infinite-dimensional) filter and characterize the solution of the stochastic optimization problem as the solution of a BSDE. Then we discuss some properties of the optimal control.

Authors: Matteo Brachetta

Determinants and Value of Corporate Social Responsibility Management: Empirical Evidence from the Insurance Industry

Tim Brasch (Coburg University of Applied Sciences and Arts)

Extreme weather events (e.g., flood disaster or forest fires) have a huge impact on the insurance industry and therefore require more attention. Moreover, supervisory authorities like EIOPA work on sustainable finance and aim to ensure that insurance companies integrate sustainability in their risk management. There, they expand the focus on environmental, social and governance (ESG) risks and recommend the implementation of a corporate social responsibility (CSR) strategy. Based on this, the goal of our paper is to empirically investigate determinants and value of corporate social responsibility management within the insurance industry.

Currently there is very little research in this regard (especially with an insurance company focus) and to the best of our knowledge we are the first to study the correlation between CSR management and the corporate financial performance (CFP), measured by Tobin's Q, in the insurance sector. In addition to that, we analyze the impact of determinants (the company's size, its financial leverage and slack as well as the return on equity) on the CSR performance using linear fixed effects models.

For this purpose, we use data from Refinitiv EIKON over a period of eleven years (2010-2020) and analyze the determinants and the value of corporate social responsibility management. Our results show, that there is a significant correlation between the ESG Score and the development of the enterprise value. Our findings also reveal a significant positive correlation between larger insurers and the corporate social responsibility management.

Authors: Tim Brasch, Christian Eckert

Dependent Loss Reserving and Risk Capital Modeling with Copula Regression and Recurrent Neural Network

Pengfei Cai (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.First, we investigate the copula regression model with Product copula, Gaussian copula, Frank copula, and Student's t copula for two dependent lines loss reserving. Next, we use DeepTriangle, a recurrent neural network (RNN) that models the complex dependence between two lines of business by using the incremental paid loss from two business lines as input. Then, we propose the matrix factorization method to impute the lower part of the loss triangles. Finally, we obtain predictive distribution for loss reserving using the bootstrap method.We apply and calibrate these three different methods on a personal and commercial automobile lines dataset. The results show they generate similar total reserves concerning the percentage difference metric but have limitations in accessing the predictive distribution and risk measures, which are more informative to actuaries and risk managers.

Authors: Pengfei Cai, Anas Abdallah, Pratheepa Jeganathan

An Efficient Approach for Computation and Interpretation of Bayesian Credibility Models for Experience Rating

Sebastian Felipe Calcetero (University of Toronto)

Bayesian credibility models for insurance are mostly mathematical intractable due to their complex structure, and therefore the calculation of credibility premiums must be obtained via simulations from the predictive distribution using Markov Chain Monte Carlo (MCMC) methods. However, such simulations are computationally expensive and even prohibitive for large portfolios. In addition, the computations end up being "black-box" procedures for the actuary, as there is no clear expression to know how the observed experience is used to upgrade premiums. In this paper we address these two challenges. At first we propose a simple, but efficient, simulation setup in which simulations are only drawn from the prior distribution, instead of the posterior one. Secondly, we propose a methodology to estimate a closed-form credibility formula from which approximated Bayesian credibility premiums can be computed for any model, therefore allowing for practical interpretations of how the previous claim experience of a policyholder can be used to derive credibility premiums.

Authors: Sebastian Felipe Calcetero, Andrei Badescu, Sheldon Lin

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Coskewness Under Dependence Uncertainty

Jinghui Chen (Vrije Universiteit Brussel)

In this paper, we study the impact of dependence uncertainty on coskewness. That is, we aim to maximize and to minimize $E[(X-E(X))(Y-E(Y))(Z-E(Z))$, where X, Y and Z have given marginal distributions.We derive these lower and upper bounds explicitly when the marginal distributions satisfy cumulative distribution functions evaluated on means are equal to one half and provide explicit expressions of the corresponding copulas that reach them. We then use these explicit bounds to introduce a notion of "standardized rank coskewness" so that it takes values in [−1, 1], and it is invariant with respect to the marginal distributions.Moreover, we provide a numerical method based on simulated annealing to estimate for all marginal distributions the risk bounds on coskewness and the corresponding copulas.

Authors: Carole Bernard, Jinghui Chen, Ludger Rüschendorf, Steven Vanduffel

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The Impacts of Carbon Tax on Economy in Production Networks Model

Ming Chen (Sun Yat-sen University)

To explore the impact of carbon tax on sectoral productions, household consumption and carbon emissions in the presence of intersectoral linkages, we add carbon tax based on sectoral carbon emissions to the production networks model consisting of sectors and household. We decompose the economic impacts of carbon tax and clarify the transmission mechanism of carbon tax shocks in a production network with input-output linkages. By applying a more general production function, we find a new effect of carbon tax on sectoral outputs, with other economical effects also being affected by the elasticity of substitution of input elements. Finally, we calibrate the parameters in the model using China's industry-level input-output data and carbon emission data, simulate the impact of carbon tax, and take the second-order effects into further consideration, finding that the effect of carbon tax on carbon emission reduction shows a trend of increasing first and then decreasing.

Authors: Ming Chen

Optimal Investment Under Ambiguity: The G-Martingale Approach

Qiguan Chen (Nanjing University)

In this paper, we study the optimal investemt problem under ambiguity. In order to accomodate uncertainty in financial market, we establish a framework to model the price process, admissible strategy, wealth process and optimal aim under nonlinear expectation theory. Moreover, we propose a sufficient condition for optimization and even obtain the explicit solution for log utility by G- martingale approach. Besides, we also generalize the model to consider the stochastic interest rate model and obtain its corresponding solution.

Authors: Qiguan Chen, Zengwu Wang, Zengting Yuan, Yulin Song

Cyber Risk Content Analysis Using Topic Modelling Approach

Yen-Chih Chen (Feng-Chia University)

With the rapid growth of cyber risks and its variety, understanding the characteristics of cyber risks is essential for insurance company. During the process of pricing and underwriting, insurance company should rely on detailed information of cyber risk. However, it’s not efficient to analysis these descriptions manually due to large volume of information. Hence, we can apply latent Dirichlet allocation (LDA) which is an automated

text analysis technique to identify underlying core topics. LDA provide important keywords within a topic and thus these keywords can be interpreted as a particular risk type. Take cyber breach events as example, we investigate the diversity of data breach events across multiple industries using the Privacy Rights Clearinghouse (PRC) database. The PRC database consists of several thousand cyber breaches events with text descriptions. In this study, coherent risk type topics are extracted from PRC database between 2005 to 2018. We find that data breaches events can be grouped into different categories and the elements in different categories can show the characteristics and trend of cyber risk. Through the outcome of LDA, we further estimate the frequency and severity of cyber risk in different topic categories. In short, our study provides a structured topography for cyber risk management by integrating the machine learning research approaches. Our results contribute new perspective on understanding breaches contents rather than conventional crude classification.

Authors: Yin-Yee Leong, Yen-Chih Chen

An Asymptotic Study of Systemic Expected Shortfall and Marginal Expected Shortfall

Yiqing Chen (Drake University)

Following recent studies of systemic risk in banking, finance, and insurance, we quantify systemic expected shortfall (SES) and marginal expected shortfall (MES) in the general context of quantitative risk management and link them to a confidence level $q \in (0,1)$. For this purpose, we consider a system comprising multiple individuals (sub-portfolios, lines of business, or entities) whose loss-profit variables are modeled by randomly weighted random variables so that both their tail behavior and the inter- dependence among them are captured. For the case of heavy-tailed losses, we derive general asymptotic formulas for the SES and MES as q ↑ 1. If restricted to the special case in which the losses have equivalent regularly varying tails, the obtained formulas are further simplified and explicitized into the value at risk of a representing ran- dom variable. Numerical studies are conducted to examine the performance of these asymptotic formulas.

Authors: Yiqing Chen, Jiajun Liu

Optimal Risk Pooling for Peer-to-Peer Insurance

Ze Chen (Renmin University of China)

Some emerging InsurTech models jointly incorporate the forms of centralized insurer's underwriting and decentralized peers' risk-sharing. Under these forms, the risk is separated into two layers under the mechanisms in which the first below-deductible part is shared within a community and second above-deductible loss, exceeding the community’s risk-bearing capacity, are covered by an insurer. In this paper, we mathematically formalize two existing business models: the individual- and group-covered peer-to-peer insurance models. From the perspective of risk averse participants, we studies the risk sharing mechanism and optimal deductible of these two models in both homogeneous and heterogeneous risk cases.

Authors: Ze Chen

Dynamic Derivative-Based Pension Investment with Stochastic Volatility: A Behavioral Perspective

Zheng Chen (Guangdong University of Technology)

This paper investigates the role of financial derivatives in pension asset allocation and studies a derivative-based optimal investment strategy for a loss-averse pension investor. The investor faces risks from both time-varying income and market return volatility. In the presence of a derivative, a semi-analytical investment strategy is derived through the fltering theory and inverse Fourier Transformation method. Through the study of optimal strategy, we discuss whether pension investors trade derivatives to hedge risks or increase returns. This paper finds that investors with different risk preferences have different motivations for trading derivatives. We find that when the reference point is very high, investors pursue risk, resulting in very large trading positions in derivatives. In addition, compared with the traditional literature, this paper finds that there is no one-to-one correspondence between the risk exposure position and the premium of random volatility, and investors will try their best to improve their derivatives trading position by taking advantage of the potential huge returns provided by volatility risk. We further explore the effects of both loss aversion and stochastic volatility on the investment strategy.

Authors: Zheng Chen, Zhongfei Li, Yan Zeng

Dynamic Random Models with Internal and External Excitation for Applications in Cyber Risk Insurance

Yousra Cherkaoui Tangi (Crest)

With the growing digital transformation of the worldwide economy, cyber risk has become a major issue. As 1% of the world's GDP (around $1,000 billion) is allegedly lost to cybercrime every year (see[CEA]), IT systems continue to get increasingly interconnected, making them vulnerable to accumulation phenomena that undermine the mutualization mechanism of insurance. Baldwin et al. [BGI+17] suggest that the Hawkes framework is suitable for cyber attacks modelling since contagion is relatively well captured. Bessy-Rolland et al. (see [BBH21]) proves that a Hawkes process with delayed exponential kernel is particularly suitable to capture the clustering and autocorrelation of inter-arrival times of public data breaches from different attack types in multiple sectors, using data collected from the Privacy Rights Clearinghouse database.We aim to extend the previous work by modelling the exogeneous factors such as the ones generated by the publication of cyber vulnerabilities that might be an external shock. Our ambition is to provide a better quantification of contagion, while correcting any correlation effects by capturing external common factors that may explain part of the systemic pattern. Indeed, cyber attacks may not only be generated by the previous cyber attacks, they can also be provoked by the exploitation of an online published vulnerability. As such we propose a Hawkes model with two kernels, one for the endogenous factor (the contagion from other cyber events) and one for the exogenous one (cyber vulnerability publications). We use parametric specifications for both the internal and exogeneous intensity kernels. We explore the inference problem based on public datasets containing features of cyber attacks found in the Veris Community Database and cyber vulnerabilities found in the National Vulnerability Dataset. We illustrate our model with simulations and discuss the impact of taking into account the cyber vulnerability kernel.

Authors: Yousra Cherkaoui Tangi, Alexandre Boumezoued, Caroline Hillairet

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Finite-Time Ruin Probabilities Using Bivariate Laguerre Series

Eric Cheung (UNSW Sydney)

In this presentation, we revisit the finite-time ruin probability in the classical compound Poisson risk model. Traditional general solutions to finite-time ruin problems are usually expressed in terms of infinite sums involving the convolutions related to the claim size distribution and their integrals, which can typically be evaluated only in special cases where the claims follow exponential or (more generally) mixed Erlang distribution. We propose to tackle the partial integro-differential equation satisfied by the finite-time ruin probability and develop a new approach to obtain a solution in terms of bivariate Laguerre series as a function of the initial surplus level and the time horizon for a large class of light-tailed claim distributions. To illustrate the versatility and accuracy of our proposed method, numerical examples are provided for claim distributions such as generalized inverse Gaussian, Weibull and truncated normal where closed-form convolutions are not available in the literature.

Authors: Eric Cheung, Hayden Lau, Gordon Willmot, Jae-Kyung Woo

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Spatial Dependency and Socio-Economic Impacts on Data Breach Risks: Nation-Wide Analysis in the U.S.

Jaehun Cho (Pohang University of Science and Technology)

This study investigates whether data breach events occurring in the U.S. are spatially correlated and if so, which socio-economic factors drive spatially correlated events. We analyze 49 states and 3,213 counties of the U.S. from 2005 to 2018 using a public dataset of data breach events and socio-economic data for spatial econometric analysis. We first calculate global and local Moran's I statistics for spatial dependency and provide evidence on county-level dependency in the number of data breach events. Using two spatial econometric approaches (spatial lag and spatial error regressions), we show that the spatial impacts of county-level population and average income are significant and positive in explaining the cyber risk frequency. This finding implies that counties adjacent to larger and richer counties tend to be more exposed to data breach events. We further investigate the spatial impacts for two more exposed states (California and New York) and the cluster of hacking risk type and observe that average income is globally significant and positive. Our findings can be useful for cyber insurers and policymakers to 1) geographically differentiate cyber risk underwriting and 2) recognize relatively more exposed regions to develop more effective policies.

Authors: Kwangmin Jung, Jaehun Cho

Pareto Optimal Risk Sharing for Multiple Policyholders

Wing Fung Chong (Heriot-Watt University)

In this talk, we solve Pareto optimal risk sharing schedules for multiple policyholders and one insurer. With minimal assumptions on their risk measures, we characterize the optimality in terms of the minimization for sum of their risk positions. Moreover, we show that, among those optimal schedules, there exists a non-negative premium arrangement for each policyholder. With coherent risk measures, the optimal indemnity schedules are further explicitly solved in terms of worst-case probability measures. Finally, the worst-case measure of the insurer is exactly solved in some special cases and is numerically solved for general cases.

Authors: Tim Boonen, Wing Fung Chong, Mario Ghossoub

Average Time Until First Income Protection Claim

Isabel Maria Cordeiro (Universidade do Minho)

In this paper we calculate the average time until first claim for different deferred periods and ages at which policies are effected. These times are calculated using the most recent available graduations of the transition intensities defined for a multiple state model for Income Protection (IP) insurance. We compare these average times with similar times calculated with graduations for an earlier period. All this information can be very useful for insurance companies selling IP policies.

Authors: Isabel Maria Cordeiro

The Perturbed Dual Risk Model with Proportional Investment

Naidan Deng (Henan University of Science and Technology)

In this paper, we consider the dual risk model perturbed by Brownian motion with proportion investment and a threshold dividend strategy. Firstly, the integro-differential equations satisfied by the expected discounted dividend payments and the ruin probability are derived. Secondly, the approximate solutions of the integro-differential equations are obtained through the sinc method. Then, the analysis of the errors between the explicit solution and sinc solution are given. Finally, the numerical examples are obtained to illustrate the effect of proportional investment on the expected discounted dividend payments and when the claim sizes follow an exponential, a mixed exponential distributions.

Authors: Naidan Deng, Chuanwei Wang

Estimating the Claims Reserve Using Gaussian Process Regression with Log-Transform Data and Compound Kernel

Xusheng Deng (Tianjin University of Commerce)

In insurance practice, the operational changes in the claims management and business practice, reserving practice and legislative changes often take place and can potentially introduce calendar-year effects. Modeling the dependence among multiple claims from the same calendar is critical to loss reserving, risk management and capital allocation for property-casualty insurers. In this paper, we try to estimate the claims reserve by applying Gaussian Process Regression(GPR) with log-transform data and compound kernel to introduce the interactions over the same calender year. We perform empirical analyses over three bussiness lines from the NAIC loss development database, comparing and demonstrating the strong performance of our models.

Authors: Xusheng Deng, Zhiyi Lu

Monotonicity Properties for Solutions of Renewal Equations with Applications to Ruin Theory

Vaios Dermitzakis (University of Liverpool/Institute for Financial and Actuarial Mathematics)

Renewal equations play an important role in applied probability. In risk theory, in particular, many quantities of interest associated with the time of ruin satisfying a defective renewal equation. We obtain sufficient conditions for the solution of a renewal equation (proper or defective) to be monotonic. Various known results concerning monotonicity of solutions appear as special cases of our results.

Authors: Vaios Dermitzakis, Konstadinos Politis

Optimal Order Execution Under Price Impact: A Hybrid Model

Marina Di Giacinto (Università degli studi di Cassino e del Lazio Meridionale)

In this paper we explore optimal execution in a market populated by a number of heterogeneous market makers that have limited inventory-carrying and risk-bearing capacity and operate in the market maximizing their profits. We show that in a proper scaling limit, optimal execution within this model can be recast as a linear-quadratic stochastic control problem. Value function and the associated optimal trading rate can be obtained semi-explicitly subject to solving a differential matrix Riccati equation. Numerical simulations are conducted to illustrate the dependence of the optimal execution strategies from the structural characteristics and the distribution of market makers.

Authors: Marina Di Giacinto, Claudio Tebaldi, Tai-Ho Wang

On the Finite Sample Properties of the Pseudo-Likelihood Estimator for Copula Model Parameters

Alexandra Dias (University of York)

A commonly used method for estimating dependence parameters in copula models is maximum pseudo-likelihood (MPL) introduced by Genest et al. (1995). It has been shown, in Kojadinovic and Yan (2010), that despite its good asymptotic properties, the finite sample performance of the MPL estimator is poor especially for weakly dependent vectors. It has also been shown that method-of-moment estimators, as Kendall's tau or Spearman's rho inversion methods, have better finite-sample performance for weakly dependent samples but worse large-sample performance. Hence, these are not the ideal solution as the strength of dependence is, in general, not known beforehand. We propose modifications to the maximum pseudo-likelihood estimator that produce estimators showing better finite-sample properties, including relative efficiency, than the inversion method of moments for weakly dependent samples. We perform a simulation study showing these results. In addition we show that the modified MPL estimators proposed here preserve the large-sample properties of the canonical MPL estimator. For now we have focussed the study of the finite-sample properties of the modified proposed MPL estimators on the Clayton copula model. The equivalent results for other copula families of interest in currently work in progress.

Authors: Alexandra Dias

Pricing Inflation-Indexed Swaps and Swaptions with Markov Regime-Switching Jump-Diffusion Models

Kai Ding (Southeast University)

In this article, we introduce an extension to the Heath-Jarrow-Morton(HJM) model and the Consumer Price Index(CPI) diffusion model that is suitable to incorporate both sudden market shocks and changes in the overall economic climate into the interest rate and inflation rate dynamics. This is realized by replacing the simple diffusion process of the original HJM/CPI model with a regime- switching jump diffusion. The Girsanov transformation is adopted to derive the arbitrage-free condition of the inflation bond market. We then derive the pricing formula of Year-on-Year Inflation Index Swap(YYIIS) and Zero Coupon Inflation

Index Swaption(ZCIISO) with the help of changing of numéraire, constructing exponential martingale and Fourier inverse transformation. Moreover, we compare the pricing formulas under different filtration, corresponding to information filtration that Markov chain can and cannot be completely observed.

Authors: Kai Ding, Xin Zhang

Demand for Multi-Year Catastrophe Insurance Contracts: Experimental Evidence for Mitigating the Insurance Gap

Thomas Dudek (Victoria University of Wellington)

People fail to insure against disasters, even when insurance is subsidized, and insured properties are often covered inadequately. We examine insurance decisions in an experiment using long-term insurance contracts to reduce such insurance gaps and contribute to our understanding of insurance choices as follows: First, many people prefer long-term insurance. Offering this type of insurance may thus increase insurance penetration. Second, underinsurance can result from the reluctance to update the sum insured if there are costs involved with this updating. Long-term insurance contracts that automatically consider price changes over time can reduce the insurance gap. Third, once people have made a decision, they tend to repeat it, demonstrating a strong preference for the status quo. Our research suggests that using this status quo bias may allow insurance companies to increase or keep constant insurance penetration. Lastly, our results confirm previous results showing that subsidies are ineffective in increasing insurance penetration.

Authors: Thomas Dudek, Eric Ulm, Ilan Noy

Risk Aggregation Under IFRS 17: An Ultimate Run-Off Adaptation of Solvency 2 Elliptic Aggregation

Tachfine El Alami (Université Claude Bernard Lyon 1)

The standard IFRS 17 requires a risk adjustment to reflect the compensation the insurance entity requires for bearing the uncertainty associated with non-financial risks. The risk adjustment is one of the primary calculations in IFRS 17 disclosures and is an influential factor to profit reporting and allocation over time. IFRS 17 does not prescribe any specific techniques on calculation methodologies; insurance entities are free to adopt their own while meeting several qualitative rules to ensure its consistency. This paper focuses on the recommendations of the paragraph B88 stating that the risk adjustment is required to reflect the degree of diversification benefit for bearing the risk. We suggest a method for aggregating elementary risk adjustments based on the Solvency 2 elliptical aggregation. We introduce the concept of ultimate run-off correlation as opposed to Solvency's one-year correlation and provide a theoretical bridge between both depending on a time diversification parameter. We explore correlation structures involving this time diversification and discuss analytical properties in terms of possible correlations values and the resulting impact on the aggregated RA behavior.

Authors: Tachfine El Alami

Modeling the Dependency in the Turkish Stock Market via the Dynamic Vine-Garch Model

Ozan Evkaya (Edinburgh University)

The dependence on financial instruments has always been an interesting topic considering their economic and political effects. To measure the change in such instruments over time and interaction between them, the stock prices are widely considered indicators in the literature. While the dynamic portfolio with a moving window approach is proposed for capturing the changing structure, the Vine-copula is used for the high-dimensional dependence. In this study, we analyze ISE100 stocks in the pre-, during-, and post-global financial crisis (GFC) periods by first dividing the stocks into subsectors. For each subsector and time period, ARMA-GARCH models are implemented and compared for different innovations. Thereafter, the dependence structure for each subsector over different periods is modeled with the R-vine copula model. Additionally, Value at Risk (VaR) and expected shortfall (ES) risk measures are computed by Monte Carlo simulation by assuming an equally weighted portfolio, constructed by the selected sector leaders. The applied model offers more consistent and sensitive results with the inclusion of Vine-copula as well as suitable innovations distribution. The primary findings of the study show that the proposed Vine-GARCH Model gives more accurate results in capturing portfolio risk compared to the classical approaches.

Authors: Ozan Evkaya, Gulden Poyraz, Bukre Yildirim Kulekci, Ismail Gur

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A Framework for Measures of Risk Under Uncertainty

Tolulope Fadina (University of Essex)

A risk analyst assesses potential financial losses based on multiple sources of information. Often, the assessment does not only depend on the specification of the loss random variable, but also various economic scenarios. Motivated by this observation, we design a unified axiomatic framework for risk evaluation principles which quantifies jointly a loss random variable and a set of plausible probabilities. We call such an evaluation principle a generalized risk measure. We present a series of relevant theoretical results. The worst-case, coherent, and robust generalized risk measures are characterized via different sets of intuitive axioms. We establish the equivalence between a few natural forms of law invariance in our framework, and the technical subtlety therein reveals a sharp contrast between our framework and the traditional one. Moreover, coherence and strong law invariance are derived from a combination of other conditions, which provides additional support for coherent risk measures such as Expected Shortfall over Value-at-Risk, a relevant issue for risk management in practice.

Authors: Tolulope Fadina, Yang Liu, Ruodu Wang

Critical Illness Insurance Model for Breast Cancer Patients After Chemotherapy

M. Ivan Ariful Fathoni (Universitas Gadjah Mada)

The insurance model in the form of Critical Illness (CI) is generally structured by a multi-status model that allows us to describe changes in insurance policies provided based on status changes experienced. The model in this study discusses the Markov process, which describes the critical illness insurance policy in each state in a continuous-time. Critical illness of breast cancer is modeled by several state states consisting of A is healthy or disease free, B is early cancer, C is cancer increase after chemo, X is died due to other factors, Y is dead from cancer. This condition is based on the response to treatment after chemotherapy. The first steps in this study are to assign a function to the transition intensity from state to state and the transition probability. We assume the intensity of mortality is modeled by the independent Gompertz-Makeham model. The transition probability of the multi-state model is the solution of the Kolmogorov forward differential equation. The next discussion is to create a formula for calculating the pure premium rate based on age intervals.

Authors: M. Ivan Ariful Fathoni, Gunardi Gunardi, Fajar Adi Kusumo, Susanna Hilda Hutajulu

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The Portfolio Diversification Effect of Catastrophe Bonds

Chi Feng (Shanghai University of Finance and Economics)

This paper examines the role of Catastrophe (CAT) bonds before and during the COVID-19 pandemic as a diversifier, a hedge, or a safe haven in a multi-asset portfolio comprised of CAT bonds, stocks, private equities, real estate, commodities, and infrastructures. Generally regarded as “zero-beta” securities, CAT bonds have gained popularity as an effective portfolio diversifier with relatively high returns. However, recent studies have suggested that under extreme financial distress, returns on CAT bonds exhibit an increasing positive correlation with returns on stock and bond markets. This paper explores the dependence in the movement of returns on CAT bonds and other instruments of the financial market before and during the COVID-19 pandemic. We employ a DCC-GARCH model and a dummy variable regression to investigate the relationship between the returns of CAT bonds and other assets under significant market stress. Our findings suggest that in the period years before the pandemic, CAT bonds have strong diversifying effect against all assets but real estate, for which they are a strong hedge and a safe haven, while during the pandemic CAT bonds are a diversifier against private equities, infrastructure, and commodities, a strong hedge against real estate, and a strong safe haven for all assets but commodities.

Authors: Chi Feng, Xudong Zeng

Distributed Insurance

Runhuan Feng (University of Illinois at Urbana-Champaign)

Traditional insurance businesses are often concentrated on a small set of insurers in markets around the world. While tight regulations of the insurance industry are well-intended to protect the interests of policyholders and ensure market stability, the legal compliance and capital requirements create prohibitively high barriers that make it impossible for small investors or companies to enter the market. The advancement of distributed ledger technology in the financial industry has given rise to a wide of peer-to-peer business models that enable participants to provide services whenever they are available. Inspired by peer-to-peer service models, we propose the first of its kind distributed insurance model, where risks and rewards can be spread in a large network of retail investors, as opposed to the concentration of market power in current markets. The algorithms are designed to raise capitals that are both legally compliant and meet the needs of limited liabilities and risk tolerance for small investors.

Authors: Runhuan Feng, Mao Li

The Role of Direct Cash Transfers Towards Extreme Poverty Alleviation - An Omega Risk Process

José Miguel Flores-Contró (University of Lausanne)

Trapping refers to the event when a household falls into the area of poverty. Households that live or fall into the area of poverty are said to be in a poverty trap, where a poverty trap is a state of poverty from which it is difficult to escape without external help. Similarly, extreme poverty is considered as the most severe type of poverty, in which households experience severe deprivation of basic human needs. In this article, we consider an Omega risk process with deterministic growth and a multiplicative jump (collapse) structure to model the capital of a household. It is assumed that, when a household is not trapped, its capital surplus grows exponentially, whereas once trapped, the capital grows linearly only due to the external support of direct transfers (cash transfers) of money provided by donors or governments. Under this model, we derive closed-form expressions of the probability of extreme poverty, which only depends on the value of the capital at that time given by some extreme poverty rate function. For different extreme poverty rate functions, we present numerical examples to illustrate the role of cash transfers on extreme poverty dynamics.

Authors: José Miguel Flores-Contró, Séverine Arnold

On a Risk Process with Deterministic Investment and Multiplicative Jumps - An Application to Poverty Trapping

José Miguel Flores-Contró (University of Lausanne)

In this article, we consider a risk process with a deterministic investment and multiplicative jump (collapse) structure to model the capital of a household. Focusing on the trapping time of such a process, where trapping occurs when the capital level of a household falls into the area of poverty, from which it is difficult to escape without external help, we introduce a function analogous to the classical Gerber-Shiu expected discounted penalty function, which incorporates information on the trapping time, the capital surplus immediately before trapping and the capital deficit at trapping. The trapping time is analysed in terms of its Laplace transform via the infinitesimal generator of the capital process. Considering the remaining proportion of capital to be distributed as a special case of the beta distribution, closed-form expressions for quantities typically studied in classical risk theory, including the capital deficit at trapping and the trapping probability, are obtained.

Authors: Kira Henshaw, José Miguel Flores-Contró, Sooie-Hoe Loke, Corina Constantinescu, Séverine Arnold, Jorge Mario Rámirez Osorio

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Double Boosting of Mean and Dispersion in Tweedie's Compound Poisson Model for Insurance Loss Prediction

Guangyuan Gao (Renmin University of China)

Tweedie's compound Poisson model is a widely used method for predicting insurance loss. It is often necessary to model both mean and dispersion of insurance loss in a Tweedie's compound Poisson model under the framework of double generalized linear models. However, the double generalized linear model is restricted to linearity of covarites, which requires deliberate feature engineering. We propose a double boosting for joint modelling both mean and dispersion. Most boosting algorithms cannot facilitate random effects or spatial effects which often appear in insurance loss prediction. Thus, in the double boosting, we pre-define suitable base learners for different types of covariates. We conduct a simulated data analysis and a real data analysis to illustrate the proposed method.

Authors: Guangyuan Gao

Affine Mortality Models with Jumps: Parameter Estimation and Forecasting

Len Patrick Dominic Garces (UNSW Sydney)

In this paper, we investigate the dynamics of age-cohort survival curves under the assumption that the instantaneous mortality intensity is driven by an affine jump-diffusion (AJD) process. Advantages of an AJD specification of mortality dynamics include the availability of closed-form expressions for survival probabilities afforded by an affine mortality specification and the ease with which we can incorporate sudden positive and negative shocks in mortality dynamics, reflecting events such as wars, pandemics, and medical advancements. As we are interested in a term structure model of mortality rates, we propose a state-space approach to calibrate the parameters of the affine mortality process. The measurement equation is given by the affine representation of the age-cohort average force of mortality and the state-transition equation is given by a discretization of the continuous-time mortality intensity dynamics. Such approach results to consistent survival curves in the sense that forecasts of survival probabilities have the same parametric form as the fitted survival curves. The presence of jumps in the mortality intensity process implies that the state-transition equation is non-Gaussian. To this end, we propose a particle filter-based Markov chain Monte Carlo approach to estimate the model parameters. We illustrate our methodology by fitting one-factor Cox-Ingersoll-Ross and Blackburn-Sherris mortality models with asymmetric double exponential jumps to historical age-cohort mortality data from USA.

Authors: Len Patrick Dominic Garces, Jovana Kolar, Michael Sherris, Francesco Ungolo, Yuxin Zhou

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Model Risk in Pricing Wind Speed Derivatives

Giovani Gracianti (University of Melbourne)

As a result of a global push towards renewable energy, including wind and solar, the interest in wind derivatives which are financial contracts devised to hedge the uncertainty of wind power generation has grown significantly. In this paper, we examine how the choice of wind speed model affects the prices of wind speed derivatives. An adequate wind speed model is essential for accurate pricing of wind derivatives. We show that generalised hyperbolic distribution, which can capture the skewness and heavy tail in wind speed data, provides much better goodness-of-fit than normal distribution. We obtain the risk-neutral prices of wind speed derivatives with Esscher transform. When different distributions are assumed for wind speed, the derivative prices vary substantially, thereby indicating a high model risk. In addition, our analysis demonstrates that the extent of model risk differs with the choice of the underlying index and the payment structure of the wind speed derivative. We conclude that model risk cannot be ignored in pricing wind speed derivatives but can be reduced through careful structuring of wind speed derivatives.

Authors: Giovani Gracianti, Rui Zhou, Johnny Li, Xueyuan Wu

The Influence of Negative Interest Rates on Life Insurance Companies

Nicolaus Grochola (Goethe University Frankfurt)

Life insurers globally have difficulties to pay out previously guaranteed minimum returns to policyholders. In many European and Asian countries, interest rates are becoming negative, thereby increasing insurers' investment risk. The aim of this paper is to empirically investigate the impact of changes in negative interest rates on the performance of life insurance companies. For this purpose, I compare the effects of interest rate movements on insurers' stock returns after falling below thresholds such as 0%. Regression results for a sample of U.S. and European insurers indicate that sensitivities increase as interest rates fall. However, the effect rises continuously and is not substantially larger due to a switch to negative interest rates compared with other thresholds. Moreover, I analyze the sources of interest rate risk in more depth. In a panel regression model, I consider changes in the level, the curvature and the slope of the yield curve, while controlling for the stock market.

Authors: Nicolaus Grochola

A Hawkes Type Mean-Variance Portfolio Optimization Model with Liability in Limit Order Book

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Qi Guo (University of Calgary)

The Hawkes process has been wildly studied in the Limit Order Book (LOB) modelling. In this paper, we investigate the mean-variance portfolio optimization problem in the High-Frequency context. The mid-price in the LOB is modeled by an exponential general compound Hawkes process (EGCHP) and the liability is modeled by a diffusion process. For the EGCHP, the Law of Large Number (LLN) and two Functional Central Limit Theorems (FCLT) are proved. We also provide numerical simulations for the EGCHP with real trading data. Then, we consider the corresponding mean-variance portfolio optimization problem. By constructing and solving the Hamilton–Jacobi–Bellman (HJB) equation, we derive an explicit optimal investment strategy in the LOB. Numerical examples of efficient frontier are also provided.

Authors: Qi Guo, Anatoliy Swishchuk

Spectral Risk Measures and Portfolio Selection with Additive and Multiplicative Background Risks

Guosen Yang (School of Business Administration)

In this paper, we examine the effects of additive and multiplicative background risks under the framework of spectral risk measures (SRMs). We investigate a portfolio selection problem with additive and multiplicative background risks under the framework of SRMs. After that, we provide a numerical example to analyze the SRM-decision maker's investment behavior and lead a comparative analysis with the closely related works. Numerical results show that the SRM-investor can flexibly choose appropriate investment strategies according to his risk preference. Furthermore, the additive and multiplicative background risks play significant effects on asset allocation. In addition, the comparative computational results demonstrate the advantages of the proposed approach to portfolio selection.

Authors: Yongjun Liu Guosen Yang Weiguo Zhang

A Probabilistic Method for a Class of Non-Lipschitz BSDEs with Application to Fund Management

Jinhui Han (The Chinese University of Hong Kong)

The present work devotes a study on the solvability of a class of non-Lipschitz and non-canonical Backward Stochastic Differential Equations (BSDEs), which naturally arises from an intertemporal mutual fund management problem, to this end, we propose a novel method of combining the techniques of Malliavin calculus and discussion on the Jacobian flow of the BSDE. Specifically, based on the intimate relationship between Yt and Zt of the BSDE via the Malliavin derivative of the former, namely, DtYt = Zt, we construct an iterative Picard converging scheme for approximating the underlying solution pair by first obtaining Zt from the derived BSDE with respect to Malliavin derivative and then recovering Yt from the underlying BSDE. A local unique existence result is first warranted over a short time horizon with carefully examined a priori estimates; indeed, each term in the iterative sequence is related to different Girsanov transforms for change of measure, comparing them demands a delicate analysis. The use of Jacobian flow further enables us to properly control the lower and upper bounds for a certain product of the forward process and Zt, which facilitates us to extend the solution globally by inductive argument. We believe that our new approach proposed here can be potentially applied to resolve many other general non-Lipschitz FBSDE systems encountered in economics and finance, especially in the presence of generic utility functions.

Authors: Jinhui Han, Sheung Chi Phillip Yam

Study on the Spatial Spillover Effect of Insurance Agglomeration on Regional Economic Growth——Empirical Research from the Yangtze River Economic Belt

Wenjing Han (University of International Business and Economics)

Due to the differences in geographical status and resource endowments among regions, insurance has presented obvious spatial agglomeration. Based on the panel data of 70 cities in three major city clusters of the Yangtze River Economic Belt from 2010 to 2019, we measure the insurance agglomeration with Entropy Weight Method. On this basis, this paper studies the spatial effect of insurance agglomeration and regional economic growth by establishing SDM. The results show that the insurance concentration and the scale of economic growth show a pattern of spatial autocorrelation in the YEB. The insurance agglomeration has obvious spatial spillover effects on regional economic growth through general financial effects and unique insurance effects, which can be divided into a positive direct effect on the local area and a positive indigo effect on adjoining regions. Notably, insurance agglomeration can promote the economic growth of the local area and neighboring regions by promoting technological innovation and industrial structure upgrading. In addition, life insurance is more space-concentrating in the YEB, but the agglomeration of property insurance has a more obvious impetus to the regional economy, especially the adjoining areas.

Authors: Wenjing Han, Guiyun You

Funding Retirement with Public Reverse Mortgages: An Evaluation of Australia's Home Equity Access Scheme

Katja Hanewald (UNSW Sydney)

We evaluate the Home Equity Access Scheme (HEAS), an Australian government-offered reverse mortgage designed to help supplement retirement income. The HEAS allows older homeowners to continue to age in place while receiving loans with their home equity as security. We construct a multi-period simulation model with financial uncertainty and health and longevity risks (including movement to aged care facilities), and use this model to consider welfare gains from HEAS use across various household structures and wealth levels. We consider different methods of utilising the HEAS both to boost retirement income and to cover unexpected costs. We also perform policy experiments that consider improvements to HEAS design, aimed at increasing welfare gains. Our results show that a government-offered reverse mortgage scheme, in which loan payments are linked to public pensions, is a welfare-enhancing method of supplementing retirement incomes. We find that, of the studied strategies, choosing to receive the maximum payment is the most welfare-enhancing method utilising the HEAS for most households. The results of different policy experiments show that increasing the maximum permissible payment from the HEAS does not benefit most households, but that reductions in the interest rate do.

Authors: Katja Hanewald, Katie Sun, Hazel Bateman

Factor Structure of Cryptocurrencies

Wenyan Hao (University of Leicester)

We investigate the cross-section asset-pricing patterns of major cryptocurrencies from 2017 to 2021. We show basis, momentum, and basis momentum factors earn statistically significant excess returns, a result consistent with the commodity futures literature. We document meaningful evidences that contrast the future returns within the factor structure. Daily factor returns are statistically and economically much stronger than weekly factor returns. Monthly factor returns are non-significant.

Authors: Wenyan Hao

How Financial Disintermediation Affects Commercial Bank Stability

Minhua He (Fudan University)

Financial disintermediation refers to that the suppliers and the demanders of funds bypass the intermediaries like banks to conduct financing directly, which continuously develops in China and has a huge influence on banking stability. This paper studies the impact of different aspects of financial disintermediation on commercial bank stability and its mechanisms. We innovatively finds with the panel threshold model that disintermediation correction effect has opposite impacts on banks of different sizes.

Authors: Minhua He

Division or Unification? An Analysis of the Potential Structural Change of the Digital Broker on the Supply Side of the Insurance Market

Wanting He (The University of Hong Kong; Southern University of Science and Technology)

To investigate potential structural changes on the insurance supply side stemming from the digitization of brokers, we developed a three-party evolutionary game model based on a cost-benefit analysis of consumers, brokers, and insurers. The evolutionary stable strategy is further analyzed to investigate the stability of the equilibrium and the sensitivity of the parameters to the stable state. We argue that the digitization of brokers

is a mega-trend in insurance markets where consumers' risk classification and mismatch costs are significant. In particular, owning underwriting authority is crucial for insurance brokers to improve social welfare if we consider the consumer experience. In addition, we discuss the feasibility of managing general agents (MGA) in the Chinese insurance market.

Authors: Wanting He, He Wang, Gene Lai, Hailiang Yang

Randomization and the Valuation of Guaranteed Minimum Death Benefits

Peter Hieber (Université de Lausanne)

In this talk, we focus on death-linked contingent claims (GMDBs) paying a random financial return at a random time of death in the general case where financial returns follow a regime switching model with two-sided phase-type jumps. We approximate the distribution of the remaining lifetime by either a series of Erlang distributions or a Laguerre series expansion, whose capability to fit the tail of the observed mortality data turns out to be much better than the commonly used series of exponential distributions.More precisely, we develop a Laurent series expansion of the discounted Laplace transform of the subordinated process at an Erlang distributed time, which leads to explicit formulae for GMDB of European type as well as related risk measures such as the Value-at-Risk (VaR) and the Conditional-Tail-Expectation (CTE).We further concentrate upon path-dependent GMDBs with lookback features like dynamic fund protection or dynamic withdrawal benefits, by relying on a Sylvester equation approach.The advantage of our approaches is that our prices are of semi-closed form, avoiding numerical Fourier inversion or Monte-Carlo simulation, leading to fast evaluation. This is necessary in risk-management, in particularly for nested simulation in the framework of Solvency II.Several numerical experiments are included.Our results have implications beyond life-insurance and GMDBs, namely in all situations where randomization or Erlangization replaces known quantities, like, for example, model parameters, by random variables. In Finance, it is for example well-known that a random maturity time leads to much more convenient valuation formulas that well approximate its non-random counterpart.

Authors: Peter Hieber, Griselda Deelstra

Optimal Use of Housing Wealth in Retirement: A Simulation Study Comparing Home Equity Release and Downsizing

Tin Long Ho (UNSW Sydney)

We study the optimal use of housing wealth in retirement, given available options (downsizing, the government-offered Home Equity Access Scheme, commercial reverse mortgages, and home reversion–type schemes) and reflecting current tax, superannuation, and age pension rules in Australia. We use state-of-the-art economic and actuarial modeling to identify the preferred approach for the use of housing wealth by Australian retiree households with different marital status, wealth portfolios, and preferences. The Home Equity Access Scheme is found to be most beneficial if households only need to boost retirement income by a limited amount. Private reverse mortgages are more attractive if households prefer a large lump sum at retirement age. Households with lower house price growth expectations should use home reversion schemes. When households have strong bequest motives, they should not downsize or use home equity release. Our results can help policymakers, financial advisers, and individuals to improve retirement outcomes.

Authors: Katja Hanewald, Hazel Bateman, Tin Long Ho

Modelling Heavy-Tailed Data with Two-Stage Mixture Regression Models

Yifan Hu (University of International Business and Economics)

The key issue in non-life classification rate-making is to find an appropriate loss distribution for modelling the insurance loss data with right skewed, heavy-tailed and multimodal features. The aim of this paper is to present a two-stage mixture regression modelling, which considers small claims in the first stage and later large claims in the second stage, and captures the policyholder heterogeneity by using mode matching method. Specifically, the two stages are spliced by the threshold. The first stage is estimating the head segment of the loss data by mixture distribution, where the weight varies across individual policyholders based on their risk features, while the second stage is modelling the tail by introducing the covariates into the parameter of different candidate distributions in a non-linear form. The EM algorithm is discussed for model estimation, and a simulation study is conducted to show the accuracy of the proposed method. The performance of the two-stage mixture regression model is evaluated by using the well-known Danish fire losses data set and a Chinese medical insurance claims data set. The results suggest that the spliced regression model outperforms competing composite models in all goodness-of-fit measures considered.

Authors: Yifan Hu

An Insurer's Optimal Strategy Towards a New Independent Business

Yuxia Huang (Central University of Finance and Economics)

In this paper, we investigate the optimal decision making of an insurer towards a new insurable business, whose risk is independent of the existing risk faced by the insurer. The insurer, who would like to maximize the expected utility under the solvency constraint, could reject this business or accept it with the help of reinsurance, whose premium is assumed to be calculated by the expected value principle. If this new business is underwritten, it is shown that a stop-loss reinsurance contract is optimal when the solvency risk is quantified by the conditional value at risk. If the regulatory regime changes to the value at risk, the optimal reinsurance form becomes a little complicated. It can be either stop-loss or two-layer under the assumption that the new risk has a strictly decreasing probability density function, and numerical examples are used to illustrate how the insurer makes decision.

Authors: Yuxia Huang, Yichun Chi, Ken Seng Tan

Statistical Classification Methods for the Combining Portfolio Strategy

Zhenzhen Huang (University of Waterloo)

Due to the well-known parameter uncertainty problem in modern portfolio theory, the combining portfolio strategy utilizes the 1/N rule as a shrinkage point to improve the performance of a sophisticated portfolio strategy, where the optimal combining coefficient is determined under the normal assumption for asset returns. To generalize the combining portfolio strategy without the normal assumption, we propose a statistical classification framework that uses logistic regression or random forest to find the combining coefficient according to prudently selected market features. Empirical studies with many market datasets show that our methods constantly generate better out-of-sample Sharpe ratio in most scenarios. Meanwhile, our methods yield a classification model with transparent interpretability of important features for evaluating the combining coefficient.

Authors: Zhenzhen Huang, Pengyu Wei, Chengguo Weng

Framework for Cyber Risk Loss Distribution of Hospital Infrastructure

Petar Jevtic (Arizona State University)

Networks like those of healthcare infrastructure have been a primary target of cyberattacks for over a decade. From just a single cyberattack, a healthcare facility would expect to see millions of dollars in losses from legal fines, business interruption, and malpractice lawsuits. As more medical devices become interconnected, more cyber vulnerabilities emerge resulting in more potential exploitations that may disrupt patient care and result in catastrophic financial losses. In this paper, we propose a bidirectional structural model of an aggregate loss distribution for cyber risk on a mixed random network. Our framework accounts for the documented cyber vulnerabilities of a hospital's trusted internal network of its major medical assets. Up to our knowledge, there exists no other models of an aggregate loss distribution for cyber risk in this setting. We contextualize the problem in the probabilistic graph theoretical framework using a percolation model and combinatorial techniques to compute the mean and variance of the loss distribution for a mixed random network that can be useful for insurers working on the implementation of cyber insurance policies, healthcare administrators, and cyber professionals.

Authors: Stefano Chiaradonna, Petar Jevtic, Nicolas Lanchier

Machine Learning of Surrender Charge: Optimality and Humanity

Bowen Jia (The Chinese University of Hong Kong)

We develop a novel Machine Learning (ML) framework to estimate the surrender charge of variable annuities with the balance between optimality induced by the market condition and human behavior. Optimality accounts for potential losses of insurers due to strategic surrender of policyholders who attempt to take advantage from the market situation. However, there exist potential human needs to surrender a variable annuity such as sudden personal financial distress. The literature contains contributions for these two sources of surrender decision separately so that we consider them simultaneously using ML. The ML framework is a Bayesian mixture of a deep-learning algorithm for optimal stopping based on potentially high-dimensional financial variables, and historical surrenders containing human behaviors. This framework offers insurers and pension funds a reliable reference to set surrender charges and to balance between profits and social responsibility as it estimates the probability that a surrender request is due to a policyholder's behavior.

Authors: Bowen Jia, Ling Wang, Hoi Ying Wong

OVX Forecasting via SVR-GARCH Method: A New Cross-Market Perspective Based on Stock Market Jumps

Gongyue Jiang (Southwest Jiaotong University)

From the perspective of cross-market effect, this paper examines the crude oil volatility index (OVX) forecasting by combining the SVR (Support Vector Regression) and GARCH-type models while considering the stock market jumps information. We extend the GARCH model by introducing the observable dynamic jumps which are calculated based on the high-frequency data of S&P 500 index (DJI-GARCH) and explore the effects of five non-parametric jump tests method (including interday and intraday jump tests) for OVX forecasting. The empirical results show that the combination of SVR and DJI-GARCH model can substantially increase the forecasting accuracy. Furthermore, we employ two trading strategies to evaluate the economic significance of our proposed method, and the results reaffirm the superiority of combining DJI-GARCH model with SVR technique for volatility index forecasting. All these findings imply that the information of the stock market can be helpful in forecasting the volatility index of the crude oil market (OVX), especially the introduction of SVR method and jump volatility of S&P 500 index. Our work can certainly provide a new insight for the OVX forecasting and cross-market research.

Authors: Gongyue Jiang, Gaoxiu Qiao, Feng Ma, Lu Wang

Optimal Robust Reinsurance Contracts with Investment Strategy Under Variance Premium Principle

Wuyuan Jiang (Hunan Institute of Science and Technology)

This paper investigates the optimal robust proportional reinsurance contracts with investment strategy under variance premium principle in a principal-agent framework. The surplus process of the insurer(agent) is assumed to follow a compound Poisson risk process. The insurer and reinsurer(principal) both are allowed to invest in a risk-free asset and a risky asset whose price process is governed by the constant elasticity of variance model. The objectives of the insurer and reinsurer are to maximize the expected exponential utility of terminal wealth with incentive compatible constraint. The reinsurer is ambiguity-averse and has determine ambiguity aversion preferences for the diffusion risk caused by the financial market and the approximated diffusion risk which comes from the claims process. The reinsurance price is described by the reinsurer's safety margin which can be decided by optimal strategies from the insurer and the reinsurer. By utilizing stochastic optimal control principle and HJB (or HJBI) equations, the optimal (robust) proportional reinsurance-investment strategy and the corresponding value functions are obtained explicitly. Finally, we also provide some numerical examples to analyse the impact of relevant parameters.

Authors: Wuyuan Jiang, Zhaojun Yang

Q-Scale Function and Ultimate Ruin Probability Under a Markov-Modulated Jump-Diffusion Risk Model with Hyperexponential Jumps

Zhengjun Jiang (BNU-HKBU United International College)

The paper studies ultimate ruin probability that ruin time is finite for an insurance company with its risk reserves governed by a Markov-modulated jump-diffusion risk model with hyperexponential jumps. By using q-scale function, the paper confirms that the ultimate ruin probability is indeed the unique fixed point of a contraction mapping and can be approximated by using an iterative equation. The paper also acquires a closed-form Lipschitz constant in Banach contraction principle.

Authors: Zhengjun Jiang

A Reverse Expected Shortfall Optimization Formula

Zhanyi Jiao (University of Waterloo)

The celebrated Expected Shortfall (ES) optimization formula implies that ES at a fixed probability level is the minimum of a linear real function plus a scaled mean excess function. We establish a reverse ES optimization formula, which says that a mean excess function at any fixed threshold is the maximum of an ES curve minus a linear function. Despite being a simple result, this formula reveals elegant symmetries between the mean excess function and the ES curve, as well as their optimizers. The reverse ES optimization formula is closely related to the Fenchel-Legendre transforms, and our formulas are generalized from ES to optimized certainty equivalents, a popular class of convex risk measures. We analyze worst-case values of the mean excess function under two popular settings of model uncertainty to illustrate the usefulness of the reverse ES optimization formula, and this is further demonstrated with an application using insurance datasets.

Authors: Zhanyi Jiao, Ruodu Wang, Yuanying Guan

Linking Annuity Benefits to Financial and Longevity Experience: A Joint Stochastic Pricing Framework

Doreen Kabuche (UNSW Sydney)

The demand for longevity guarantees remains low due to high costs, in spite of the protection they can offer for various risks to which individuals are exposed at old age. Longevity-linked products with flexible guarantees and related solutions have gained popularity in recent years due to their cost-effectiveness. We investigate linked annuity products, in which insurers and policyholders share risks. Our motivation stems from the need to reduce the guarantees' prices to policyholders and the default risk faced by providers due to financial and systematic longevity risks, while preserving a lifetime benefit, above a minimum amount. We propose a framework for pricing longevity and financial guarantees based on periodic fees charged to the policy fund value. The benefit amount is updated to the mortality and financial experience, allowing participation in longevity/mortality experience and return on investments. Based on the affine stochastic model, particularly the Arbitrage Free Nelson Siegel (AFNS) framework, we advise the realistic price of the risk retained by the provider. We illustrate our ideas numerically using three products: a financial linked product, a longevity linked product and a financial-longevity linked product.

Authors: Doreen Kabuche, Annamaria Olivieri

Dual Formulation of the Optimal Consumption Problem with Multiplicative Habit Formation

Thijs Kamma (Maastricht University)

This paper provides a dual formulation of the optimal consumption problem with internal multiplicative habit formation. In this problem, the agent derives utility from the ratio of consumption to the internal habit component. Due to this multiplicative specification of the habit model, the optimal consumption problem is not strictly concave and incorporates irremovable path-dependency. As a consequence, standard Lagrangian techniques fail to supply a candidate for the corresponding dual formulation. Using Fenchel's Duality Theorem, we manage to identify a candidate formulation and prove that it satisfies strong duality. On the basis of this strong duality result, we develop an evaluation mechanism to measure the accuracy of analytical or numerical approximations to the optimal solutions.

Authors: Thijs Kamma, Antoon Pelsser

Exact and Asymptotic Analysis of Multivariate Hawkes Population Processes

Raviar S. Karim (University of Amsterdam)

This paper considers multivariate population processes in which multivariate Hawkes processes dictate the stochastic arrivals. We establish results to determine the corresponding time-dependent joint probability distribution, allowing for general intensity decay functions, random intensity jumps and exponential sojourn times. We obtain an exact, full characterization of the time-dependent joint transform of the population process and its underlying intensity process in terms of a fixed-point representation and corresponding convergence results. We also derive the asymptotic tail behavior of the population process and its underlying

intensity process in the setting of heavy-tailed intensity jumps. By exploiting the results we establish, arbitrary joint spatial-temporal moments and other distributional properties can now be readily evaluated using standard transform differentiation and inversion techniques, and we illustrate this in a few examples.As a special case, we consider the class of exponential intensity decay functions which imply the joint processes to be Markov. Applying the Markov property directly, the time-dependent joint transform characterization is obtained in terms of a system of ODEs. We exploit this transform to derive analytic expressions for transient and stationary multivariate moments, auto- and cross-variances. Further analysis reveals a nested sequence of block matrices that yields these moments in explicit form and brings important computational advantages.

Authors: Raviar S. Karim, Roger J.A. Laeven, Michel R.H. Mandjes

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Projecting Life Expectancy Using Cause-of-Death-Specific Mortality Scenarios

Torsten Kleinow (Heriot-Watt University)

During the past decade, improvements in all-cause mortality rates and life expectancies for males and females in England and Wales have slowed down. In this paper, cause-specific mortality data for England and Wales from 2001 to 2018 are used to investigate the causespecific contributions to the slowdown in improvements. Cause-specific death counts in England and Wales are modelled using negative binomial generalised linear models and a breakpoint in the linear temporal trend in log mortality rates is investigated. Cause-specific scenarios for future mortality rates 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. We find that reduced improvement rates at older ages for the mortality from diseases of the circulatory system, as well as the worsening of mortality caused by mental and behavioural disorders and diseases of the nervous system provide the greatest contributions to the decline of improvements in age-standardised mortality rates and period life expectancies. In most scenarios for future life expectancies we find that the reversion of the improvement rates for a single cause of death will not be sufficient to restore improvement rates in life expectancies seen at the beginning of this century.

Authors: Torsten Kleinow, Alexander Yiu, George Streftaris

Reverse Sensitivity Testing for Compound Poisson Processes

Emma Kroell (University of Toronto)

One way to quantify uncertainty in risk evaluations in a financial or actuarial setting is using sensitivity analysis, where one studies the relationship between the variability in model outputs and uncertainty in model inputs. We build on a particular type of sensitivity analysis called reverse sensitivity testing, which has recently been introduced in the literature. We generalise the reverse sensitivity framework by developing a methodology applicable to Levy-Ito processes, which proceeds as follows: First, we introduce a stress to a stochastic process by increasing a risk measure evaluated at the process’s terminal time. Second, we derive the stressed probability measure under which the stochastic process fulfils the stress and that has minimal Kullback-Leibler divergence. Finally, we study the characteristics of the stochastic process under the stressed probability measure and illustrate them using numerical experiments. We also consider an example of a portfolio where one process is stressed, and examine the impact of this stress on the other processes.

Authors: Emma Kroell, Silvana M. Pesenti, Sebastian Jaimungal

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Asset Price Modeling and Options Pricing with Asymmetric Exponential Power Distribution

Yongzeng Lai (Wilfrid Laurier University)

Financial asset price modeling is very complex, but it is also a very important topic in finance. In the famous Black-Scholes-Merton's option pricing model, it is assumed that the underlying asset price follows a geometric Brownian motion or lognormal process. Under this assumption, closed formulas for many European option prices can be derived. However, due to the complexity of asset prices behavior, as it was well-known, there were some drawbacks to the Black-Scholes-Merton's option pricing model. Therefore, various models were proposed to improve the Black-Scholes-Merton model.In this paper, we propose to use the asymmetric exponential power distribution process to model an asset price process. Our extensive empirical study using %the most recent real stock prices data from both North American and Chinese markets shows that the asymmetric exponential power distribution model performs much better than the lognormal process model in modeling stock prices. Efficient simulation methods for options pricing under the asymmetric exponential power distribution model for the underlying asset prices have been developed.

Authors: Yongzeng Lai

The Location of a Minimum Variance Squared Distance Risk Functional

Zinoviy Landsman (University of Haifa)

In this paper, 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. We also study the mean-variance approach based on the balanced sum of an expectation and a variance of the square of the aforementioned Euclidean distance and control for the closeness of LES(X) and LVS(X). The proposed theory and the results are distribution free, meaning that we do not assume any particular distribution for the random vector X. The results are demonstrated with real data of Danish fire losses.

Authors: Zinoviy Landsman, Tomer Shushi

Insurance Guaranty Premium via Exchange Options

Gaeun Lee (Sungkyunkwan University)

Insurance guaranty schemes have been adopted to compensate policyholders for losses due to the insolvency of insurance companies. We derive explicit pricing formulas for risk-based premiums to focus on insurers' financial stability incorporating catastrophe risk of insurers' liabilities and asset-liability management (ALM) risk. The pricing formula of insurance guaranty fund is derived under regulatory forbearance. To deal with the insurance guaranty funds' payoff structure, this paper introduces new types of exchange options: early exchange options and barrier exchange options which allow multi-step boundaries. With these options, we can reflect jumps in value of underlying asset. Explicit pricing formulas are derived by using jump models with binomial approach. Also, we present sensitivity analysis on jump sizes, ALM risks and regulatory levels to provide guidance to financial authorities and insurers.

Authors: Hangsuck Lee, Seongjoo Song, Gaeun Lee

Variable Annuities via Piecewise Linear Barrier Options

Minha Lee (Sungkyunkwan university)

Barrier options have been instrumental in satisfying various market demands. This paper introduces piecewise linear barrier options and provides their pricing formulas. To this end, we establish the analytical piecewise linear boundary crossing probability and explain how to approximate arbitrary boundary crossing probabilities. In addition, we show that a financial instrument with early exercise is decomposable into a knock-out barrier option and immediate rebate, which casts a new illumination of the value of early exercise. We consider a Variable Annuity with Guaranteed Minimum Accumulation Benefit rider and surrender option to illustrate the decomposition. Extensive numerical experiments validate theoretical findings.

Authors: Hangsuck Lee, Hongjun Ha, Minha Lee

An Innovation of Reverse Mortgages in Taiwan: Crossover Risk Insurance, Deferred Life Annuity, and Spouse Annuity

Yung-Tsung Lee (National Chiayi University)

Reverse mortgages in Taiwan are recourse loans with an explicit term and provide a term certain annuity. To reduce the risk associated with lending, it is common for lenders to have the right to terminate a contract once the loan balance exceeds the collateral property. Borrowers are lost income streams and are at risk of homelessness in case of maturity or early termination, though the major function of reverse mortgages is to generate income and assure the elder economic security. By contrast, HECMs (Home equity conversion mortgages) are non-recourse loans and can be tenure, which means that borrowers can have a constant income stream from reverse mortgages.There is also a lack of protection for spouses in Taiwan's reverse mortgages. Most reverse mortgages in Taiwan have only one borrower and do not consider the economic security of surviving spouse. The risk of running out of money exists when a spouse lives longer than the borrower. To avoid such fears, the initial loan amount is determined by the younger spouse's age under the HCEM program. A surviving co-borrowing spouse can enjoy the same rights and receive proceeds continuously, and a surviving non-borrowing spouse, with certain requirements, can stay in the collateral property.There are some unique properties of reverse mortgages in Taiwan. The loan amount is determined by the loan-to-value ratio and the collateral property value. The unique payment type is a monthly annuity, which equals the loan amount divided by the number of months for the loan. Borrowers should repay the accrued interest monthly. Often, but not always, there is an upper limit on the monthly interest repayment, which is one-third of the monthly annuity income. The unpaid interest would be paid off at the end of the contract. For the unpaid interest, the Land Bank of Taiwan has a patent in interest charge, which charges the interest on principal only. Furthermore, for products of the Land Bank, if the loan-to-value ratio is less than 50%, there is no interest repayment until the contract ceases.This study suggests an innovation of reverse mortgages in Taiwan to enhance the protection for borrowers and surviving spouses without changing the current contract framework. Specifically, the innovation extends the coverage by incorporating crossover risk insurance, deferred life annuity, and spouse annuity into the prevailing products. Borrowers can select the coverage by paying additional premiums, which would be deducted from the annuity income. Lee et al. (2021) built the pricing model under the Land Bank's product framework. Following Lee et al. (2021), this study builds the pricing model for the innovative product and gives numerical examples to show the feasibility of the proposed contract. We hope that the innovative product can strengthen the market acceptance of reverse mortgages and enhance the elder economic security in Taiwan.

Authors: Yung-Tsung Lee, Meng Hsuan Tsai

Portfolio Selection Criteria Based on Generalized Herd Behavior Index for Bespoke Basket

Churui Li (KU Leuven)

Pioneered by Dhaene, J., Linders, D., Schoutens, W. & Vyncke, D.(2012, IME), the Herd Behavior Index (HIX) of a basket is defined as the ratio of the risk-neutral variance of the basket price to that of the comonotonic version of the price, which measures the expected degree of co-movement among the stock prices in the basket and is able to capture their non-linear dependence. On one hand, the proposed HIX is model-free since option prices of a tradable basket, such as Dow Jones and S&P 500, and of its stock components are the only inputs, which are directly observable from the market. On the other hand, such model-free HIX is restricted to only tradable baskets, each with pre-determined weights on the stock components, and hence hinders one from implementing it as a portfolio selection criteria. In this talk, we propose a model-based approach to extend the HIX for any bespoke baskets. It thus allows us to refine the Markowitz portfolio theory by proposing a selection criteria which minimizes the generalized HIX.

Authors: Wing Fung Chong, Churui Li, Daniël Linders, Gertjan Verdickt

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Robust Optimal Investment and Consumption Strategies for Pooled Annuity with Partial Information and Exit Penalty

Danping Li (East China Normal University)

This paper considers the robust optimal investment and consumption problem for the pooled annuity funds, in which both the financial market and mortality probability of participants in the pool are partially observable. Moreover, the pool member is allowed to exit pool annuity with penalty and she is an ambiguity-averse investor. Under the expected utility maximization, we derive the robust optimal investment and consumption strategies by employing filtering techniques and Hamilton-Jacobi-Bellman equation. Finally, we show the effects of model parameter on the optimal strategies and compare the results through numerical examples.

Authors: Lin Xie, Lv Chen, Linyi Qian, Danping Li, Zhixin Yang

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Equilibrium Pricing of Variable Annuities with Discount Rate Uncertainty

Dongchen Li (Brock University)

Variable annuities are one of the most popular equity-linked insurance products. They are prevailingly valued using the risk-neutral pricing approach in the literature. Nevertheless, this approach is problematic due to impractical assumptions and misaligned results from market observations. In this paper, we propose a new equilibrium pricing model for variable annuities within a principal-agent framework. In consideration of the long-term horizon of variable annuities and heterogeneity of discounting for a group of policyholders, we allow uncertainty in policyholders' subjective discount rates. We demonstrate that the equilibrium pricing model can reconcile the mismatch stemmed from the risk-neutral pricing approach: the resulting insurance fees and policyholder behavior are much more consistent with the empirical observations, and insurers persistently participate in the market even with high initial expenses due to high profitability of the product. Moreover, policyholders' uncertainty in discount rates amplifies these findings and further reduces the gap between theoretical results and market observations. This in return provides some evidence to the presence of discount rate uncertainty in real variable annuity market.

Authors: Min Dai, Bin Li, Dongchen Li, Yumin Wang

Optimal Design for Network Mutual Aid

Jingchao Li (Shenzhen University)

Network mutual aid platforms is one of the popular risk-sharing models in recent years, and they have almost 200 million members in China. However, current mutual aid platforms does not satisfy the actuarial rules in either the apportionment method or the pricing principle. Hence a variety of mutual aid models which enable mutual aid members with different risks to exchange their risks in a transparent and actuarial fair way have been proposed in this paper. Besides, the decision-making frameworks for participants choosing between the mutual aid platform and similar insurance products, or choosing no risk sharing are constructed respectively. Decisions are made based on the principle of maximising expected utility. Moreover, the optimisation problems of maximising pro t and minimising risk are constructed respectively. Through the principle of individual fairness and relative fairness, the problem of adverse selection of the platform similar insurance products to discuss the advantages of the optimised plan.

Authors: Jingchao Li

Asymptotic Results of Tail Moment and Tail Central Moment for Dependent Risks

Jinzhu Li (Nankai University)

We consider a financial or insurance system with a finite number of individual risks described by real-valued random variables. We focus on two kinds of risk measures, referred to as the tail moment (TM) and tail central moment (TCM), which are defined as the conditional moment and conditional central moment of some individual risk in the event of system crisis. The first order TM and the second order TCM coincide with the popular risk measures called the marginal expected shortfall (MES) and tail variance (TV), respectively. Asymptotic expressions are derived for the TM and TCM with any positive integer orders, when the individual risks are pairwise asymptotically independent and have the distributions from certain classes including both light-tailed and heavy-tailed distributions. The obtained formulas possess concise forms unrelated to dependence structures, and hence enable us to estimate the TM and TCM efficiently. Some issues about premium principle and optimal capital allocation are revisited in the asymptotic point of view to demonstrate wide applications of our results. We also give a numerical study on the relative errors of the obtained asymptotic results under some specific scenarios when there are two individual risks in the system.

Authors: Jinzhu Li

Sustainable Investing in Corporate Bonds: Evidence from the U.S. Life Insurance Companies

Wenchu Li (Temple University)

Investment strategies involving environmental, social, and governance (ESG) considerations have gained rising attention in recent years. Although an increasing number of asset managers claimed the incorporation of ESG criteria into their investment portfolio constructions, the largely voluntary disclosure and reporting of ESG-related activities make it harder to obtain a comprehensive view of the actual integration extent (Matos, 2020). Moreover, the majority of the sustainable investing studies examine equity investment, and there is relatively limited evidence on debt markets. This study examines the incorporation of sustainable investing in corporate bonds of U.S. life insurance companies. U.S. life insurers are the largest institutional investors in the U.S. corporate bond market. Considering the initial transition costs, the long-term investment horizon of life insurers amplifies the potential financial benefits of sustainable investing in the long run. Therefore, the U.S. life insurance industry provides an ideal environment to examine sustainable investing in bond markets.

Moreover, on November 22, 2021, AM Best announced to include the ESG section into the Enterprise Risk Management assessment in the Best's Credit Reports (AM Best, 2021). This increasing transparency emphasizes the impact of ESG risks on insurers' credit ratings, providing life insurers with additional incentives to incorporate sustainable investing.By merging life insurers' year-end corporate-bond holdings from 2005 to 2019 with the potential bond issuers' corporate social responsibility (CSR) measures constructed using the MSCI KLD database following the framework of Servaes and Tamayo (2013), I found that life insurers gradually increased their holdings in corporate bonds issued by positive CSR-rated issuers over time, but at a slower growth rate. Further analysis will be conducted to identify sources of this trend by distinguishing the impact of life insurers actively moving toward positive CSR-rated firms from bond issuers improving their CSR scores. This paper contributes to the sustainable investing literature by focusing on debt financing and adds to the life insurers' corporate-bond investments literature by examining the impact of bond issuers' ESG performance on life insurers' investment behavior.

Authors: Wenchu Li

Optimal Defined-Contribution Pension Management with Financial and Mortality Risks

Wenyuan Li (University of Waterloo)

This paper studies the optimal defined-contribution (DC) pension management under the stochastic interest rates and expected inflation. Besides financial risk, we consider the mortality risk before retirement and introduce life insurance to the pension portfolio. We formulate this pension management problem by a Hamilton-Jacobi-Bellman (HJB) equation and derive its explicit solution under the constant relative risk aversion (CRRA) utility. To complete the analysis, we also provide the explicit solution's global existence condition and verification theorem. Our numerical research shows that the pension member's demand for life insurance exhibits a hump shape with age and a "double top" pattern for the real short rates and expected inflation (high demand when the real short rates and expected inflation are both high or both low). These demand patterns are caused by the combined effects of the components in the optimal insurance strategy. To summarize, our model builds a DC pension account that resembles a variable annuity with endogenously determined time-varying death benefits. It can inspire more future work on creating actuarial products that satisfy the individual's bequest demand.

Authors: Wenyuan Li, Ken Seng Tan, Pengyu Wei

Ensemble Distributional Forecasting for Insurance Loss Reserving

Yanfeng Li (UNSW Sydney)

Loss reserving generally focuses on identifying a single model that can generate superior predictive performance. However, different loss reserving models specialise in capturing different aspects of loss data. This is recognised in practice in the sense that results from different models are often considered, and sometimes combined. For instance, actuaries may take a weighted average of the prediction outcomes from various loss reserving models, often based on subjective assessments. However, such methods are typically based on ad-hoc rules. This is further complicated in situations where the full distribution of claims is of interest (as opposed to just the mean).In this paper, we propose a framework to objectively combine (i.e. ensemble) multiple stochastic loss reserving models such that the strengths offered by different models can be utilised effectively. A notable innovation of our framework is that it is tailored for the features inherent to reserving data. These include, for instance, accident, development, calendar, and claim maturity effects. Crucially, the relative importance and scarcity of data across accident periods renders the problem distinct from the traditional ensembling techniques in statistical learning.Our ensemble reserving framework is illustrated with a complex synthetic dataset. In the results, the optimised ensemble outperforms both (i) traditional model selection strategies, and (ii) an equally weighted ensemble. In particular, the improvement occurs not only with central estimates but also relevant quantiles, such as the 75th percentile of reserves (typically of interest to both insurers and regulators).

Authors: Benjamin Avanzi, Yanfeng Li, Bernard Wong, Alan Xian

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Earthquake Parametric Insurance with Bayesian Spatial Quantile Regression

Yunxian Li (Yunnan University of Finance and Economics)

During the last two decades, there has been a significant increase in the economic costs of natural disasters. Various parametric insurance instruments have been developed to help the government to withstand the economic losses caused by natural disasters, of which, earthquake parametric insurance in Yunnan Province is a special case. It sets the earthquake magnitude as the payment trigger. However, as a main limitation of parametric insurance, basis risk is inevitable. To reduce basis risk, a Bayesian spatial quantile regression model is proposed. Earthquake parametric insurance, including its payment mechanism and pricing, is then

discussed based on the proposed model and methodologies. The impact of an earthquake hazard, risk exposure, and vulnerability on economic loss are analyzed and considered in the quantile regression model. Because risk exposure and vulnerability at the epicenter cannot be observed, they will be treated as latent variables in the quantile regression model. Bayesian approaches are applied, and spatial correlation is considered to construct the prior distributions for the latent variables. Earthquake parametric insurance has been purchased in Yunnan province since 2014 as it is a highly seismic region. To reduce the basis risk, the proposed model and methods are applied to evaluate the earthquake economic loss. From historical records of earthquakes in Yunnan Province from 1992 to 2019, the payments and premiums of 16 regions in Yunnan Province are calculated. The results show that the loss ratio is more reasonable than the current earthquake insurance, and the basis risk is then reduced.

Authors: Yunxian Li

A New Class of Composite Gbii Regressions with Varying Threshold for Modelling Heavy-Tailed Data

Zhengxiao Li (University of International Business and Economics)

The four-parameter generalized beta distribution of the second kind (GBII) has been proposed for modelling insurance losses with heavy-tailed features. The aim of this paper is to present a parametric composite GBII regression modelling by splicing two GBII distributions using mode matching method. It is designed for simultaneous modeling of small and large claims and capturing the policyholder heterogeneity by introducing the covariates into the location parameter. In such cases, the threshold that splits two GBII distributions varies across individuals policyholders based on their risk features. The proposed regression modelling also contains a wide range of insurance loss distributions as the head and the tail respectively and provides the close-formed expressions for parameter estimation and model prediction. A simulation study is conducted to show the accuracy of the proposed estimation method and the flexibility of the regressions. Some illustrations of the applicability of the new class of distributions and regressions are provided with a Danish fire losses data set and a Chinese medical insurance claims data set, comparing with the results of competing models from the literature.

Authors: Zhengxiao Li, Fei Wang, Zhengtang Zhao

A Simple and Nearly Optimal Investment Strategy for Minimizing the Probability of Lifetime Ruin

Xiaoqing Liang (Hebei University of Technology)

We study the optimal investment strategy to minimize the probability of lifetime ruin under a general mortality hazard rate. Motivated by Moore and Young (2006), we explore the error between the minimum probability of lifetime ruin and the achieved probability of lifetime ruin if one follows a simple investment strategy from Young (2004), except that the constant mortality rate is replaced by the general mortality function. We also include numerical examples to illustrate the estimation. We show that the nearly optimal probability of lifetime ruin under the simplified investment strategy is quite close to the original minimum probability of lifetime ruin under reasonable parameter values.

Authors: Xiaoqing Liang, Virginia R. R. Young

Mortality Forecasting with Neural Tangent Kernel Regression

Hong Beng Lim (The University of Iowa)

Best practices concerning neural network architectures tend to be application-specific, which is a significant hurdle for neural network applications in actuarial science. For many network architectures, kernel regression using Neural Tangent Kernels (NTKs) is equivalent to training neural networks with layers of infinite width (Jacot et al., 2018). NTK regression is significantly faster than training its finite-width counterpart, and empirically it has also consistently delivered comparable performance. Importantly, NTK regression sidesteps the need to specify the number of nodes in each layer while simplifying the training process. This talk explores the pros and cons of using NTK regression in lieu of finite-width neural network architectures for mortality forecasting, an area of active interest in actuarial science.

Authors: Hong Beng Lim, Siyang Tao, Nariankadu Datatreya Shyamalkumar

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Generalised Option-Based Portfolio Insurance Strategy

William Lim (Australian National University)

We introduce a genearalised option-based portfolio insurance strategy (GOPIS) which is an extension of the traditional option-based portfolio insurance (OBPI) and option-based performance participation (OBPP) proposed by Zagst et al. [Journal of Banking & Finance, 105 (2019), 44-61]. The GOPIS consists of a reserve portfolio that secures the floor of investment value at maturity, and an investment portfolio in which the investor participates. We demonstrate that GOPIS can accommodate an investor who wishes to maximize the expected constant relative risk aversion utility of the portfolio while mitigating the risk that the portfolio value falls below the minimum floor. Finally, we compare the GOPIS with the OBPI and OBPP in various dimensions such as expected utility and stochastic dominance by extending the analytical expressions for moments of the distribution of investment value proposed by Zagst et al.

Authors: William Lim, Gaurav Khemka, Catherine Donnelly

Calibrating Probability Equivalent Level of VaR-ES

Liyuan Lin (University of Waterloo)

Recently Li and Wang (2022) introduced a new risk measure called Probability Equivalent Level of VaR-ES (PELVE) to derive the equivalent probability level when replacing ES with VaR. In this paper, we study a PELVE calibration problem where we set to find a distribution that yields a given PELVE. We discuss the cases when one-point, two-points and a PELVE function are given. For one-point and two point calibration problem, we construct explicit distribution function. When a PELVE function is given, we develop a numerical method to find distribution and we also characterize all the distributions that have a constant PELVE. We further study the monotonicity and convergence properties of PELVE. We present sufficient conditions that show these properties are closely related to the hazard rate function of a random variable, which makes us able to identify propertied of PELVE for important examples.

Authors: Liyuan Lin

A Note on Dependence and Volatility in P And Q

Biwen Ling (KU Leuven)

In this paper, we illustrate how risk-neutral dependence can differ substantially from real-world dependence. This implies that forward looking measures such as the VIX, see Chicago Board Options Exchange (2003), and the HIX, see Dhaene, Linders, Schoutens & Vyncke (2012), which are based on observed option prices, may give wrong risk management information. As an example, we characterize the set of risk-neutral martingale measures in a simple two-dimensional market model and show that depending on the choice of the market regarding the pricing measure, risk-neutral correlations can be high or low. We provide an example illustrating the difference between risk-neutral and real-world correlation, which is called the "correlation gap". We show how dispersion trading can be used to exploit this correlation gap.

Authors: Jan Dhaene, Daniel Linders, Biwen Ling, Qian Wang

Extreme Analysis of Flood Disaster Risks in China with Insurance and Financial Management

Chengxiu Ling (Xi'an Jiaotong-Liverpool University)

Catastrophic losses caused by natural disasters receive a growing concern about the severe rise in losses and frequency. The constructions of insurance and financial management scheme become increasingly necessary to diversify the disaster risks. Given the frequent and severe occurrence of floods in China, this paper investigates the extreme analysis of flood-related huge losses and extreme precipitations using Peaks-Over-Threshold method and Point Process (PP) model. These findings are further utilized for both designs of flood insurance and flooding catastrophic bond: (1) Using the extrapolation approach in Extreme Value Theory (EVT), the estimated Value-at-Risk (VaR) and conditional VaR (CVaR) are given to determine the cross-regional insurance premium together with the Grey Relational Analysis (GRA) and Multiple-Criteria Decision-Marking (MCDM) method. The flood risk vulnerability and threat are analyzed with both the geography and economic factors into considerations, leading to the three layered premium of the 19 flood-prone provinces. (2) To hedge the risk for insurers and reinsurers to the financial market, we design a flooding catastrophe bond with considerate trigger choices and the pricing mechanism to balance the benefits of both reinsurers and investors. To reflect both the market price of catastrophe risk and the low-correlated financial interest risk, we utilize the pricing mechanism of Tang and Yuan (2021) to analyze the pricing sensitivity against the tail

risk of the floods' disaster and the distortion magnitude. Additionally, our trigger process is carefully designed using a compound Poisson process modelling both the frequency and the layered intensity of the flood disasters. Finally, constructive suggestions and policies are proposed concerning the flood risk warning and prevention.

Authors: Chengxiu Ling, Yixuan Liu, Zhiyan Cai, Jiayi Li

Pricing Double-Barrier Parisian Options

Chun-Yang Liu (Liaoning University)

Parisian options are a useful real-option tool in risk management, particularly for corporate bankruptcy protection. However, in the past, only one barrier with the Parisian feature was studied in the literature, possibly due to the additional complication that arises with the co-existence of two barriers. In this paper, we present an analytic solution for the valuation of European-style double-barrier Parisian options by casting the pricing problem into three inter-coupled partial differential equations. These are then solved using a dimension reduction procedure and the "moving window" technique. Our solution is in an explicit and analytical form that is written in terms of multiple integrals. This represents an important advantage over the purely numerical approaches previously published in the literature.

Authors: Chun-Yang Liu, Song-Ping Zhu

Inf-Convolution and Optimal Allocations for Tail Risk Measures

Fangda Liu (University of Waterloo)

Inspired by the recent developments in risk sharing problems for the Value-at-Risk (VaR), the Expected Shortfall (ES), or the Range-Value-at-Risk (RVaR), we study the optimization of risk sharing for general tail risk measures. Explicit formulas of the inf-convolution and Paretooptimal allocations are obtained in the case of a mixed collection of left and right VaRs, and in that of a VaR and another tail risk measure. The inf-convolution of tail risk measures is shown to be a tail risk measure with an aggregated tail parameter, a phenomenon very similar to the cases of VaR , ES and RVaR. Optimal allocations are obtained in the setting of elliptical models, and several results are established for tail risk measures and risk sharing problems in the presence of model uncertainty. The technical conclusions are quite general without assuming any form of convexity of the tail risk measures. Our analysis generalizes in several directions the recent literature on quantile-based risk sharing.

Authors: Fangda Liu, Tiantian Mao, Linxiao Wei, Ruodu Wang

Research of the Effect of Directors' and Officers' Liability Insurance on Corporate Fraud

Guiyun You (University of International Business and Economics)

In recent years, the problem of corporate fraud has been highly concerned by people from all walks of life. Regulators and stakeholders hope to establish a standardized enterprise risk management system and strengthen supervision to reduce the behavior. As a non-compulsory supervision measure through the market, D&O insurance will have an impact on corporate fraud. However, due to the moral hazard and adverse selection caused by information asymmetry in the insurance industry, the mechanism of the impact of the insurance on corporate fraud is complex. Therefore, it is necessary to deeply study the influence.By introducing the "External supervision effect", "Risk transfer effect" and "Moral hazard effect" of the insurance, we find that there is an "inverted U-shaped" relationship between D&O insurance and corporate fraud, which makes the dominant effect of the insurance change with the duration of insurance, and even the transformation of the dominant effect status. In addition, we explore the moderating effect on the influence in different environments.

Authors: Guiyun You, Huidan Liu, Ying Sun

Optimal Dividend Policy Under a Contagious Market Until Bankruptcy

Guo Liu (University of Melbourne)

In this paper, we consider the optimal dividend policy for an insurance company under a contagious financial market, where the occurrence of a claim can trigger sequent claims. This clustering effect is modelled by a self-exciting Hawkes process where the intensity of claims depends on the historical path of itself. In addition, we include the concept of bankruptcy to allow the insurance company to operate with temporary negative surplus. The objective of the management is to obtain the optimal dividend strategy that maximises the expected discounted dividend payments until bankruptcy. The Hamilton–Jacobi–Bellman variational inequalities (HJBVIs) are derive rigorously. When the claim amount follows exponential distributions, explicit solutions of the value function and the optimal barrier curve are obtained for a constant bankruptcy rate. We also present a numerical example to demonstrate the impact of key parameters on the optimal dividend strategy.

Authors: Guo Liu

Pricing Defaultable Bonds and Credit Derivatives in the Presence of Shock Risk and Unpredictable Recovery

Haibo Liu (Purdue University)

Consider a defaultable bond whose payoff is contingent on the occurrence of a default event. Suppose that the financial market is vulnerable to shock risk, which has impacts on the default intensity, the risk-free interest rate, the reference rate, and the regime switching of the market state. Further suppose that the recovery rate in the event of default contains an exogenous (hence, unpredictable) component in addition to its contingence on the market performance until default. Thus, our work exhibits two features: the shock risk, which captures profound impacts of exogenous shock events on all aspects of the market; the unpredictable component, which is embedded in the recovery rate to capture additional uncertainty on the market. Assuming that the default intensity, the interest rate, and the reference rate jointly follow a general three-dimensional jump-diffusion process with coefficients governed by the regime of the market, we develop a risk-neutral pricing measure which prices the aforementioned various risk sources in an integrated manner. This pricing framework is directly applicable to other credit derivatives in the presence of shock risk and unpredictable recovery.

Authors: Haibo Liu, Qihe Tang

Distributionally Robust Reinsurance with Value-at-Risk and Conditional Value-at-Risk

Haiyan Liu (Michigan State University)

A basic assumption of the classic reinsurance model is that the distribution of the loss is precisely known. In practice, only partial information is available for the loss distribution due to the lack of data and estimation error. We study a distributionally robust reinsurance problem by minimizing the maximum Value-at-Risk (or the worst-case VaR) of the total retained loss of the insurer for all loss distributions with known mean and variance. We show that a three-point distribution achieves the worst-case VaR of the total retained loss of the insurer, from which the closed-form solutions of the worst-case distribution and optimal deductible are obtained. Moreover, we show that the worst-case Conditional Value-at-Risk of the total retained loss of the insurer is equal to the worst-case VaR, and thus the optimal deductible is the same in both cases.

Authors: Haiyan Liu, Tiantian Mao

Modelling the Joint Extremes of Air Pollution Risks

Jiajun Liu (Xi'an Jiaotong-Liverpool University)

Modelling and estimating reliably the extreme air pollution risks are highly important for insurance companies, government agencies and the general public. This paper contributes to extreme risk management by modelling the extreme air pollution risks via extreme value theory (EVT). We conduct an empirical study using the daily air quality index (AQI) of Shanghai and Beijing in 2016-2019. With the clustering trend for extreme values showed by the preliminary data analysis, to better model the dependent series, two declustering methods: Intervals and Runs, were applied to generate long-term independent units. Based on the estimated bivariate generalized Pareto distribution, we quantify the extreme dependence between PM2.5 and PM10 concentration in these two regions. Methodologically, the bivariate exceedance model is employed to show significant tail dependence between these two indexes, which indicates that the extreme value of one index was likely to happen when the other was already extremely large, and their additive effect were suggested to aggravate the extent of air pollution.

Authors: Chengxiu Ling, Jiajun Liu, Jingyi Xu

Valuation of Hybrid Pension Scheme Liabilities Under Inflation

Shuai Liu (Anhui Polytechnic University)

In recent years, with the worldwide preference for hybrid pension schemes, it has become relevant to assess the level of liability of hybrid pension systems. This paper builds on the hybrid pension liability assessment approach proposed by Dirk Broeders et al. [1] with a further refinement to take inflation risk into account, assuming that inflation risk is measured by a price index that obeys a geometric Brownian motion. A simulation-based pricing framework is then introduced to assess the hybrid pension liability. The results show that the introduction of inflation risk increases the total outstanding liability of hybrid pensions. Furthermore, inflation is negatively correlated with the total outstanding liability of the hybrid pension scheme, while inflation volatility is positively correlated with it.

Authors: Liu Shuai, Wang Chuanyu, Xue Juan, Wang Lan

One Axiom to Rule Them All: A Minimalist Axiomatization of Quantiles

Peng Liu (University of Essex)

We offer a minimalist axiomatization of quantiles among all real-valued mappings on a general set of distributions through only one axiom. This axiom is called ordinality: quantiles are the only mappings that commute with all increasing and continuous transforms. Other convenient properties of quantiles, monotonicity, semicontinuity, comonotonic additivity and elicitability in particular, follow from this axiom. Furthermore, on the set of convexly supported distributions, the median is the only mapping that commutates with all monotone and continuous transforms. On a general set of distributions, the median interval is pinned down as the unique minimal interval-valued mapping that commutes with all monotone and continuous transforms. Finally, our main result, put in a decision-theoretic setting, leads to a minimalist axiomatization of quantile preferences. In banking and insurance, quantiles are known as the standard regulatory risk measure Value-at-Risk (VaR), and thus, an axiomatization of VaR is obtained with only one axiom among law-based risk measures.

Authors: Tolulope Fadina, Peng Liu, Ruodu Wang

Heterogeneous Reinsurance Premiums Under a Trilateral Stochastic Differential Reinsurance and Investment Game

Yan Liu (Nankai University)

This article investigates a trilateral stochastic differential reinsurance and investment game between one reinsurer and two insurers, involving a non-zero-sum stochastic differential game and a stochastic Stackelberg differential game. The insurers are the followers of the Stackelberg game and can purchase proportional reinsurance from the reinsurer. In addition, the relationship between the two insurers is competitively described by the non-zero-sum stochastic differential game, and their strategies should consider the relative performance. The reinsurer is the leader of the Stackelberg game and can price heterogeneous reinsurance premiums. We assume that the reinsurer should pay attention to the wealth level of insurers, whether from social planners or the long-term development of the reinsurance business. The purpose of the reinsurer is to maximize the expected utility of the combination of the three players' terminal wealth. The degree to which a reinsurer pays attention to an insurer depends on the coefficient. We derive the equilibrium strategy and value functions using dynamic programming and backward induction. Several numerical examples show that the coefficient is proportional to the reinsurance premium of the corresponding insurer and inversely proportional to the reinsurance ratio. Finally, we provide numerical examples to demonstrate the effects of other parameters on the equilibrium strategy.

Authors: Xiufang Li, Yan Liu, Xiaowei Chen

Uncertainty Aversion and Equity Improvement

Yang Liu (University of Waterloo)

We address the relationship between risk equity and aggregate uncertainty avoidance. We find a fundamental conflict between the two concepts in a setting where the model of Keeney [Keeney (1980) Equity and public risk. Oper. Res. 28(3):527–534] is equipped with uncertainty. Further, we characterize these concepts with the ambiguity and risk attitudes of the decision maker in the framework of the α-maxmin preference.

Authors: Yang Liu, Tiantian Mao, Ruodu Wang

Pricing Catastrophe Bonds Under Transitions of the Physical and Economic Environment

Yuhao Liu (UNSW Sydney)

Over the past several decades, catastrophe (CAT) bonds have become a novel financial instrument for insurers and reinsurers to mitigate their catastrophic losses and for investors to diversify their investment portfolios. In this work, we consider a multi-period CAT bond. The arrival process of the underlying CAT event is modeled by a Cox process, and the intensity process, the interest rate process and the reference rate process are assumed to jointly follow an affine jump-diffusion model that are affected by the transitions of certain physical and economic factors. In this way, various types of risks are embedded in the CAT bond and all should be properly priced. We aim at a risk-neutral pricing formula, which amounts to constructing an equivalent pricing measure allowing for proper market prices of risk. As our main result, we obtain a semi-closed form pricing formula, which enables numerical solutions. Extensive numerical studies and sensitivity tests are conducted.

Authors: Haibo Liu, Yuhao Liu, Qihe Tang, Jinxia Zhu

Policy Iteration Algorithm for Optimal Dividend Problem in Cramer-Lundberg Risk Model with Transaction Costs

Zhaoyang Liu (Nankai University)

We study an optimal dividend problem for the Cramer-Lundberg risk model with transaction costs. We aim to present a formal description of the optimal strategy and provide a policy iteration algorithm with rigorous numerical analysis. An auxiliary optimization problem is introduced by maximizing dividend payment with terminal reward up to the arrival-time of the first claim, and solved completely in the sense that the explicit formulas for both optimal strategy and value function are derived. In view of the relationship between the auxiliary problem and the original problem, we obtain a description of the optimal strategy for the original dividend problem. We characterize the value function as a minimal nonnegative solution of an optimal equation. So, under any conditions it can be approximated by the iteration algorithm starting with the initial zero-valued policy, that is the policy of no dividend payment at all. These, together with the results on the auxiliary problem, establish a rigorous numeral analysis for the policy iteration algorithm in general situation. Finally, we provide some numerical examples to further explain the algorithm.

Authors: Guoxin Liu, Yuying Liu, Zhaoyang Liu

On the Speed of Recovery of a Lévy Risk Process

M.A. Lkabous (University of Southampton)

In this talk, we introduce the concept of the speed of recovery of a Lévy risk process, which is the duration between the last recovery time and the ruin time. Our results improve the existing literature in which, for some cases, only the Laplace transforms are known. Additionally, we handle two kinds of a Parisian ruin as well: with an exponential and fixed clock of the so-called red period. As special cases, we investigate the cases of a Brownian motion risk process and Cramer-Lundberg risk model with exponential claims. We also study two applications of our results. This is

Authors: M.A. Lkabous, Ronnie Loeffen, Z. Palmowski

Optimal Prevention Strategies in Risk Theory

Stephane Loisel (Université Claude Bernard Lyon 1)

In this talk, we propose and study a first risk model in which the insurer may invest into a prevention plan which decreases claim intensity. We determine the optimal prevention investment for different risk indicators. In particular, we show that the prevention amount minimizing the ruin probability maximizes the adjustment coefficient in the classical ruin model with prevention, as well as the expected dividends until ruin in the model with dividends. We also show that the optimal prevention strategy is different if one aims at maximizing the average surplus at a fixed time horizon. A sensitivity analysis is carried out. We also prove that our results can be extended to the case where prevention starts to work only after a minimum prevention level threshold. We then study the case where prevention only works for severe claims. At the end of the talk, we shall explain how to target prevention towards the right policyholders in health insurance using some data analytics techniques.

Authors: Stephane Loisel

Research on the Proportion of Subordinates and the Pricing of Asset Securitization Products in Accounts Receivable in China

Rui Ma (Anhui Polytechnic University)

As an innovative financial instrument, accounts receivable asset securitization products play an important role in the real economy of financial services. Based on the data of China's accounts receivable asset securitization products from 2015 to 2021, this paper takes the subordinated proportion as the main explanatory variable, studies the impact of the subordinate proportion on the issuance price spread of asset-backed securities in China's accounts receivable after controlling the characteristics of bonds and the characteristics of the issuing entity. It is found that the difference between the subordinate proportion and the issuance price of asset-backed securities in China's accounts receivable has a significant positive effect, and the subordinate proportion significantly increases the financing cost of the promoter. Both credit ratings and underlying asset quality have a significant impact on the spreads on issues of such securitization products. This paper provides a reference for the optimal design of accounts receivable asset securitization products in China and investors in the accounts receivable asset securitization market. According to the research results, it is suggested that the originators can ensure the healthy and sustainable development of the asset securitization market of accounts receivable of Chinese enterprises by appropriately controlling the level of the secondary proportion or strengthening the screening of underlying assets.

Authors: Rui Ma, Chuanyu Wang, Zemin Liu

Dynamic Mean-Variance Problem with Frictions

Guiyuan Ma (Xi'an Jiaotong University)

We study a dynamic mean–variance portfolio selection problem with return predictability and trading frictions from price impact. Applying mean-field type control theory, we provide a characterization of an equilibrium trading strategy for an investor facing stochastic investment opportunities. An explicit equilibrium strategy is derived in terms of the solution to a generalized matrix Riccati differential equation, and a sufficient condition is also provided to ensure the latter’s well-posedness. Our solution indicates that the investor should trade gradually towards a target portfolio which accounts for return predictability, price impact and time-consistency. Moreover, an asymptotic analysis around small liquidity costs shows that the investor’s target portfolio is an equilibrium portfolio without price impact in the first-order sense, and that her first-order approximated value function does not deteriorate significantly for sufficiently small liquidity costs. Finally, our numerical results demonstrate that the target portfolio is more conservative than an equilibrium portfolio without price impact.

Authors: Alain Bensoussan, Guiyuan Ma, Chi Chung Siu, Sheung Chi Phillip Yam

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A New Mean-Variance Model for Uncertain Portfolio Selection with Inflation Taking Linear Uncertainty Distributions

Di Ma (University of Science and Technology Beijing)

As a common multiplicative background risk, inflation rate affects not only the return but also the risk of investment. To take the impact of inflation on portfolio into account, treating the return of risky asset and inflation rate as uncertain variables, we propose an uncertain mean-variance model and give the the deterministic forms of the model. Then we analyse the impact of inflation risk on portfolio risk based on the

deterministic form of the model when the return of risky asset and inflation rate taking linear uncertainty distributions. We also discuss the optimal solution of the model and show how the optimal investment proportion in the risky asset changes when the mean or breadth of inflation rate changes based on the linear deterministic form. Finally, we provide numerical examples to illustrate the application of our method and show the effect of inflation on portfolio selection.

Authors: Xiaoxia Huang, Di Ma, Kwang-Il Choe

Longevity Risk and the Consumer Price Index

Qingxiao Ma (University of Amsterdam)

In the literature, economic growth has been shown to be an important factor that explains changes in mortality probabilities. Economic growth is commonly measured via the Gross National Product (GDP), but we consider in this paper the Consumer Price Index (CPI) as a more natural factor to explain the mortality dynamics. It is namely the CPI that approximates the affordability of health care, food and housing. We augment the well-known Lee-Carter model with the observable CPI factor, and test this model using data from the USA, Canada, France and Australia. We show that the in-sample model fit of our proposed model, as measured by the adjusted R-squared and BIC value, improves compared with the Lee-Carter model (either augmented with the GDP factor or not). Moreover, we also show that the out-of-sample forecasting performance of our proposed model, as measured by the mean squared forecast error (MSFE), is a considerable improvement. In summary, the use of CPI to model mortality dynamics is shown to perform better than the use of GDP. This paper is joint with Tim Boonen (University of Amsterdam).

Authors: Qingxiao Ma , Tim Boonen

A Dynamic Programming Approach to Price VAs Within a Stochastic Mortality Framework

Rosario Maggistro (University of Trieste)

We propose a discrete time model, based on dynamic programming, to price variable annuities with GLWB within a stochastic mortality framework. Although our set-up is very general and only requires the Markovian property for the mortality intensity and the asset price processes, in the numerical implementation of the model we shape the former as a non-mean reverting square root process, and the latter as an exponential Lévy process. In this way we get a tractable stochastic model for efficient pricing of the GLWB. We also provide the verification, through backward induction, of the bang-bang condition for the set of discrete withdrawal strategies of the model. This result allows to drastically reduce the computational time needed to search the optimal withdrawal in the backward recursive step of our dynamic algorithm and provides, as a by-product, an interesting contract decomposition. In conclusion, we present numerical examples and compare the results obtained for different market parameters and policyholder behaviours.

Authors: Anna Rita Bacinello, Rosario Maggistro, Ivan Zoccolan

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Collective Risk Models with FGM dependence

Etienne Marceau (Laval University)

Collective risk models, in which the aggregate claim amount of a portfolio is defined in terms of as a sum of a random number (frequency) of random claim amounts (severities), play a crucial role. In these models, the classical approach is to assume that the random number of claims and their amounts are independent, even if this might not always be the case. We consider a class of collective risk models, in which the dependence structure of the random number of claims and the individual claim amounts is defined in terms a multivariate Farlie-Gumbel-Morgenstern (FGM) copula. By leveraging a one-to-one correspondence between the family of FGM copulas and the family of multivariate symmetric Bernoulli random vectors, we find closed-form expressions for the moments and Laplace-Stieltjes transform of the aggregate claim amount. We examine the dependence properties of the proposed class of collective risk models. Even if the Farlie-Gumbel-Morgenstern copula may only induce moderate dependence, we show through numerical examples that the cumulative effect of dependence can generate large ranges of values for the expectation, the variance, and risk measures (such as the Tail-Value-at-Risk and the entropic risk measure) of the aggregate claim amount. We present applications of the proposed class of collective risk models in various contexts of non-life insurance.

Authors: Etienne Marceau

Modeling Economic Cost of Obesity in the United States- State Level Analysis

Tatjana Miljkovic (Miami University)

Estimating the economic impact of obesity in the United States is increasingly important. Prior actuarial studies about obesity-related costs in the United States focused more on the national-level direct and indirect costs that evolved over a short time horizon. The most popular estimation procedures included prevalence-based and incidence-based methods. We propose a new methodology for building the state-level direct and indirect economic cost data associated with obesity. Our model is developed using a unique top-down methodology that integrates a prevalence-based approach with various medical-level costs, economic, demographic, and socio-economic factors. A bootstrapping technique is integrated with the state-level cost in order to estimate the average cost per person. We hope that our study will further assist actuaries that are working in the healthcare sector as well as policymakers at the state level, promote interest in this topic, and open discussion for further research in this area.

Authors: Tatjana Miljkovic

Reinsurance Treaty Minimizing the Ruin Probability Using a Diffusion Approximation

Alexandra Bugalho de Moura (Univesity of Lisbon)

The optimal reinsurance problem minimizing the probability of ruin is analysed by means of an approximation of the surplus process through a diffusion process. The surplus process includes different reinsurance premium calculation principles, different reinsurance strategies, and possible dependences of the underlying risks. The diffusion process includes a Brownian motion process and its parameters incorporate the characteristics of the underlying surplus process. Other than the minimization of the probability of ruin, the minimization of the variance of the surplus process and the maximization of the drift are considered.The relation between the variance and the drift of the diffusion process is also discussed. For some reinsurance treaties, analytical solutions are obtained. Nevertheless, in some cases, the optimal solutions are found numerically. Application examples are presented to illustrate the results.

Authors: Alexandra Bugalho de Moura, Carlos Oliveira, Adrialina Botnariuc

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CDS Index Tranches Pricing Under Thinning-Dependence Structure with Regime Switching

Wanrong Mu (Soochow University)

In this paper, we give two kinds of copula functions of default time based on the thinning-dependence structur, which are under the case without regime switching and with regime switching. We derive some closed-form expressions of CDS index tranches pricing by copula functions and marginal distribution functions. We also give an empirical example using the data of the maturity with 5 years of CDX NA IG series 25 to show the feasibility of the proposed copula functions. And compare to Clayton and Gaussian copula, we find the copula under the case with regime switching can change dependence structure by changing parameters so that it is suitable to practice.

Authors: Wanrong Mu

Optimal Dividends Under a Drawdown Constraint and a Curious Square-Root Rule

Nora Muler (Universidad Torcuato di Tella)

In this talk, we address the problem of optimal dividend payout strategies from a surplus process that is a Brownian motion with drift under a drawdown constraint. A drawdown constraint on dividends means that the dividend rate paid to the shareholders can never decrease more than a given percentage "a" of the historical maximum. We consider the case in which a ceiling on the maximum rate of dividends is imposed and show the asymptotic behavior of the optimal strategy and the optimal value function when this ceiling on dividend rates goes to infinity. We present the conditions under which a two-curve strategy is optima and how to find these optimal curves solving a system of ODE'S coming from a variational approach. We also show what happens with the optimal two-curve strategy when the ceiling on dividend rates goes to infinity and how the take-the-money-and-run strategy is optimal in the presence of a drawdown dividend constraint for large surpluses. The surplus level from which a take-the-money-and-run strategy is optimal is a simple formula and involves the inverse of the square root of the percentage "a". In numerical examples we see how these two-curves strategies (depending on the percentage "a") are an interpolation between the optimal one-curve strategy in the case of ratcheting constraints (a=1) studied in [1] and the classical optimal barrier without constraints (a=0) studied for instance in [2] and [3].

Authors: Hansjoerg Albrecher, Pablo Azcue, Nora Muler

Joint Lifetime Modeling with mIPH Distributions

Alaric Jules Antoine Müller (University of Lausanne)

Acyclic phase-type (PH) distributions have been a popular tool in survival analysis, thanks to their natural interpretation in terms of ageing towards its inevitable absorption. It is therefore interesting to consider the potential of multivariate PH distributions for the modelling of joint human lifetimes. In the univariate case, it was recently demonstrated in Albrecher, Bladt, Bladt and Yslas (2021) that introducing time-inhomogeneity into the stochastic construction of the PH distribution can greatly reduce the number of needed dimensions for an adequate fit of mortality rate curves.In this talk, we will consider an extension to the bivariate setting for the modelling of joint lifetimes. In contrast to previous models in the literature that were based on separate estimation of the marginal behavior and the dependence structure through a copula, using a new time-inhomogeneous version of a multivariate PH class (mIPH) we show how to model joint lifetimes without separating the estimation of marginal and dependence properties. This also leads to a more natural causal interpretation of the resulting model. The main advantages of this mIPH class are its flexibility, denseness on the positive orthant and, unlike the MPH* class, statistical tractability. The idea is to introduce the dependence between the different components through a sharing of the initial state. This creates dependence, while still maintaining favourable properties of independence. We provide additional attributes of the mIPH class and an adapted estimation procedure that allows for right-censoring and covariate information. We show that initial distribution vectors can be tailored to reflect information that may affect the dependence of random variables, using multinomial regressions to predict the influence of covariates on starting probabilities. Moreover, we highlight the flexibility and parsimony in terms of needed phases that is introduced by time-inhomogeneity. We illustrate our results on the famous dataset of joint lifetimes of Frees, Carriere and Valdez (1996), where 10 phases turn out to be sufficient for a reasonable fitting performance. We finally interpret the results in terms of a correlated ageing mechanism of joint lifetimes that goes beyond a statistical fit.

Authors: Hansjörg Albrecher, Martin Bladt, Alaric Jules Antoine Müller

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Sustainability of Agricultural Income Insurance Under Climate Change and Market Uncertainty

Ezgi Nevruz (Hacettepe University)

In agricultural income insurance, farmers are protected from their future losses of income caused by the change in yield and the difference between realised and expected price of product. In order to determine the coverage of the government-backed farmer income insurance in Turkey, which was launched in November 2021, the expected income is calculated by the product of average historical yields and average historical prices updated by estimated inflation. However, it is possible that deterministic approaches are insufficient to reflect agricultural income volatility. Under climate change and market uncertainty, the financial resilience of farmers depends on sustainability of income insurance since farmers' willingness to pay for this product is greater compared to other agricultural products. In order to examine the effectiveness of climate-related financial risk management, climatic and economic assumptions must be regularly validated. In this study, stochastic modelling helps us to measure the impact of uncertainty surrounding these assumptions on farmers' income and indemnity of income insurance. We take into account yield-price correlation and earnings growth relative to producer price index in the indemnity model to make it more comprehensive.

Authors: Ezgi Nevruz

Portfolio Performance Under Benchmarking Relative Loss and Portfolio Insurance: from Omega Ratio to Loss Aversion

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Tak Wa Ng (**Laval University**)

We study an optimal investment problem under a joint limited expected relative loss and portfolio insurance constraint with a general random benchmark. By making use of a static Lagrangian method in a complete market setting, the optimal wealth and investment strategy can be fully determined along with the existence and uniqueness of the Lagrangian multipliers. Our numerical demonstration for various commonly-used random benchmarks shows a trade-off between the portfolio outperformance and underperformance relative to the benchmark, which may not be well captured by the widely-used Omega ratio and its utility-transformed version, reflecting the impact of the benchmarking loss constraint. We develop a new portfolio performance measurement indicator via solving an equivalent optimal asset allocation problem with a benchmark-reference-based preference. We show that the expected utility performance can be well depicted by looking at this new portfolio performance ratio, suggesting a more suitable portfolio performance measurement under a limited loss constraint relative to a possibly random benchmark.

Authors: Tak Wa Ng, Thai Nguyen

Optimal Asset Allocations in DC Pension Funds Under Forward Utility Preferences

Tsz Hin Ng (University of Illinois at Urbana-Champaign)

We consider the problem of optimal dynamic asset allocation for defined contribution pension funds. Instead of assuming a fixed terminal utility, we construct forward utility preferences of a pension member, which suit better the long term feature of a pension fund that evolves in response to the dynamically changing market and salary conditions. Herein, the homothetic forward processes of power and exponential utilities are considered. The resulting utility process and investment strategy can be represented in terms of a pseudo fund under an exogenously chosen investment strategy, which connects with the relative performance criteria in fund management.

Authors: Tsz Hin Ng, Wing Fung Chong

Risk Management Under Weighted Limited Expected Loss

Thai Nguyen (Université Laval)

We introduce and solve an optimal asset allocation problem under a weighted limited expected loss (WLEL) constraint, which contains the risk management problem under a limited expected loss (LEL) constraint as a special case and presents an appropriate internal risk management tool for firms. We observe that a WLEL constraint makes the optimizing investor pursue less volatile payoffs than the unconstrained Merton solution. Compared to the LEL-constrained problem with the same weighted default threshold, the WLEL optimal terminal wealth displays a less dispersed distribution with a smaller variance, suggesting a more secure risk management framework. Further, we carry out a general equilibrium analysis in the presence of a WLEL risk manager, confirming the comparably conservative investment behavior of the WLEL manager.

Authors: Thai Nguyen, An Chen

Application of Survival Analysis Method to Find Out Time to Default Salary Based Credit Debtor at XYZ Bank

Singgih Aji Nugroho (Universitas Indonesia)

This research was conducted to examine the distribution of default debtors of ABC Bank's Salary Based Credit from the start of credit given and explain the characteristics of the debtor that affects the risk of default. The results of this study can be used by ABC Bank to strengthen credit risk control and effective strategies in marketing Salary Based Credit at ABC Bank. The Survival Analysis method used in this study is Kaplan Meier's non parametric method and the Cox Proportional Hazard semi-parametric method. The results of the assessment with kaplan Meier method are used to determine the distribution of time to default Salary Based debtors since the credit is given. While the Cox Propotional Hazard method is used to explain the characteristics of the debtor that can affect the occurrence of defaults. The data sample used is a Salary Based debtor realized in December 2015 and observed until December 2018 with the category of debtors who are still actively working. The results of the assessment using Kaplan Meier method state that Salary Based debtors start defaulting in the sixth month and continue to experience an increase in the number of default debtors until the end of observation. Using the Cox Proportional Hazard Method shows that the characteristics of the debtor that affects the occurrence of default are the territory of domicile and marital status. While the characteristics of the product that affect the occurrence of default is the time period.

Authors: Singgih Aji Nugroho, Lenny Suardi

Ratemaking in a Changing Environment

Nii Okine (Appalachian State University)

Regarding the multivariate approach to pricing insurance contracts for non-life insurers, the literature has mainly focused on using detailed information from policies and closed claims. Information regarding open claims from Reported But Not Settled and Incurred But Not Reported claims are usually ignored. However, the information on open claims can reflect shifts in the distribution of the expected claim payments better than closed claims. Such shifts may be needed to be reflected in the ratemaking process earlier rather than later, especially when insurers are experiencing environmental changes. Therefore, ignoring open claims during the multivariate ratemaking process may lead to biased estimates and, consequently, inaccurate premiums. This paper presents an intuitive ratemaking model, employing a marked Poisson process framework, which ensures that the multivariate risk analysis is done using all reported claims and makes an adjustment for Incurred But Not Reported claims based on the reporting delay distribution. Using data from the Wisconsin Local Government Property Insurance Fund, we find that by determining rates based on current data, the proposed ratemaking model leads to better alignment of premiums and provides insurers with a more profitable portfolio.

Authors: Nii Okine

Domestic Credit Channelization to Private Sector and Economic Growth: An Empirical Analysis

Sudan Kumar Oli (University of International Business and Economics)

This paper has examined the impact of the domestic credit channelization to the private sectors on economic growth in Nepal by using time-series data from the period 1960 to 2020. The paper has been investigated because of two reasons: First, fund channelization is a key factor for capital formation and secondly, the means of fund channelization does matter in the effective utilization of funds. Results of the Johansen co-integration test reject the null hypothesis of no co-integration. As suggested by Engle and Granger (1987), the vector error correction model shows that there is a significant relationship between domestic credit to private sectors and GDP growth in the long run. Analysis results also present evidence of a significant long-run causal relationship between domestic credit to private sectors through banks and other means with GDP growth. The study also applied the JB test, D-W test, and LM test for the robustness test. These robustness test results concluded that the analysis results are not spurious to the generalization and implementation of the study outcomes. Overall, the analysis suggests that domestic credit to the private sector through banks has a significant role in economic growth in the long term.

Authors: Sudan Kumar Oli

Aggregate Claims Process Based on the Hidden Markov Model

Mustafa Asim Ozalp (Hacettepe University)

The main objective of insurance companies is to hedge policyholders against losses in exchange for a certain premium. In order to be hedging in the underwriting year, a fair premium must be charged and a sufficient amount of capital and reserves must be established. Hence, predicting the claims frequency/amounts (individual or aggregate) in the underwriting year is important since it is directly related to premium and reserving. The well-known approach in modeling aggregate claim amounts of the portfolio for n policyholders is to sum all amounts during the period; it is assumed that claim frequency follows a particular discrete distribution and claims severity follows a continuous distribution. However, the assumption of independence of frequency and severity is not convenient in practice and the dependence between frequency and severity has been searched for the last 20 years. In general, the prediction of aggregate claims models is an important issue for actuaries, because of pricing and reserving. Hence, we focus on the aggregate claims model that included individual heterogeneity and serial correlation in the perspective of insurers. First, individual heterogeneity is being discussed. In this study, we model to aggregate claims which included heterogeneity caused by unobservable variables under the hidden Markov Model.

Authors: Mustafa Asim Ozalp, Sule Sahin, Kasirga Yildirak

Interpretable Machine Learning Algorithms for Crop Insurance: Hail Risk in Turkey

Mustafa Asim Ozalp (Hacettepe University)

In insurance modeling, determining the features of the insured asset is one of the most fundamental problems. One of the most important questions is to determine the contribution of the features to the risk. In this study, the analysis of the variables depending on the hail risk, which is one of the natural disaster risks, is examined in agricultural insurance, which is getting more and more attention today among non-life insurance. In this study, multi-stage clustering methodology is used for separation of locations by using locational contiguousness, claim frequency and claim severity information. Spherical k-means is used for locational clustering at first stage, and k-means algorithms are employed for claim history (both severity and frequency) clustering for each sub-clusters hierarchically.

ECMWF database is utilized as meteorological data source for obtaining features for modelling hail risk. After data processing, variable selection and feature importance results by means of various machine learning algorithms are examined. Results are given on how meteorological variables can affect the claim frequency and claim amount components. ML algorithms are compared for hail risk modeling with both claim frequency and severity components separately. As it is known, although machine learning algorithms are evaluated by making a "black box" analogy, we aim to increase the interpretability of the results we obtained with the "SHAP" approach in our study.

Authors: Mustafa Asim Ozalp, İsmail Gur, Kasirga Yildirak

A Longevity Basis Risk Hedging Framework Under Collateralization

Selin Özen (Ankara University)

Index-based longevity swaps provide many advantages over the other hedging instruments to life insurance companies and pension plans. Insurers and pension plan providers can transfer their longevity exposures to the capital markets at lower costs by using these securities. However, mismatches between the liability of the hedger and the hedging instrument cause longevity basis risk. Moreover, since longevity-linked instruments are traded in OTC, each involved party is exposed to the counterparty default risk. Therefore, regulators have emphasised the role of the credit risk mitigation tools such as collateralization for the improvement of swap contracts' credit quality. In this paper, we introduce a hedging framework for longevity basis risk in the context of collateralization. It is assumed that both parties are posting collateral and they re-hypothecate it to increase the benefits of this transaction. A hypothetical pension plan is built to illustrate the effects of collateralization and risk reduction degree. Different mortality models and different amounts of collateral are used to compare the hedge effectiveness levels of the plan. The analyses show that bilateral collateral posting increases longevity basis risk reduction and hedge effectiveness level.

Authors: Selin Özen, Şule Şahin

Large Deviations and Ruin Problems for Grey Gaussian Processes

Barbara Pacchiarotti (Università degli Studi di Roma Tor Vergata)

In this paper we introduce a new class of multidimensional processes, the grey Gaussian processes, which generalizes the grey Brownian motion. For this class of processes we get a pathwise large deviations principle and, as application, we deduce some asyptotic estimates of level cross probabilities. In particular we consider two multi-dimensional ruin problems where the surplus process is modelled by a particular grey Gaussian process. For both models we consider exit probabilities from a halfspace and from a quadrant and in both cases we obtain an explicit asymptotic estimate.

Authors: Barbara Pacchiarotti

Premium Control with Reinforcement Learning

Lina Palmborg (Stockholm University)

We consider a premium control problem in discrete time formulated in terms of a Markov decision process. In a simplified setting, the optimal policy can be derived with dynamic programming methods. However, these classical methods are not feasible in a more realistic setting due to the dimension of the state space. Hence, to combat the curse of dimensionality we explore reinforcement learning techniques, using linear function approximation. We illustrate the appropriateness of the approximate optimal policy compared with the true optimal policy in a simplified setting, and further demonstrate that the approximate optimal policy outperforms benchmark policies in a more realistic setting where classical approaches fail.This is based on joint work with F. Lindskog.

Authors: Lina Palmborg

Multi-State Modelling of Functional Disability and Health Status Using Australian Cross-Sectional Data

Kyu Hyung Park (The Australian Research Council (ARC) Centre of Excellence in Population Ageing Research (CEPAR))

Multi-state modelling of functional disability and/or health status is essential for projections of population by functional disability status and for estimation of healthy/unhealthy life expectancies. Understanding these risks is critical to informing developments in public aged care policy and private long term care insurance. Fitting a model for Australian population has been challenged by lack of availability of longitudinal data providing relevant covariates and transitions between states. Using six unlinked cross-sectional data sets with prevalence of functional disability and illness across 20 years (data in the Survey of Disability, Ageing and Caring 1998, 2003, 2009, 2012, 2015 and 2018), we estimate a multi-state model by determining transition parameters that best explain the observed changes of prevalence in Australia. Our model is new in that for the first time we model transitions between five states (healthy, disabled but not ill, ill but not disabled, disabled and ill and dead) using age, sex and trend factors for those aged 60 or greater using this Australian data. Functional disability is identified based on autonomy of activities of daily living. Illness is defined as having any of acute illness conditions including cancers, dementia, Alzheimer's disease, heart disease, angina and myocardial infarction. Using the fitted model, we estimate observed and projected population distributions by functional disability state and (healthy) life expectancy, assess the importance of factors in the model, and provide a comparison of the results with previous studies.

Authors: Kyu Hyung Park, Michael Sherris

Robust Retirement and Life Insurance with Inflation Risk and Model Ambiguity

Kyunghyun Park (The Chinese University of Hong Kong)

We study a robust consumption-investment problem with retirement and life insurance decisions for an agent who is concerned about inflation risk and model ambiguity. Assuming that an inflation-linked index bond and a stock are available in the market, this paper considers a comprehensive setup of ambiguity in the return, volatility, and correlation parameters in the joint dynamics of their market prices. With a finite planning horizon, the agent has a general utility function with different marginal utilities of consumption before and after retirement. Combining the classical dual approach and the G-stopping time theory, we derive the novel robust strategies using integral equation representations. We numerically and extensively investigate the effects of ambiguity from different sources on the robust decisions. While model ambiguity generally leads the ambiguity- and risk-averse agent to decrease the consumption rate, life insurance purchase, and investment demands, it also generates contrasting effects on robust retirement time and wealth level. Specifically, model ambiguity lowers the target wealth level to immediate retirement of a young agent but increases the retirement time of an older agent compared to the case of known parameters. A rich agent takes ambiguity more seriously than a poor agent in the sense of adjusting the strategies on a more significant scale.

Authors: Kyunghyun Park, Hoi Ying Wong, Tingjin Yan

A Multivariate Risk-Theoretic Approach to the Matrix Sequential Probability Ratio Test

Oscar Peralta (University of Lausanne)

Suppose that we have a collection of iid observations $X_1, X_2 \ldots$ for which we want to test multiple hypothesis of the type $H_i = \{\text{The sample follows the distribution } F_i\}, i = 1, \ldots, M.$ The matrix sequential probability ratio test (MSPRT) is a well-established statistically significant method to reach a decision once a particular stopping rule is fulfilled. In this talk, we study the MSPRT under the assumption that each distribution F_i is the exponentially tilted version of a base distribution G which has nonnegative support. In particular, we reframe its associated decision and stopping rule as a first passage problem for a multivariate risk process with common shocks. We further transform this into a first passage problem of a piecewise linear barrier for a univariate renewal process. Our findings not only shed light into the MSPRT, but unveil potential directions of interest for the risk theory community.

Authors: Oscar Peralta, Hansjoerg Albrecher

Implied Value-at-Risk and Model-Free Simulation

Andrea Perchiazzo (Vrije Universiteit Brussel)

We propose a novel model-free approach for extracting the risk-neutral quantile function of an asset using options written on this asset. We develop two applications. First, we show how for a given stochastic asset model our approach makes it possible to simulate the underlying terminal asset value under the risk-neutral probability directly from option prices. Specifically, our approach outperforms existing approaches for simulating asset values for stochastic volatility models such as the Heston, the SVI, and the SABR models. Second, we estimate the option implied Value-at-Risk (VaR) and the option implied Tail Value-at-Risk (TVaR) of a financial asset in a direct manner.

Authors: Carole Bernard, Andrea Perchiazzo, Steven Vanduffel

Sensitivity Measures Based on Scoring Functions

Silvana M. Pesenti (University of Toronto)

We propose a holistic framework for constructing sensitivity measures for any elicitable functional T of a response variable. The sensitivity measures, termed score-based sensitivities, are constructed via scoring functions that are (strictly) consistent for T. These score-based sensitivities quantify the relative improvement in predictive accuracy when available information, e.g., from explanatory variables, is used ideally. We establish intuitive and desirable properties of these sensitivities and discuss advantageous choices of scoring functions leading to scale-invariant sensitivities. Since elicitable functionals typically possess rich classes of (strictly) consistent scoring functions, we demonstrate how Murphy diagrams can provide a picture of all score-based sensitivity measures. We discuss the family of score-based sensitivities for the mean functional (of which the Sobol indices are a special case) and risk functionals such as Value-at-Risk, and the pair Value-at-Risk and Expected Shortfall. The sensitivity measures are illustrated using numerous examples, including the Ishigami-Homma test function. In a simulation study, estimation of score-based sensitivities for a non-linear insurance portfolio is performed using neural nets.

Authors: Silvana M. Pesenti, Tobias Fissler

Optimal Dividend Strategies with Reinsurance Under Contagious Systemic Risk

Ming Qiu (University of Melbourne)

This paper studies the multi-dimensional mixed singular-regular stochastic control problems subject to reduced-form default driven by contagious intensities. The dynamic of surplus is given by a system of diffusion processes with two controls and the intensity of the reduced-form model increases when defaults occur. We derive the recursive Hamilton-Jacobi-Bellman variational inequalities by dynamic programming principle and present the analytical and recursive solutions. We prove that the solutions are classical and recursively associated with each other by the default states. The verification theorem is presented and we also present the numerical demonstrations.

Authors: Ming Qiu, Zhuo Jin, Shuanming Li

Improving Business Insurance Loss Models by Leveraging Insurtech Innovation

Zhiyu Quan (University of Illinois at Urbana-Champaign)

Recent transformative and disruptive developments in the insurance industry embrace various InsurTech innovations. Particularly 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 unprecedently combine real-life proprietary insurance claims information and features, empowered by InsurTech, describing insured businesses to create enhanced tree-based loss models. Empirical study shows that the supplemental data sources created by InsurTech innovation help significantly improve the underlying insurance company's in-house or internal pricing models. We further demonstrate how InsurTech proliferates firm-level value creation and affect insurance product development, pricing, underwriting, claim management and administration practice.

Authors: Zhiyu Quan

Introduction to Switching Loss Distribution for Climate Disasters: A Case Study of United States Climate Disaster Losses

Ali Raisolsadat (University of Prince Edward Island)

Since the late 21st century, our world has experienced extreme weather events accompanied by minor to extensive losses to individuals and communities. In 2015, the United Nations proposed a resolution, the Paris Agreement, to enforce and help nations mitigate and adapt to the changes in the earth's climate. Since then, the signatory parties have implemented plans to increase their resilience and set sustainability goals to further mitigate and prevent extreme events from happening in the future. While the signatory governments are busy creating policies for mitigation, the scientific community, specifically those in the field of insurance and finance, needs to provide policymakers with adaptation options for severe climate events and their physical impacts. Turner et al. (2019) has shown that there is a significant concern that privatized companies are neither accurately reporting their risk nor preparing for climate change physical impacts. Therefore, by studying the United States weather-climate billion-dollar disasters since 1980, we decided to construct an accurate general loss distribution to provide a helpful model for policymakers and further motivate the financial and insurance industry to consider climate change risk planning. The main contribution of this study was the construction of new distribution, called Switching Loss Distribution for the billion-dollar weather and climate disasters, using the idea of momentum of historical loss values. For this study, our goal was not only to show how simple it is to consider the impacts of climate change but to construct a loss distribution that (1) would have the ability to differentiate losses between a climate disaster losses and climate catastrophe losses, (2) would be simple to understand (naive approach), (3) have robust for parameter selection, and (4) can be adapted to different scenarios of climate change loss modeling. After creating the Switching Loss Distribution, we showed how simple the parameter selection is and how well the model performed for its robustness.

Authors: Kai Liu, Xander Wang, Ali Raisolsadat

Evaluating the Tail Risks of Multivariate Aggregate Losses

Jiandong Ren (Western University)

In this paper, we study the tail risk measures for several commonly used multivariate aggregate loss models where the claim frequencies are dependent but the claim sizes are mutually independent and independent of the claim frequencies. We first develop formulas for the moment (or size biased) transforms of the multivariate aggregate losses, showing their relationship with the moment transforms of the claim frequencies and claim sizes. Then we apply the formulas to compute some popular risk measures such as the Tail Conditional Expectation (TCE) and Tail Variance (TV) of the multivariate aggregated losses and to perform capital allocation analysis.

Authors: Wenjun jiang, Jiandong Ren

Optimal Mix Among PAYGO, EET and Individual Savings

Zhaojie Ren (Tsinghua University)

In order to deal with the aging problem, pension system is actively transformed into the funded scheme. However, the funded scheme does not completely replace PAYGO (Pay as You Go) scheme and there exist heterogeneous mixes among PAYGO, EET (Exempt, Exempt, Taxed) and individual savings in different countries. In this paper, we establish the optimal mix by solving a Nash equilibrium between the pension participants and the government. Given the obligatory PAYGO and EET contribution rates, the participants choose the optimal consumption and individual savings to achieve the objective. The results extend the ``Samuelson-Aaron" criterion and establish the heterogeneous preference orderings among the pension schemes of the different cohorts. The government is fully aware of the optimal feedbacks of the participants. And it chooses the optimal PAYGO and EET contribution rates to maximize the overall utility of the participants weighted by each cohort's population. As such, the negative population growth rate leads to the decline of the PAYGO attractiveness as well as the increase of the older cohorts' weight in the government decision-making. The optimal mix is the comprehensive result of the two effects.

Authors: Zhaojie Ren, Zongxia Liang, Lin He, Yilun Song

Estimation of Reserves for Credit Insurance Claims Using the Munich Chain Ladder & Bornhutter-Ferguson Method

Arif Agung Riyadi (Universitas Indonesia)

The deceleration in Indonesia's economic growth has impacted many factors, one of that is insurance. Insurance companies, as risk recipients, receive many claims, particularly on credit insurance from banks. This paper aims to estimate claims reserve, especially in credit insurance using Munich Chain-Ladder Method and Bornhuetter-Ferguson Method. Both methods are the development of the Chain-Ladder method in estimating claims reserves. In the Munich Chain Ladder method, the estimated reserve of claims uses the correlation between the claims paid and the claims reported in the state of a parameter as a development factor to determine the projected claims. Additionally, The Bornhuetter-Ferguson method uses an additional parameter in the state of the premium obtained to calculate the expected ultimate claim to determine the claim reserve. The application of an appropriate estimation method will result in a more efficient claim reserve so that the insurance companies are more precise in managing financial performance to anticipate the emergence of claims on credit insurance. The results demonstrate that the use of the Bornhuetter Ferguson method in credit insurance provides lower claims reserve estimates and claims projections than Munich Chain-Ladder and Classic Chain-Ladder.

Authors: Arif Agung Riyadi, Lenny Suardi

Application of Multiple Decrement Tables: Analysis of Pension Security Claims Under Competing Risks

Yaumil Rizki (University of Indonesia)

This paper analyses cause–of–claim of pension security and to estimate survival time of individual claims pension for the first time. Pension security is given when participants due to old age (after retirement), due to disability, and when the participant passes away. The study combines survival analysis using multiple decrement tables and competing risks models. Our aim is to estimate the decrement pattern of several causes–of-claims as Competing Risk. The analysis of cause-of-claim pension security is a new study to consider as a competing risk. For the conclusion, our numerical results based on data of Indonesia pension security can show the probability of cause-of-claim Pension Security at a certain age. Therefore in the future, insurance companies can determine the premium of pension security effectively and can manage pension funds properly.

Authors: Yogo Purwono, Yaumil Rizki

Survival Analysis of Cardiovascular Patients Participants of National Health Insurance In Indonesia

Fera Rusanti (Indonesia University)

This study aims to analyze the survival of patients with heart disease in National Health Insurance Participants. This study uses BPJS Kesehatan (Social Security Health Agency In Indonesia) sample data from 2015 to 2020. Survival analysis is carried out using two methods, namely the non-parametric method using the Kaplan Meier method and the semiparametric method using the Cox Proportional Hazard model. The Kaplan Meier method is used to determine the time distribution of death in patients with heart disease. Furthermore, using the Cox Proportional Hazard model to determine the effect of gender, age, participant segment, domicile and the presence of comorbidities on the time of death. This study limits the definition of time of occurrence as the time of death of a cardiac patient with a final cardiac diagnosis. Deaths from cardiac patients but with a final diagnosis of non-cardiac disease are considered as censoring data. The results of this study indicate that the factors of age, sex, number of comorbidities significantly affect the survival time of patients with cardiovascular disease.

Authors: Fera Rusanti, Lenny Suardi

Projection of Successor Excellence Branch Manager XYZ Bank Using Survival Model

Andzar Syafa'atur Rahman (University of Indonesia)

Branch Manager is a key strategic position for Bank XYZ in running business as one of the largest banks in Indonesia. An accurate Branch Manager succession planning model is one of the strategic tools for XYZ Bank to support business continuity in digital economy era. The succession planning model that is currently being developed uses the principle of job person match based on descriptive analysis where the successor is given a score based on the suitability of the successor profile with job profile. This paper aims to build Branch Manager succession planning model based on the Survival Model using 1,117 workers who have held the position of Branch Manager in the period 2012 – 2021. The covariates used in this paper include demographics, performance, competency, and areas of expertise based on the time spent by workers on the job. Meanwhile, the survival time in the study is the period from an employee is accepted as a permanent employee to become an Excellence Branch Manager, which is for the first-time getting performance with an average value of more than 3.00 for 3 periods of Branch Manager performance appraisal. Based on the Survival Model, the covariates that influence succession planning as an Excellence Branch Manager are the time spent by employees in the job related to the field of Small and Medium Business, and Governance, Risk and Compliance. The job with these areas of expertise can be employee's career path before becoming an Excellence Branch Manager.

Authors: Andzar Syafa'atur Rahman, Lenny Suardi

Actuarially Market Consistent Valuations of Catastrophe Bonds

Saeid Safarveisi (KU Leuven)

This paper introduces a framework consisting of three steps for catastrophe bonds pricing. The renewal process and Cox-Ingersoll-Ross (CIR) process are considered to model uncertainty sources associated with insurance and financial risks, respectively, which behave independently from one another. Under the assumption that the underlying risk process attached to a CAT bond is traded simultaneously in the capital market and reinsurance market, we combine a two-step valuation method with the concept of actuarially market consistent valuation, in which a class of all equivalent measures corresponding to the insurance risk is selected such that a renewal compound process (used as the loss index in the pay-off function) preserves its structure when changing probability measure. Applying the Bayesian inference together with the information extracted from historical data, capital market, and reinsurance market enables us to fully calibrate the pricing model. In addition, the proposed framework allows us to assess the effect of different inter-arrival time distributions on the CAT bond price, which has not been discussed in the literature at the time of writing this paper. Coupled with the aforesaid advantage, the obtained pricing formula under some special cases of the renewal process can account for the market prices of claim frequency, claim severity, and internet rate separately.

Authors: Saeid Safarveisi, Dixon Domfeh, Arpita Chatterjee

Tail Correlations of Sub-Portfolios

Sebastian Schlütter (Mainz University of Applied Sciences)

Tail correlations are used in the so-called square-root formula to aggregate risk measurements of risk categories or business segments under consideration of stochastic dependencies and diversification effects, respectively. In several capital requirement approaches, such as the Solvency II standard formula, risk aggregation is organized in two levels: firstly, individual risks, so-called submodules, are aggregated at the level of sub-portfolios, so-called modules. Afterwards, the risks of modules are aggregated to the diversified capital requirement of the firm.This paper shows that correlation parameters between sub-portfolios can be viewed as weighted sums of the individual risks. Our weighting formula is valid under all eligible concepts of correlations, including Pearson correlations, downside correlations (Ang and Chen, 2002), VaR-implied tail-correlations (Mittnik 2014), and sensitivity-implied tail-correlations (Paulusch and Schlütter, 2022). To calibrate correlations between sub-portfolios, our weighting formula enhances the stability of estimates: if the observed time series are shorter for some individual risks than for others (e.g. due to new business segments or asset categories), we can make use of longest possible overlaps. We illustrate this advantage in the spirit of estimating undertaking specific parameters of the standard formula for an insurance company.We also point out specific pitfalls in the calibration of correlations within and between sub-portfolios. For most correlation concepts, it can be impossible that the two-level square-root formula meets important properties of the “true” risk measurement that builds on the multivariate distribution of all individual risks. We show how sensitivity-implied tail-correlations can – to a certain degree – overcome these pitfalls.

Authors: Joachim Paulusch, Sebastian Schlütter

Robust Classification via Support Vector Machines

Salvatore Scognamiglio (University of Naples "Parthenope")

Classification models are very sensitive to data uncertainty, and finding robust classifiers that are less sensitive to data uncertainty has raised great interest in the machine learning literature [1,2]. This paper aims to construct robust Support Vector Machine classifiers under feature data uncertainty via two probabilistic arguments. The first classifier, Single Perturbation, reduces the local effect of data uncertainty with respect to one given feature and acts as a local test that could confirm or refute the presence of significant data uncertainty for that particular feature. The second classifier, Extreme Empirical Loss, aims to reduce the aggregate effect of data uncertainty with respect to all features, which is possible via a trade-off between the number of prediction model violations and the size of these violations. Both methodologies are computationally efficient and our extensive numerical investigation highlights the advantages and possible limitations of the two robust classifiers on synthetic and real-life insurance claims and mortgage lending data, but also the fairness of an automatized decision based on our classifier.

Authors: Salvatore Scognamiglio, Vali Asimit, Ioannis Kyriakou, Simone Santoni, Rui Zhu

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Multi-Population Modelling and Forecasting Life-Table Death Counts

Hanlin Shang (Macquarie University)

When modelling the age distribution of death counts for multiple populations, we ought to consider three features: (1) how to incorporate any possible correlation among multiple populations to improve point and interval forecast accuracy through multi-population joint modelling; (2) how to forecast age distribution of death counts so that the forecasts are non-negative and have a constrained integral; (3) how to construct a prediction interval that is well-calibrated. Within the framework of compositional data analysis, we apply a log-ratio transform to transform a constrained space into an unconstrained space. We apply multivariate and multilevel functional time series methods to forecast period life-table death counts in the unconstrained space. Using the age-specific period life-table death counts in England and Wales from 1841 to 2018 obtained from Human Mortality Database (2021), we investigate one-step-ahead to 30-step-ahead point and interval forecast accuracies of the proposed models and make our recommendations.

Authors: Hanlin Shang, Ruofan Xu, Steven Haberman, Ruofan Xu

Modeling Life Annuities as Fuzzy Random Variables

Arnold F. Shapiro (The Pennsylvania State University)

In the conclusion to Shapiro (2013), where future lifetime was modeled as a fuzzy random variable (FRV), it was suggested that a logical next step would be to merge a FRV future lifetime with a FRV interest rate, and to use them to evaluate various accumulation and discount models in insurance. Andrés-Sánchez and Puchades (2017), who constructed a FRV by merging a fuzzy discount rate with a stochastic mortality rate,

expressed a similar sentiment. This paper is a follow-up to those suggestions. Building on Shapiro (2013) and Wang (2019), we show how to model life annuities when both future lifetime and interest rates are fuzzy random variables.Andrés-Sánchez, J., González-Vila Puchades, L., 2017. The valuation of life contingencies: A symmetrical triangular fuzzy approximation. Insurance: Mathematics and Economics 72, 83–94.Shapiro, A. F., 2013. Modeling future lifetime as a fuzzy random variable. Insurance: Mathematics and Economics 53, 864-870.Wang, D., 2019. A net premium model for life insurance under a sort of generalized uncertain interest rates, in: Destercke, S., Denoeux, T., Gil, M.Á., Grzegorzewski, P., Hryniewicz, O. (Eds.), Uncertainty Modelling in Data Science, Springer International Publishing, Cham. 224–232.

Authors: Arnold F. Shapiro, Dabuxilatu. Wang

Study of Institutionalized Elderly Profiles Derived from Multiple Health Factors

Aleksandr Shemendyuk (University of Lausanne)

Due to advanced medicine and increased quality of life, people live longer. In many developed countries the population aging comes with a series of issues related to the organization and the financing of long-term care. The determinants of the overall institutionalized care burden are well-studied in previous works and, thus, the understanding of the expenses is achieved. On the other hand, the organization of the institutionalized long-term must satisfy the requirements of both institutions and elderly. One way to optimize the management is to leverage the information on health issues of the elderly to assess the required qualifications of the personnel and the allocation of newcomers. In this research we aim to determine the typical health profiles of institutionalized elderly using novel longitudinal data from nursing homes in the canton Geneva in Switzerland. Our data contains comprehensive information of the health factors such as psychological and sensory functions impairments, levels of limitations, and pathologies, on about 18 000 individuals covering the period from 1996 to 2018. First, we perform a spectral clustering algorithm and determine typical health profiles of the institutionalized elderly. Then, using a multinomial logistic regression we study the effects of the health factors that determine the health profiles. Our main findings show that there are eight typical profiles, the biggest of which consists of the most “healthy” elderly who on average require the least amount of help for their daily needs and who stay in the institution the longest. We show that, unlike the age at entry and the gender, the limitations and the set of pathologies are relevant factors in determining the health profile. Our study sheds light on the typical structures of elderly health profiles, which can be used by the institutions to organize infrastructure and human resources as well as by the insurance companies to derive profile-based products bringing additional insurance coverage in case of needs and in line with elderlies’ health trajectories.

Authors: Aleksandr Shemendyuk, Joël Wagner

Robust Life-Cycle Model with Background Stochastic Mortality Risk

Yang Shen (UNSW Sydney)

We consider a robust lifecycle planning problem with stochastic mortality risk, which cannot be hedged in the financial market. By the dynamic programming principle approach, we derive the Hamilton-Jacobi-Bellman-Issac (HJBI) equation for the optimisation problem. Due to the incompleteness of the market, the HJBI equation does not admit a closed-form solution. We overcome this difficulty and find approximate solutions for the robust optimal strategies and value function using the perturbation approach for nonlinear partial differential equations. Numerical studies show that the approximate solutions can achieve reasonable accuracy. Sensitivity analysis confirms that an investor with different risk profiles may behave in completely different patterns when facing uncertain stochastic mortality risk. Particularly, depending on the level of risk aversion, either longevity risk or mortality risk is a concern for the investor in the worst-case scenario of the stochastic mortality model. This complements the result in Shen and Su (NAAJ 23(4): 598–625, 2019), where an uncertain but deterministic mortality model is considered.

Authors: Yang Shen

Out-of-Model Adjustments of Variable Annuities

Zhiyi Shen (Morgan Stanley)

Motivated by the wide use of the Black-Scholes (BS) model by the insurance industry to price/risk-manage variable annuities, this paper responds to the following questions:What volatility parameter shall the insurer plug into the BS model? How to justify? What risk can be offset by the model? What is the residual risk undertaken by the insurer?Specifically, we derive a model-free decomposition of the no-arbitrage price into the

BS model price in conjunction with three out-of-model adjustment terms. This sheds light on different sources of risk behind variable annuities. We further identify the P&L slippage and leakage of the BS-based hedging strategy given that the market diverges from the model assumptions. We finally show that the pricing, risk and hedging models can be separated from each other in managing the risks of variable annuities.

Authors: Zhiyi Shen

A Bias-Corrected Least-Squares Monte Carlo for Utility Based Optimal Decisions in Retirement

Pavel Shevchenko (Macquarie University)

The Least-Squares Monte Carlo (LSMC) method has gained popularity in recent years due to its ability to handle multi-dimensional stochastic control problems, including problems with state variables affected by control. However, when applied to the stochastic control problems in the multi-period expected utility models, the regression fit tends to contain errors which accumulate over time and typically blow up the numerical solution. In this study we propose to transform the value function of the problems to improve the regression fit, and then using either the smearing estimate or smearing estimate with controlled heteroskedasticity to avoid the re-transformation bias in the estimates of the conditional expectations calculated in the LSMC algorithm. We also present and utilise recent improvements in the LSMC algorithms such as control randomisation with policy iteration to avoid accumulation of regression errors over time. Presented numerical examples demonstrate that transformation method leads to an accurate solution. In addition, in the forward simulation stage of the control randomisation algorithm, we propose a re-sampling of the state and control variables in their full domain at each time t and then simulating corresponding state variable at t+1, to improve the exploration of the state space that also appears to be critical to obtain a stable and accurate solution for the expected utility models. We present results of the method applied to finding of the optimal decisions for annuitisation, housing and reverse mortgage in retirement.

Authors: Pavel Shevchenko, Johan Andréasson

Mortality in the United States' Border Regions: A Closer Look at the U.S.-Mexico and U.S.-Canada Borders

Onofre Alves Simões (ISEG-ULisboa)

The objective of this work is to explore the mortality trends in the United States' border regions. Using the Center of Disease Control and Prevention's WONDER database, we examine overall mortality from 1999-2019 through the calculation of standardized mortality ratios for the border region versus the non-border areas. We analyse sub-populations of the border by state, ethnicity, and cause of death, and we use varying combinations of confounders in our standardization including age, gender, and cause of death. The findings confirm significant differences between the border and non-border regions, with opposite results at each border. When accounting for all confounders, the border region at the Mexican border has lower mortality than the non-border region, and at the Canada border, the border region has higher mortality than the non-border region. In this manner, the county of residence and proximity to the border could be a useful contributor to mortality estimations.

Authors: Onofre Alves Simões, Melanie Jean Joerger

On Corporate Demand for Insurance: A Dynamic Perspective on Property Insurance

Mario Sikic (University of Zurich)

Why do firms purchase property insurance?

When the firm has access to external capital and corporate liquidity, what is the effect of protecting productive capital on firm value? We address these questions by analysing the drivers of corporate property insurance when a risk-neutral firm is subject to various frictional costs. The problem is formulated in a dynamic, infinite time horizon model with endogenous investment, financing and demand for coverage against shocks to productive capital.

We show that firms' demand for property insurance is driven by the relative size of the costs imposed by financial constraints. These include capital issuance costs, corporate taxes and agency costs of holding cash. Numerical simulations reveal that risk-neutral firms purchase property insurance mainly in response to costly cash retention due to agency costs and, to a lesser extent, to increase debt capacity. We study the impact of adding the insurance channel on firm value, given different choices of available financing decisions. However, due to the complexity of the model, we additionally use Shapley Values as aggregate measures of the impact of property insurance on firm value relative to other corporate policies when frictional costs exist. We examine Shapley Values associated with firms subject to different financial constraints and confirm the twofold nature of demand for property insurance by risk-neutral firms: i) it represents a form of contingent capital that substitutes for corporate liquidity in the presence of agency costs of holding cash and ii) it helps improve firm value by increasing debt capacity and, in turn, relaxing borrowing constraints.

Authors: Andrea Bergesio, Mario Sikic, Pablo Koch-Medina

European Option Pricing with Market Frictions, Regime Switches and Model Uncertainty

Tak Kuen Siu (Macquarie University)

A pricing model for European options which incorporates market frictional costs, regime switches and model uncertainty is discussed. Regimes switches are due to changes in an economic environment, and model uncertainty is attributed to misspecification of transition intensities for economic regimes. The selling and buying prices of a European option are determined through stochastic optimal control and nonlinear partial differential equations. A fair value is determined by a closed-form solution to a minimization problem based on a relative entropy. The fair value is consistent with the one obtained using the Esscher transform. Numerical methods and results for implementing the pricing model are presented. The numerical results indicate that when controlling for model uncertainty about economic regimes, market frictional costs are more significant than regime switches in accounting for the fair, selling and buying prices of the European option.

Authors: Tak Kuen Siu

Modeling the Mortality Rates μ(x,t) Using Stochastic, Non-Gaussian Linear Scalar Filter Models with Switches.

Piotr Sliwka (Cardinal S.Wyszynski University, Warsaw)

The ability to precisely model mortality rates μx,t plays an essential role in healthcare's economic point of view. The existing SARS-CoV-2 pandemic has resulted in the growth of epidemiological models that mainly describe the virus's evolution and spread, affecting many public life spheres (social, economic, institutional, administrative, etc.). Nowadays, the high dynamics of changes also force adjusting their parameters to forecasting models' situations. Therefore, it can be observed that there is still a need to search for models that consider the variability of parameters over time. Some authors have proposed using the methodology of stochastic dynamic hybrid (switched) systems. They thought the dynamic systems consisted of several subsystems described by deterministic or stochastic differential equations. These subsystems have the same structures and different parameters. The submodels can change over time according to a given switching rule, creating a hybrid system. Recently this idea was developed by [1] - [5]. The paper will present the class of Promislov-Milevsky models, including non-gaussian linear scalar filter models with switches and examples of potential applications. The results obtained in the works [1] - [5], showing the advantage over, among other things, the commonly used Lee-Carter model, encourage further research on the evolution and development of this type of model.

Authors: Piotr Sliwka

Inference for the Tail Conditional Allocation: Large Sample Properties and Insurance Risk Assessment

Jianxi Su (Purdue University)

We develop large-sample statistical inference for the tail conditional allocation (TCA), also known as the marginal expected shortfall, at the level of utmost generality and thus widest real-world applicability. In particular, the two random variables involved in the definition of the TCA are not required to have finite first moments, nor do they need to have continuous cumulative distribution functions. An insurance inspired simulation study has been designed to illustrate numerical performance of the obtained statistical inference results.

Authors: Nadezhda Gribkova, Jianxi Su, Ricardas Zitikis

A Multivariate Frequency-Severity Framework for Healthcare Data Breaches

Hong Sun (Lanzhou University)

Data breaches in healthcare have become a substantial concern in recent years, and cause millions of dollars in financial losses each year. It is fundamental for government regulators, insurance companies, and stakeholders to understand the breach frequency and the number of affected individuals in each state, as these are directly related to the federal Health Insurance Portability and Accountability Act (HIPAA) and state data breach laws. However, an obstacle to studying data breaches in healthcare is the lack of suitable statistical approaches. We develop a novel multivariate frequency-severity framework to analyze breach frequency and the number of affected individuals at the state level. A mixed effects model is developed to model the square root transformed frequency, and the log-gamma distribution is proposed to capture the skewness and heavy tail exhibited by the distribution of numbers of affected individuals. We further discover a positive nonlinear dependence between the transformed frequency and the log-transformed numbers of affected individuals (i.e., severity). In particular, we propose to use a D-vine copula to capture the multivariate dependence among conditional severities given frequencies due to its inherent temporal structure and rich bivariate copula families. The rejection sampling technique is developed to simulate the predictive distributions. Both the in-sample and out-of-sample studies show that the proposed multivariate frequency-severity model that accommodates non-linear dependence has satisfactory fitting and prediction performances.

Authors: Hong Sun

Statistical Modeling of Data Breaches and Its Application in Cyber Insurance

Meng Sun (Simon Fraser University)

Data breach incidents result in severe financial loss and reputational damage, which raises the importance of using insurance to manage and mitigate cyber risks. We analyze data breach chronology collected by Privacy Rights Clearinghouse (PRC) since 2001 and propose a Bayesian generalized linear mixed model for data breach incidents. Our model captures the dependency between frequency and severity of cyber losses and the behavior of cyber attacks on entities across time. When investigating breach frequencies, we take into consideration cyber related risk characteristics such as types of breach, types of organization and entity locations recorded in chronology, as well as the time trend effects. Estimation of model parameters are presented under Bayesian framework using a combination of Gibbs sampler and Metropolis-Hastings algorithm. The proposed frequency model can be combined with a finite mixture severity model to make predictions on aggregate cyber losses. Risk mitigation and rate filing applications of the proposed frequency-severity model in cyber insurance are discussed.

Authors: Meng Sun, Yi Lu

Applications of Hawkes Processes in Insurance

Anatoliy Swishchuk (University of Calgary)

In this talk, I'll construct a general risk model R(t) based on Hawkes process [1] (we call it General compound Hawkes process (GCHP) [4,5,6]), and then I'll discuss two applications of this risk model in insurance: 1) Merton investment problem [2,3,6] and 2) optimal investment with liability [6,7]. For the first problem 1), an investor starts with initial capital, R(o)=u, and then wishes to decide how much money to invest into risky and risk-free assets to maximize the capital. For the second problem 2), we consider a continuous-time mean–variance portfolio selection model with multiple risky assets and one liability in an incomplete market with the goal to maximize the expected terminal wealth while minimizing the variance of the terminal wealth [7]. The risky assets' prices are governed by geometric Brownian motions while the liability described by the GCHP. We solve both problems by using diffusion approximation for the GCHP. In problem 1) we construct and solve HJB equation for the expected utility function [6]. The second problem 2) is solved by applying general stochastic linear-quadratic control technique [7].

Authors: Anatoliy Swishchuk

Cyber Risk Assessment by Classic Insurance Model

Yutaro Takagami (Graduate school of Waseda)

Today, the danger of cyber incidents is more and more increasing, and several non-life insurance companies have introduced cyber risk insurance. It is needed to predict the damage cost of cyber incidents with low calculation cost, then we try to apply classic insurance model to that.We use PRC dataset (https://www.privacyrights.org/data-breaches), which includes about 9000 data of cyber incidents in America for 15 years. We model the frequency of incidents by negative binomial distribution and the quantity of each incident by generalized pareto distribution. We assume that the value of negative binomial parameter changes over time, following ARIMA process. Then we construct compound distribution of negative binomial and generalized pareto, and consider the total quantity of incidents per one term (1 week or 1 month etc.). Because it is very difficult to calculate VaR or TVaR of compound distribution model, we derive approximate values of such risk index by using methods of extreme value theory and insurance mathematics.Our research is composed of 4 steps. First, we divide the data into training period and prediction period. Second, we estimate parameters of compound distribution using training period data. Third, calculate approximated VaR and TVaR in prediction period by estimated distribution. Last, we compare them to prediction period data and verify the prediction accuracy.Today, the danger of cyber incidents is more and more increasing, and several non-life insurance companies have introduced cyber risk insurance. It is needed to predict the damage cost of cyber incidents with low calculation cost, then we try to apply classic insurance model to that.We use PRC dataset (https://www.privacyrights.org/data-breaches), which includes about 9000 data of cyber incidents in America for 15 years. We model the frequency of incidents by negative binomial distribution and the quantity of each incident by generalized pareto distribution. We assume that the value of negative binomial parameter changes over time, following ARIMA process. Then we construct compound distribution of negative binomial and generalized pareto, and consider the total quantity of incidents per one term (1 week or 1 month etc.). Because it is very difficult to calculate VaR or TVaR of compound distribution model, we derive approximate values of such risk index by using methods of extreme value theory and insurance mathematics.Our research is composed of 4 steps. First, we divide the data into training period and prediction period. Second, we estimate parameters of compound distribution using training period data. Third, calculate approximated VaR and TVaR in prediction period by estimated distribution. Last, we compare them to prediction period data and verify the prediction accuracy.

Authors: Yutaro Takagami

An Alternative Insurance Model Against New Emerging Risks

Muhsin Tamturk (University of Leicester)

This joint work proposes a new insurance model (called More for Less Model) against new emerging risks [1]. Briefly, the company charges more premiums than necessary from the insured, but it undertakes to reimburse part of them if there has been no claim. Our goal is to compare this model to a (re)insurance model [4, 5] by examining the finite-time ruin probabilities, capital and the expected deficit at ruin. The approach is based on simple calculations of path integrals [7] and properties of an underlying family of Sheffer polynomials [2, 3, 6]. The main motivation is to offer an alternative insurance coverage in today's changing world. The talk is based on a joint work with Claude Lefèvre, Université Libre de Bruxelles.

Authors: Muhsin Tamturk

Investment-Consumption with Unemployment and Reemployment Driven by Regime Switching

Cheng Tao (Tianjin University)

This paper studies optimal investment and consumption problems for an individual whose employment state is driven by an inhomogeneous Markov chain. We consider two types of individuals distinguished by whether they take the risk of unemployment into consideration when making decisions to maximize the overall consumption and the wealth at retirement. Explicit expressions for the optimal strategies and value functions are deducted by solving the corresponding regime-switching Hamilton-Jacobi-Bellman equations. By comparing the two types of decision makers, we prove the necessity of considering unemployment risk. Numerical results also imply that unemployment will lead to a greater decline in consumption levels for young people than elderly people.

Authors: Ximin Rong, Hui Zhao, Cheng Tao

On a Time-Changed Lévy Risk Model with Capital Injections and Periodic Observation

Ye Teng (Chongqing University)

In this paper, we consider the stochastic volatility of the surplus process and use the time-changed Lévy process to model the surplus flow of an insurance company. Assuming that a continuous-time change process determines the time of capital injection, we use the Cox-Ingersoll-Ross (CIR) process to describe the activity rate process in random time variation. To obtain closed expressions for the finite-time expected discounted penalty function and the finite-time expected total discounted cost of capital injections before ruin, we use the Fourier cosine series expansion method to approximate the density function. Both error analysis and numerical simulation results demonstrate the accuracy and effectiveness of the method. The effects of parameters and optimal reinsurance strategies are also studied.

Authors: Ye Teng, Zhimin Zhang

Influence of DB Pension De-Risking on Pension Betas and Firm Value

Ruilin Tian (North Dakota State University)

This study aims to resolve conflicting viewpoints about the influence of pension de-risking on firm value from a unique perspective, considering dynamic pension asset beta and de-risking adjusted pension liability beta. Based on manually collected de-risking data of US-based companies with DB plans for the period 1994-2018, we find that pension de-risking can effectively reduce firms' net pension risk burden, measured by the net pension beta. In addition, pension de-risking can alleviate negative impact of pension liability beta on firm's net pension beta as well as firm beta. The divested pension obligations along with the lessened net pension risk contribution to firm's overall risk bring an improvement of market prospects on firm's future performance and investment opportunities, signaled by an increase of the firm's Tobin's Q ratio.

Authors: Ruilin Tian, Jun Chen

An Integrated Study of Cyber Risk and Cyber Security

Zhiwei Tong (The University of Iowa)

Cyber risk is a top business concern nowadays and has been attracting an increasing attention during the coronavirus pandemic and the Ukraine crisis. Companies can purchase cybersecurity plans to reduce its likelihood of being compromised by cyber attacks, and insurance policies to transfer cyber losses to insurers. We perform an integrated study where there is an insurer who sells a cyber insurance product and a company who can purchase the insurance and a certain cybersecurity plan. In doing so, we model the company’s IT structure by a network and assume that the insurer has the pricing power. This way the insurer can internalize the contagion risk within the company into the insurance premium. The company makes its purchase decisions of the insurance and the cybersecurity plan, and then the insurer will adjust the premium to optimize its profitability. We characterize this Stackelberg equilibrium between the two parties, and study the effect of the network’s structure on the company’s purchase decision and the insurer’s profitability.

Authors: Yang Feng, Zhiwei Tong

Flood Risk and the Option to Adapt Under Uncertainty

Chi Truong (Macquarie University)

This paper examines optimal adaptation strategies for coastal flood risk management under the growth of loss exposure and the uncertainty of sea level rise. Using a generalised extreme value distribution to quantify flood risk, we use contingent claims and a real options framework to determine the optimal investment pathways for multiple possible adaptation projects, as well as the optimal investment timing for a multi-staged project. Investing based on a real options model adds substantial value to an adaptation project due to adaptation flexibility when both big and small projects are available. We show that the combination of loss exposure growth and sea level rise makes adaptation particularly important to possible flood risk management in the coastal cities of New York and Copenhagen. We also show that multi-staged projects can help adapt under the uncertainty of sea level rise effectively.

Authors: Chi Truong

Pricing Renewable Energy Investment in Presence of Trend, Seasonality, Mean Reversion and Price Spikes

Chi Truong (Macquarie University)

In this paper, we introduce a new modelling framework for pricing renewable energy investment projects. We allow electricity price to be composed of trend, seasonality, mean reversion and price spikes in an additive model and allow renewable energy to follow heavy tailed distributions in a multiplicative model. Our framework allows us to derive a closed form solution for the profits generated by renewable investment projects and facilitates the task of project evaluation. The developed model is used to examine six different deseasonalization approaches, two of which represent our new contribution. Using case studies of solar and wind investment projects in four states of Australia, we find that to provide accurate seasonality adjustment, the Jensen effect from log transformation in multiplicative frameworks must be considered. In addition, for solar projects, an additional adjustment is needed to take into account the covariance between renewable energy and electricity price. For wind projects, the best approach is to assume a constant generation to deal with the non-linear production issue. However, care needs to be taken in estimating the constant generation level, particularly in the presence of trending renewable energy.

Authors: Chi Truong

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 non-tradable 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 a wide range of scenarios, individuals withdraw pension 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 policies are more conservative compared to the case with risk-less labor income and CRRA preferences.

Authors: Servaas van Bilsen, Roger Laeven, Theo Nijman

Mortality/Longevity Risk-Minimization with or without Securitization

Michèle Vanmaele (Ghent University)

In this talk we will address the risk-minimization problem, with and without mortality securitization, à la Föllmer–Sondermann for a large class of equity-linked mortality contracts when no model for the death time is specified. This framework includes situations in which the correlation between the market model and the time of death is arbitrary general, and hence leads to the case of a market model where there are two levels of information—the public information, which is generated by the financial assets, and a larger flow of information that contains additional knowledge about the death time of an insured. We will derive the dynamics of the value processes of the mortality/longevity securities used for the securitization, and decompose any mortality/longevity liability into the sum of orthogonal risks by means of a risk basis. Next, we will quantify, as explicitly as possible, the effect of mortality on the risk-minimizing strategy by determining the optimal strategy in the enlarged filtration in terms of strategies in the smaller filtration. We will obtain risk-minimizing strategies with insurance securitization by investing in stocks and one (or more) mortality/longevity derivatives such as longevity bonds.

Authors: Tahir Choulli, Catherine Daveloose, Michèle Vanmaele

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AI in Longevity Risk Management: Improved Long-Term Projections by Machine Learning

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Peter Vekas (Corvinus University of Budapest)

While human mortality has decreased significantly since the beginning of the past century, resulting in unprecedented increases in human life expectancies, several authors have noted a historical pattern of diminishing mortality decline at relatively younger ages along with accelerating improvements among the elderly. Li, Lee and Gerland (2013) call this phenomenon the ’rotation’ of the age pattern of mortality decline. A somewhat simplistic explanation of this is that spectacular decreases in infant and childhood mortality rates (e.g., due to widespread vaccination programs and improved child nutrition) are less and less possible, while costly medical procedures to extend life at advanced ages are increasingly available.The practical actuarial significance of the topic is that ignoring rotation in long-term mortality forecasts may lead to a severe and systematic underestimation of the old-aged population, which exacerbates longevity risk and may lead to serious adverse financial consequences for life and health insurers as well as pension schemes.The popular model of Lee and Carter (1992) as well as many other mortality forecasting techniques do not allow for rotation at all. To correct this shortcoming, Li, Lee and Gerland (2013) introduced a variant of the Lee–Carter model including rotation. This model extension assumes that the evolution of mortality improvement rates follows a parametric equation, whose two parameters govern the speed of rotation and the level of life expectancy where the process begins.We use age-specific mortality rates of all countries by gender from the Human Mortality Database (HMD), and split the available time periods by country into a training set spanning from the first available year up to 1990, a validation set from 1991 to 1999 and a test set containing all years after 1999. Instead of fixed values of the two parameters mentioned in the previous paragraph, as suggested by Li, Lee and Gerland (2013), we propose to treat them as hyperparameters and optimize them on the validation set, as it is customarily done in machine learning, in order to improve long-term forecasting performance. Additionally, we propose deep neural networks specifically designed to capture the rotation of mortality decline in order to produce even more data-driven rotation schedules free of any prior assumptions, and we tune the hyperparameters of the networks on the validation set. As a third candidate, we also propose a generalized additive model involving the bivariate spline approximation of the residuals of the Lee–Carter model. This approach is halfway between fully parametric models such as the variant of the Lee–Carter model including rotation and fully data-driven ones such as deep neural networks.We use the test set to assess and compare the performance of the rotated variant of the Lee–Carter model including hyperparameter tuning, the deep neural network capturing rotation and the spline GAM approach. We will point out which approach works best in the long run in every country, which countries are more or less prone to rotation, and how actual rotation schedules differ from the parametric form hypothesized by Li, Lee and Gerland (2013).Finally, we use our models to assess longevity risk in a pension scheme and point out the potential financial benefits of implementing our improved methods of capturing rotation in mortality data, and also elaborate on the potential impact of COVID-19 and how it is best incorporated into these models.

Authors: Peter Vekas, Ronald Richman, Laszlo Kovacs

Optimal Consumption and Investment for General Preferences

Michel Vellekoop (University of Amsterdam)

We propose a new approach to determine optimal strategies for consumption and investment under uncertainty for a general class of utility functions. It is based on the extension of an existing method to solve optimal investment and indifference pricing problems to the more complicated case which involves consumption. We define a new class of utility functions for which exact solutions can be found, and use these to generate sequences of approximating preferences and discretization schemes for the stochastic dynamics of the risky assets. We then prove convergence to viscosity solutions of Hamilton-Jacobi-Bellman equations for the fast recursive algorithm that exploit the properties of this sequence.We illustrate our approach using known results for a number of different optimization problems and then show how the method can be used for cases for which no closed-form solutions are available, which makes it possible to treat consumption and valuation problems that involve empirically observed preferences.

Authors: Michel Vellekoop, Marcellino Gaudenzi

On a Bivariate Sarmanov Distribution with Composite Marginals for Bivariate Auto Insurance Costs

Raluca Vernic (Ovidius University of Constanta)

In auto insurance, the companies usually measure two severity variables, one for the claims with only material damage and another for the claims that include body injury. In this work, we focus on the two cost variables, i.e. on the bivariate severity. To model the bivariate severity, a bivariate lognormal distribution could be used. However, it is known that this distribution has a restricted dependence structure, and it is not enough heavy-tailed for actuarial data. On the other hand, the bivariate Pareto can be too heavy-tailed for the small and medium data, and it only allows positive dependence. This is why we want to define a bivariate distribution that separate the bivariate extreme severities from the small and medium ones.In the univariate case, to model statistical data coming from two different distributions, the composite or two-spliced distribution has been defined by considering different distributions in subdivided intervals. Starting with Cooray and Ananda [1], the composite Lognormal-Pareto distribution has been intensively studied in connection to actuarial data, see also [2], [3]. Following this line, we propose a bivariate distribution having as marginals two composite Lognormal-Pareto distributions joint in a Sarmanov dependency structure. We chose Sarmanov’s

bivariate distribution based on its ability of joining different types of marginals in flexible dependence structures. The resulting model is able to separately capture the marginal and joint behaviour of small, medium and extreme severities.The limits for Pearson linear correlation coefficient and Spearman and Kendall rank correlation coefficients are analysed. We also discuss the parameters estimation of this bivariate distribution and, in a numerical study, we compare the fit of this distribution with other distributions, on two insurance data sets.

Authors: Raluca Vernic, Catalina Bolance, Montserrat Guillen

Cross-Sectional Quantile Regression for Estimating Conditional Var During Periods Of High Volatility

Xenxo Vidal-Llana (Universitat de Barcelona)

Evaluating value at risk (VaR) for a firm's returns during periods of financial turmoil is challenging because there is too much volatility in the market. We propose estimating conditional VaR and expected shortfall (ES) for a given firm's returns using quantile regression with cross- sectional (CSQR) data about other firms operating in the same market. An evaluation using US market data between 2000 and 2020 shows that our approach has certain advantages over a CAViaR model. Identification of low-risk firms and a reduction in computing times are additional advantages of the new method described.

Authors: Xenxo Vidal-Llana, Montserrat Guillen

Optimal Per-Loss Reinsurance and Investment Problem Under Negative Correlation Assumption

Fudong Wang (Nanjing Normal University)

In this paper, we consider the optimal reinsurance and investment strategies for the insurance company with the mean-variance premium principle. The surplus process of the insurer is described by the diffusion model which is an approximation of the classical Cramer-Lundberg model. The insurer can purchase per-loss reinsurance and invest her surplus in a financial market consisting of a risk free asset and a risky asset. We assume that the insurance market and the financial market are negatively correlated. Two optimization problems, maximizing the expected utility of the terminal wealth with a hazard rate and minimizing the probability of absolute ruin, are studied. Using the dynamic programming and Lagrange multiplier methods, we reduce the infinite-dimensional problem to the one-dimensional problem, then get the closed-form expressions of the optimal reinsurance and investment strategies and the corresponding value functions. From the results, we find that the negative correlation has some different and important impacts on the optimal strategies for the two different optimization problems.

Authors: Fudong Wang

Measurement of Crop Revenue Insurance on Small Areas: Under China's Insurance Plus Futures

Hui-Min Wang (Shandong University)

Based on the development of crop revenue insurance under the background of insurance plus futures mode in China, we explore the measurement of revenue insurance premium rates suitable for China's actual situation. Specifically, we use the small area crop yield estimation method "Density Ratio Model" to estimate the yield distribution, and combine with Copula, use the Density Ratio Copula Model to calculate the small area revenue insurance premium rates. At the same time, based on the soybean yield data of 16 cities in Shandong Province and the transaction price data of the soybean No. 1 futures contract on the Dalian Commodity Exchange from 2006 to 2017, the revenue insurance rates of soybean in 16 cities of Shandong Province are empirically calculated. The calculation results of the premium rates show that there is heterogeneity of the soybean revenue insurance premium rates in different cities. After we verify the practicability of our work, it can be found that the Density Ratio Copula Model is more effective than other models in calculating the revenue insurance premium rates, thus ensuring the reliability of the premium rates calculation results. Therefore, it is suggested that China should adopt differentiated revenue insurance premium rates according to the specific conditions of different regions, and carry out relevant policies for crop revenue insurance according to local conditions, so as to promote the sustainable development of crop revenue insurance under insurance plus futures mode in China.

Authors: Hui-Min Wang, Yang Xiao, Xiao-Dong Yan, Dian-Jiang Yu

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It Is Not Only up to You! The Effect of Retirement on Healthcare Utilization-The Role of Physician Incentives

Jiyuan Wang (Central University of Finance and Economics)

We examine the effect of retirement on healthcare utilization using a unique administrative data set from a tertiary hospital in southeast China, with a particular focus on the role of physician incentives. We use a fuzzy regression discontinuity design that exploits the discontinuity in retirement rates at statutory retirement ages. We find that retirement has a significantly positive impact on outpatient care expenditures, and the effect is more pronounced when the physician has more incentives. We also examine the heterogeneous effects of other physicians' characteristics. For example, young and male physicians are more likely to exaggerate the retirement effect on health care utilization.

Authors: Jiyuan Wang, Ya Gao, Jiankun Lu, Xiaomin Zhong

The Value of Outside Information: Identifying Asymmetric Information Across Markets Using Evidence from China

Jiyuan Wang (Central University of Finance and Economics)

Identifying asymmetric information is of crucial importance in modern economies. Existing studies focus on investigating relationship between underlying risks of individuals and their revealed choices in a single market. This paper provides evidence that identifying asymmetric information of a certain market by leveraging information from another market can be practically useful. We employ a unique data set of randomly selected debtors that includes consumption loan records and detailed credit cards information. Our results find that credit card market information facilitate adverse selection in consumption loan market, and vice versa. The data set also allows us to separate debtors' ex post moral hazard behaviors from adverse selection, and our results also unveil moral hazard by using trans-market information.

Authors: Jiyuan Wang, Ya Gao, Shouyang Wang, Daiyuan Li

Time-Consistent Mean-Variance Reinsurance-Investment Problem with Long-Range Dependent Mortality Rate

Ling Wang (The Chinese University of Hong Kong)

This paper investigates the time-consistent mean-variance reinsurance-investment (RI) problem faced by life insurers. Inspired by recent findings that mortality rates exhibit long-range dependence (LRD), we examine the effect of LRD on RI strategies. We adopt the Volterra mortality model proposed in Wang et al. (2021) to incorporate LRD into the mortality rate process and describe insurance claims using a compound Poisson process with intensity represented by the stochastic mortality rate. Under the open-loop equilibrium mean-variance criterion, we derive explicit equilibrium RI controls and study the uniqueness of these controls in cases of constant and state-dependent risk aversion. We simultaneously resolve difficulties arising from unbounded non-Markovian parameters and sudden increases in the insurer's wealth process. While the exiting literature suggests that LRD has a significant effect on longevity hedging, we find that reinsurance is a risk management strategy that is robust to LRD.

Authors: Ling Wang, Mei Choi Chiu, Hoi Ying Wong

Optimal Investment-Consumption-Insurance Problem with Default Risk

Pin Wang (Soochow University)

The paper analyzes the optimal investment, consumption and life insurance purchase problem for the wage earner in a defaultable market. The wage earner can allocate his or her wealth among the following securities: a money market account, a stock, a corporate bond and life insurance. Using dynamic programming approach, we derive optimal consumption, investment and life purchase strategies in the pre-default and post-default case respectively. We also provide an explicit formula for the CRRA utility. Numerical examples are performed to illustrate the influence of model parameters on the strategies and to present the corresponding economic interpretations.

Authors: Pin Wang, Guojing Wang, Rui Mu

E-Backtesting Risk Measures

Qiuqi Wang (University of Waterloo)

Expected Shortfall (ES) is the most important risk measure in finance and insurance. One of the most challenging tasks in risk modeling practice is to backtest ES forecasts provided by financial institutions, based only on daily realized portfolio losses without imposing specific models. Recently, the notion of e-values has gained attention as potential alternatives to p-values as measures of uncertainty, significance and evidence. In this paper, we use e-values and e-processes to construct a model-free backtest of ES using the notion of universal e-statistics, which can be naturally generalized to many other risk measures and statistical quantities.

Authors: Qiuqi Wang, Ruodu Wang, Johanna Ziegel

An Axiomatization of Conditional Mean Risk Sharing

Ruodu Wang (University of Waterloo)

The conditional mean risk sharing (CMRS) rule enjoys several nice properties and has found recent applications in decentralized insurance risk sharing. Other risk sharing rules also exist in the risk management literature and practice. One naturally wonders whether CMRS has a unique role that no other risk sharing rules have. Among the properties of CMRS, risk fairness, actuarial fairness, and merging independence are simple and arguably natural, which we take as axioms for risk sharing. We establish the surprising fact that these three very basic axioms uniquely characterize CMRS; no other risk sharing rules satisfy these properties. Other nice properties of CMRS, such as universal improvement, linearity, and law invariance, follow from the three basic axioms.

Authors: Ruodu Wang

Dynamic Optimal Adjustment Policies of Hybrid Pension Plans

Sheng Wang (Tsinghua University)

In this paper, we propose two methods to dynamically adjust the contribution rate and the benefit rate of the hybrid pension fund: the semi-transparent case and the transparent case. The adjustment coefficients (time-varying or constant) and the asset allocation policy are controlled to minimize the disutility of the adjustment risk and the unsustainable risk. The adjustment rates are proportional to the unfunded liability (gap) of the hybrid pension fund, and the gap is estimated by the dynamically updated contribution and benefit rates. This forms the nested structure of the optimization problem, which could be solved based on a multi-dimensional stochastic control problem. The results show that the optimal policy adjusts the contribution and the benefit rates fairly among the cohorts and reduces the terminal fund gap effectively in the two cases. Comparing with the semi-transparent case, the adjustment risk is more undertaken by the current participants and the pension rules are more stable after a long time in the transparent case.

Authors: Sheng Wang, Zongxia Liang, Lin He

Statistical Inference for Bifurcating Autoregression Models

Xing Wang (Illinois State University)

Bifurcating autoregressive (BAR) processes are used to model the bifurcating cell lineage tree, several extensions of this model have been studied and various estimators for unknown parameters have been proposed. In this talk, we did the statistical inference for the BAR(p) model. First, the least-squares estimators and the empirical likelihood estimator of the model parameters for a pth-order bifurcating autoregressive process

(BAR(p)) is explored and their limiting properties are derived. Next, the confidence regions for BAR(p) parameters are constructed based on both the parametric and non-parametric estimation. Finally, using Monte-Carlo simulation, we estimated the coverage probabilities and constructed the confidence intervals. The two method's accuracy is compared from different aspects.

Authors: Xing Wang

Optimal Reinsurance for Multivariate Risks

Yinzhi Wang (Southwestern University of Finance and Economics)

Optimizing reinsurance contracts is a big topic of study in the field of actuarial science from both theoretical and practical perspectives. Actuarial literature contains countless formulations and analytical results of what optimal reinsurance should mean for a single risk, but there is limited research on the optimal solution when the cedent runs many lines of business and asks to manage the risk effectively. In this paper, we extend the problem of optimal reinsurance to a multivariate framework where the cedent has multiple risks which cannot be bundled together into one. More specifically, we have chosen to solve the problem by using layer contracts and a more industrial based criterion, which is to balance risk and profit through a ratio where a risk measure is divided on expected surplus. Analytical results regarding the solution for the optimal parameters of multivariate risks are given in the paper. They suggest that in the bivariate case, with the expected premium principle, the solution is either balanced, with equal upper limits of the layers, or completely unbalanced, with one finite upper limit and one infinite one, corresponding to a stop-loss contract, depending on the marginal loss distributions. An extensive simulation study is also performed to confirm the analytical results, and extend them, in particular for a more general and realistic premium principle.

Authors: Yinzhi Wang

Bridging the First and Last Passage Times for Lévy Models

Zijia Wang (University of Waterloo)

Historically, research in ruin theory has largely focused on the analysis of the first passage time of a surplus process below a threshold level (namely, the so-called time of ruin). More recently, there has been an accrued interest in the analysis of the last passage time below level 0, mainly in the framework of spectrally negative Lévy processes (SNLPs). In an effort to bridge the first and the last passage times' analyses, as well as provide a unified framework for theoretical studies, we introduce two types of random times, namely s_r and l_r, where the parameter r can be interpreted as a measure of a decision maker's aversion to negative surplus. The two random times can not only recover the first and last passage times as limiting cases, but also capture more pathwise information of the underlying surplus process. For the class of spectrally negative Lévy processes, the Laplace transform of these two random times is explicitly derived in terms of the well-used scale functions. Concurrently, a few new results in fluctuation theory of spectrally negative Lévy processes are obtained.

Authors: David Landriault, Bin Li, Mohamed Amine Lkabous, Zijia Wang

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Novel Executive Stock Options and Their Implications

Morten Wilke (Ulm University)

Executive stock options (ESOs) were introduced into managers' compensation plans in the US in the 1950s (e.g., Lambert et al. (1989)). They shall incentivize managers to steer the firm in the shareholders' interest. In our paper, we consider performance-vested ESOs which link the manager's remuneration to some benchmark such as a competitor's stock price. We study and compare the impact of various novel ESOs such as up-and-in call options on the investment strategies pursued by a manager of the firm. Specifically, we use the martingale approach to derive optimal strategies in the presence of ESOs and we expound on which trade-off between shareholders' and debtholders' interests they imply.

Authors: Morten Wilke, An Chen, Steven Vanduffel

Irreversible Reinsurance: A Singular Control Approach

Hoi Ying Wong (The Chinese University of Hong Kong)

Reinsurance demand is often investigated with the classical stochastic control framework by regarding the reinsurance level as a regular control variable. However, reinsurance contracts are not traded and dynamic adjustment of the reinsurance strategy is practically infeasible. In addition, reinsurance contracts are long-term commitments and irreversible. It is at great expense to close the reinsurance cover before the contract maturity. We propose a novel irreversible reinsurance framework, where the insurer enters into reinsurance contracts at a sequence of best appropriate times and the contracts are never reversed afterwards. When the contract is entered into, the insurer specifies the amount of reinsurance. We model the insurer's risk exposure by a mean-reverting process as inspired by stochastic mortality modelling and the property loss data from US catastrophes, and then formulate the reinsurance decision into a two-dimensional degenerated singular control problem. The bounded insurer's risk retention makes our setup closely related to the finite-fuel problem. The optimal reinsurance purchase rule is triggered by a free-boundary that characterizes the optimal relationship between the risk exposure and the reinsurance demand. We conduct a numerical study to investigate the features of the singular reinsurance strategy and its dependency on the model parameters.

Authors: Tingjin Yan, Kyunghyun Park, Hoi Ying Wong

A Bivariate Laguerre Series for Joint Ruin Probabilities in a Two-Dimensional Risk Process

Jae-Kyung Woo (UNSW Sydney)

In this paper, we consider a two-dimensional insurance risk model where each business line faces not only stand-alone claims but also common shocks that induce dependent losses to both lines simultaneously. The joint ruin probability is analyzed, and it is shown that under some model assumptions it can be expressed in terms of a bivariate Laguerre series with the initial surplus levels of the two business lines as arguments. Our approach is based on utilizing various attractive properties of Laguerre functions to solve a partial-integro differential equation satisfied by the joint ruin probability, so that continuum operations such as convolutions and partial differentiation are translated to lattice operations on the Laguerre coefficients. For computational purposes, the bivariate Laguerre series needs to be truncated, and the corresponding Laguerre coefficients can be obtained through a system of linear equations. The computational procedure is easy to implement, and a numerical example is provided that illustrates its excellent numerical performance. Finally, the results are also applied to address a related capital allocation problem.

Authors: Hansjoerg Albrecher, Eric Cheung, Haibo Liu, Jae-Kyung Woo

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Optimal Reinsurance-Investment Problem for a General Insurance Company of a Contagion Risk Model

Fan Wu (Southeast University)

In this paper, we study an optimal management problem for a general insurance company that contains an insurer and a reinsurer. The general company aims to derive the optimal reinsurance-investment strategy under the mean-variance criterion. The claim process described by a generalized compound dynamic contagion process introduced by Dassios and Zhao [16] (Dassios, A., Zhao, H., 2017. A generalized contagion process with an application to credit risk. International Journal of Theoretical and Applied Finance 20(1) https://doi.org/10.1142/S0219024917500030) which allows for self-exciting and externally-exciting clustering effect for the claim arrivals and the processes of the risky assets are described by the jump-diffusion models. Based on practical considerations, we suppose that the externally-exciting clustering effect will simultaneously affect both the price of risky assets and the intensity of claims. To overcome the inconsistency issue caused by the mean-variance criterion, we formulate the optimization problem as an embedded game and solve it via a corresponding extended Hamilton-Jacobi-Bellman equation. The equilibrium reinsurance-investment strategy is obtained, which depends on a solution to an ordinary differential equation. In addition, we demonstrate the derived equilibrium strategy and the economic implications behind it through a large number of mathematical analysis and numerical examples.

Authors: Fan Wu, Xin Zhang, Zhibin Liang

Optimal Investment, Consumption and Time of Annuitization Post Retirement with Subjective Evaluations of Mortality Probability

Huiling Wu (Central University of Finance and Economics)

This paper studies the optimal multi-period investment allocation, consumption and annuitization strategy in a defined contribution pension plan for the retirees with mortality risk and bequest motive. At retirement, the retirees have a subjective evaluation to their mortality probability. According to the subjective evaluations, the retirees are divided into two main groups: the first group cannot live up to the maximum time of annuitization with probability one; the second group can live up to the maximum time with a certain probability. Since retirement, the retirees withdraw an amount from the pension fund for the daily-life consumption, and then invest the remaining wealth in a risk-free asset and a risky asset until the time of death or the annuitization time. The optimal time of annuitization is set to be the time that maximizes the sum of the accumulated expected utility of consumption from the time of retirement to the time of death or annuitization, the accumulated expected utility of annuitization from the time of annuitization to the time of death and the expected bequest utility. By adopting the power utility, this paper obtains the closed-form optimal investment-consumption strategy and the conditions under which the first group of the retirees do not buy the annuity during the whole lifetime and the second group buy the annuity at the maximum time of annuitization. Finally, numerical analysis is provided to analyze the effects of gender, the survival period, the bequest utility, the discount function, the risk aversion, the financial environment and the annuity prices on the annuity behaviors of the retirees.

Authors: Huiling Wu, Pu Liao

Model Aggregation for Risk Evaluation and Robust Optimization

Qinyu Wu (University of Science and Technology of China)

We introduce a new approach for prudent risk evaluation based on stochastic dominance, which will be called the model aggregation (MA) approach. In contrast to the classic worst-case risk (WR) approach, the MA approach produces not only a robust value of risk evaluation but also a robust distributional model which is useful for modeling, analysis and simulation, independent of any specific risk measure. The MA approach is easy to implement even if the uncertainty set is non-convex or the risk measure is computationally complicated, and it provides great tractability in distributionally robust optimization. Via an equivalence property between the MA and the WR approaches, new axiomatic characterizations are obtained for a few classes of popular risk measures. In particular, the Expected Shortfall (ES, also known as CVaR) is the unique risk measure satisfying the equivalence property for convex uncertainty sets among a very large class. The MA approach for Wasserstein and mean-variance uncertainty sets admits explicit formulas for the obtained robust models, and the new approach is illustrated with various risk measures and examples from portfolio optimization.

Authors: Qinyu Qinyu Wu, Tiantian Mao, Ruodu Wang

Deep Insights of Reinsurance Research: A Review of Main Streams and Development Track

Zhaoxia Wu (Yunnan University of Finance and Economics)

Nowadays, reinsurance is attracting increasing attention from academics as a strong barrier for insurers in the event of encountering significant risks. Although there are many studies on various aspects of reinsurance, few scholars have analyzed them using scientometric methods, which is beneficial for beginners interested in reinsurance research and scholars who want to create further research results. Therefore, this paper applies the methodology to describe the status quo, emerging trends and development in this research area. Based on the 1593 publications retrieved from Web of Science between 1934 and 2021, this study provides the mapping knowledge domain of reinsurance research. Through a series of visualizations including author co-citation network, cited reference clusters, collaborations networks, burst detection, keyword time zone view and main path analysis, this paper presents reinsurance mainstreams and the publications that contributed significantly to the research, summarizes the countries, institutions, journals, and authors that have made outstanding contributions to the field and describes the emerging trends and cutting-edge approaches and the research hotspots in the field over time. We found the following conclusions. (1) The number of reinsurance research papers has shown an obvious three-stage growth. (2) The research results in reinsurance are multipolar regarding authors and more concentrated in terms of countries/regions and journals. (3) The latest frontier trend is the application of stochastic control methods to solve the optimal reinsurance problem. (4) In the main path analysis, there are many repeated nodes, which mainly focus on the research of optimal reinsurance. In conclusion, this paper provides a comprehensive and multi-dimensional analysis of reinsurance research, allowing readers to understand the development of the field more intuitively and easily.

Authors: Wei Zhou, Zhaoxia Wu

Optimal Management of DC Pension Fund Under Relative Performance Ratio and VaR Constraint

Yi Xia (Tsinghua University)

This paper investigates the optimal management of defined contribution pension plan under the Omega ratio and Value-at-Risk (VaR) constraint. Interest and inflation risks are considered, and the financial market consists of a cash, a zero-coupon bond, an inflation-indexed zero-coupon bond, and a stock. The goal of the pension manager is to maximize the performance ratio of the real terminal wealth under VaR constraint. An auxiliary process is introduced to transform the original problem into a self-financing problem. We obtain the optimal terminal wealth under different cases by combining the linearization method, Lagrange dual method, martingale method, and concavification method. There are fourteen cases for the convex penalty function, while there are six cases for the concave penalty function. Besides, when the penalty and reward functions are both power functions, the explicit forms of the optimal investment strategies are obtained. Numerical examples are shown to illustrate the impacts of the performance ratio and VaR constraint.

Authors: Yi Xia, Guohui Guan, Zongxia Liang

Study on Rice Income Insurance Pricing Model and Risk Dispersion Mechanism

Qingyao Xie (Southwestern University of Finance and Economics)

As a kind of insurance that can guarantee both crop price and yield, planting income insurance has gradually become an important tool to guarantee farmers' income and food security in China in recent years. However, its specific form, premium rate and operation process in different regions need to be explored. As an important rice producing area in China, Sichuan province has a high potential demand for rice planting income insurance, but there are few studies on rice planting income insurance in Sichuan Province. In this paper, grey forecasting method, Copula function and Monte Carlo simulation were used to determine the premium rate and analyze the risk diversification mechanism of rice planting income insurance in Sichuan Province, based on the historical data of rice planting in Sichuan Province. The results showed that under the protection level of 80%~100%, the gross premium rate of rice plantation income insurance in Sichuan province ranged from 3.98% to 11.25%, and the risk and related dispersion mechanism of rice plantation income insurance were analyzed. On the basis of qualitative and quantitative analysis, this paper not only fills in the gap of pricing model and risk analysis of rice planting income insurance in Sichuan province to a certain extent, but also puts forward practical suggestions for Sichuan province to promote the subsequent pilot of rice planting income insurance.

Authors: Qingyao Xie

Research on the Redistribution Effect of Social Insurance Under Information Asymmetry

Yuantao Xie (University of International Business and Economics)

In a complete market without information asymmetry, social insurance is operated according to the market rule of actuarial fairness and has no redistribution function. The purpose of this study is to prove that in an incomplete market with asymmetric information social insurance is an important part of redistribution policy and an important supplement to the tax-transfer system to fulfill the government’s redistribution function. This paper constructs a microeconomic model with information asymmetry to illustrate how this redistribution function is realized, and discusses the optimal social insurance policy and government decision by optimizing the objective function. This paper conducts an empirical study based on Chinese data, calculates the pension wealth and total wealth at the individual level, and analyzes the redistribution effect of pension wealth on household property distribution according to the Gini coefficient and Lorenz curve.

Authors: Yuantao Xie, Yu Chen, Yue Zhang

Anti-Discrimination Insurance Pricing: Regulations, Fairness Criteria, and Models

Xi Xin (UNSW Sydney)

On the issue of insurance discrimination, a grey area in regulation has resulted from the growing use of big data analytics by insurance companies – direct discrimination is prohibited, but indirect discrimination using proxies or more complex and opaque algorithms can be tolerated without restrictions. This phenomenon has recently attracted the attention of insurance regulators all over the world, and stricter insurance discrimination regulations are being discussed and considered by regulators. Meanwhile, various fairness criteria have been proposed and flourish in the machine learning literature with the rapid growth of artificial intelligence (AI) in the past decade, which mostly focus on classification decisions. In this paper, we introduce the fairness criteria that are potentially applicable to insurance pricing as a regression problem to the actuarial field, match

them with different levels of potential and existing anti-discrimination regulations, and implement them into a series of existing and newly proposed anti-discrimination insurance pricing models, using both generalized linear models (GLMs) and gradient boosting trees. Our empirical analysis compares the outcome of different models and analyse their impact from the perspectives of both group fairness and individual fairness.

Authors: Xi Xin, Fei Huang

On a Compound Poisson Risk Model with Two-Sided Jumps and Proportional Investment

Jiaen Xu (Henan University of Science and Technology)

In this paper, a compound Poisson risk model with two-jumps and proportional investment is considered. The downward jumps represent the claims, while the upward jumps are also allowed to represent the random gains. Suppose an insurance company invests all of its surplus in two kinds of investments, one is risk-free (such as bank accounts) and the other is risky (such as stocks), in a certain proportion. First, the corresponding Hamilton–Jacobi–Bellman（HJB） equation is solved. Then, the integro-differential equations satisfied by the expected total discounted dividend until ruin and the discounted penalty function are derived, and its approximate solutions are obtained by using sinc method. Finally, numerical examples are given when the claim sizes obey different distribution.

Authors: Jiaen Xu, Chunwei Wang, Naidan Deng

The Influence of Survival Expectation on the Demand of Commercial Medical Insurance for the Middle-Aged and Elderly--Based on Both Perceptual and Rational Perspectives

Rui Xu (Central University of Finance and Economics)

This paper studies the impact of survival expectation on the demand for commercial medical insurance for the middle-aged and elderly in China from perceptual and rational perspectives. Results show that the perceptual survival expectation is easily affected by external shocks, which leads to positive effects, while it is stable from the rational perspective. these will be suppressed by the traditional concept of family caring and bequest motivation. Related effects are transmitted through residents' social enthusiasm and life satisfaction, Heterogeneity analysis shows that modern living environment, specific life stages and abundant material conditions are important conditions for such a significant impact.

Authors: Rui Xu, Xiaojun Wang, Hui Meng, Ming Zhou

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

Yanbin Xu (Nanyang Technological University)

Flood, by far the most frequent natural peril, has caused a third of the natural disaster-related fatalities since 2011. While around 29% of the world's population is exposed to flood risk, only 5% of the flood losses are insured in the emerging market and just 34% in the developed economies in the past decade. A calibratable flood risk modeling framework that can be transferable to different markets will help enhance the development of flood insurance in general. The existing literature has documented various machine learning models that can make fairly accurate predictions for short-term and long-term flood risks for the purpose of loss mitigation. However, these flood risk models (1) do not systematically embed market-specific information, and (2) are not created for the purpose of insurance policy pricing.The objective of this paper is to propose a physics-based hierarchical machine learning framework to fill this gap in flood risk modeling. We embed high-resolution climate data as well as hydraulic data (water level, flow speed, etc.) at important locations, such as dams, levees, reservoirs, harbors, and river crossings into the model. A hierarchical machine learning model structure is created according to geographical locations. Using the Mississippi river as a laboratory, we demonstrate that the proposed physics-based hierarchical machine learning models has superior performance compared to conventional machine learning model benchmarks. The proposed model improves prediction accuracy because our global optimization allows the model to borrow spatial and temporal information. In addition, the physics-based hierarchical structure improves the interpretability of the machine learning models and partially resolves the difficulty of flood risk estimation due to anthropogenic effects.

Authors: Yanbin Xu, Ken Seng Tan, Wenjun Zhu

Dynamic Optimal Reinsurance and Dividend-Payout in a Finite Time Horizon

Zuoquan Xu (The Hong Kong Polytechnic University)

This paper studies a dynamic optimal reinsurance and dividend-payout problem for an insurance company in a finite time horizon. The goal of the company is to maximize the expected cumulative discounted dividend payouts until bankruptcy or maturity which comes earlier. The company is allowed to buy reinsurance contracts dynamically over the whole time horizon to cede its risk exposure with other reinsurance companies. This is a mixed singular-classical control problem and the corresponding Hamilton-Jacobi-Bellman equation is a variational inequality with a fully nonlinear operator and subject to a gradient constraint. We obtain the C2,1 smoothness of the value function and a comparison principle for its gradient function by the penalty approximation method so that one can establish an efficient numerical scheme to compute the value function. We find that the surplus-time space can be divided into three non-overlapping regions by a risk-magnitude and time-dependent reinsurance barrier and a time-dependent dividend-payout barrier. The insurance company should be exposed to a higher risk as its surplus increases; be exposed to the entire risk once its surplus upward crosses the reinsurance barrier; and pay out all its reserves exceeding the dividend-payout barrier. The estimated localities of these regions are also provided.

Authors: Zuoquan Xu, Chonghu Guan, Rui Zhou

Portfolio Risk Analysis of Excess of Loss Reinsurance

Li Xun (Changchun University of Technology)

Consider a catastrophe insurance market in which primary insurers purchase excess of loss reinsurance to transfer their higher-layer losses to a reinsurer. We conduct a portfolio risk analysis for the reinsurer. In doing so, we model the losses to the primary insurers by a mixture structure, which effectively integrates three risk factors: common shock, systematic risk, and idiosyncratic risk. Assume that the reinsurer holds an initial capital C_n that is in accordance with its market size n. When expanding its business, the reinsurer needs to comply with a certain VaR-based solvency capital requirement, which determines an infimal retention level r_n according to the initial capital C_n. As our main results, we find the limit of r_n and then establish a weak convergence for the reinsurance portfolio loss. The latter result is applied to approximate the distortion risk measures of the reinsurance portfolio loss. In our numerical studies, we examine the accuracy of the obtained approximations and conduct various sensitivity tests against some risk parameters.

Authors: Qihe Tang, Zhiwei Tong, Li Xun

Universal Poisson Approximations for Wiener Functionals Arisen in Financial and Insurance Models

Phillip Yam (The Chinese University of Hong Kong)

It is a well-known simple fact that the limit of a compensated Poisson process, as the intensity goes to infinity, is a Brownian motion, but does the same result hold for general Wiener functionals? In this talk, we propose a global, chaos-based procedure for the discretization of Wiener functionals of Brownian motion into one of a Poisson process with intensity $\lambda > 0$. Under this discretization, we study the weak convergence, as the intensity of the underlying Poisson process goes to infinity, of Poisson functionals and their corresponding Malliavin-type derivatives to their Wiener counterparts. More specifically, we derive a convergence rate of $O(\lambda^{(-1/4)})$ for the Poisson discretization of Wiener functionals by combining the multivariate Chen-Stein method with both the Poisson and Wiener calculi. At the first glance, the proposed sufficient condition for establishing this convergence rate requires the knowledge of the kernel functions in the Wiener chaos, which apparently limits its potential use as most of the Wiener functionals are so general that it is hard to find their kernels explicitly, let alone to verify this mild sufficient condition. Nevertheless, most of the Wiener functionals in finance should be a classical function of certain non-linear SDE solutions, and one of our main results is to get around the above complications; specifically, we can still establish the convergence of Poisson discretizations of solutions to a broad class of nonlinear SDEs with respect to Brownian motion. Moreover, numerical experiments also support the optimality of the convergence rate of 1/4; besides, the discretized Malliavin operators can be further applied to approximate the Greeks in option pricing framework. To the best of our knowledge, these are the first results in the literature on the universal convergence rate of a global discretization of a generally useful class of Wiener functionals.

Authors: Jinhui Han, Nicolas Privault, Phillip Yam

Series Expansion Formula for Scale Matrices and Applications in Ruin Theory

Kazutoshi Yamazaki (University of Queensland)

We derive a new series expansion formula for the scale matrix for Markov additive processes with a constant drift and general finite-activity one-sided jumps. This generalizes the series expansion formula of the scale function obtained in Landriault & Willmot (Scand. Actuar. J., 2020) for the Cramer-Lundberg process. Its applications in ruin theory, optimal dividends, and sequential testing are discussed.

Authors: Kazutoshi Yamazaki, Jevgenijs Ivanovs

Optimal Strategies with Stochastic Wage and Multi-Payments Critical-Illness Insurance

Shiqi Yan (Central University of Finance and Economics)

This paper studies the optimal investment, consumption and critical illness insurance purchase decisions of households with random income flow. We innovatively introduce the critical illness insurance with multiple claims into the family asset allocation problem. The policy can pay the indemnity separately in the event of critical illness and death of the bread-earner of the family. It is assumed that once critical illness occurs, the family income is reduced by a certain percentage because of the decreased working capacity caused by earner's health condition. The explicit solution of the problem is obtained in the form of CARA utility function. From numerical simulation, we analyze the effect of risk aversion coefficient of family, and the effect of the income reduction ratio change on the optimal decision. It is found that the optimal life insurance purchase decision is not a monotonous function related to income and financial market, but affected by risk aversion. The increase of risk aversion will lead to a decrease in the expenditure of insurance in the early stage, and households will focus more on the accumulation of wealth through savings.

Authors: Shiqi Yan

Local Mean-Variance Asset-Liability Management with Temporary and Persistent Price Impacts

Tingjin Yan (East China Normal University)

It is well documented that large institutional investors, such as insurance corporations, experience significant price impacts on their trades. This paper investigates the optimal asset-liability management problem in an illiquid market with both temporary and persistent price impacts. We adopt the local mean-variance criterion in Garleanu and Pedersen (2013, 2016) to formulate the problem in a finite-horizon setup with multiple risky assets. We derive closed-form optimal strategies in the discrete- and corresponding continuous-time model settings, under mild conditions that preclude cheap price manipulation. It is suggested that the investor should trade gradually toward a dynamic benchmark portfolio adjusted by the liability process. Meanwhile, the investor's trading aggressiveness is a trade-off between the persistent price impact and the liability risk. A thorough numerical analysis is also conducted to illustrate the implications of temporary and persistent market frictions, as well as the liability process, on the optimal portfolio.

Authors: Tingjin Yan, Jinhui Han, Guiyuan Ma, Chi Chung Siu

A Modified Classification Tree Method for Imbalanced Insurance Loss Data

Liang Yang (Southwestern University of Finance and Economics)

Simple machine learning models and ensemble learning models have been used to model loss costs for short-term insurance contract. In most short-term insurance claim datas, there is typically a large proportion of zero claims that leads to imbalances resulting in inferior prediction accuracy of these traditional approaches. This article provide a new method to measure the data imbalance between different data structure and has proved Its good mathematical characteristics in additivity and comparability. Based on this new method, we construct a new loss function and a new reggresion tree model called IDRT(Imbalance descend regression tree). We examine and compare the predictive performance of IDRT and other traditional prediction models using real insurance datasets. Our empirical results show that IDRT produce more accurate predictions without the loss of intuitive interpretation.

Authors: Liang Yang, Xiang Shu Wu

The Consistency of Mean-Risk Models with Dominance Rules: An Analysis Based on Uncertainty Theory

Tingting Yang (University of Science and Technology Beijing)

Due to the complexity of financial market, there exists the environment in which uncertainty theory is suitable for guiding investment decisions. In the uncertain environment, there are two methods to solve the portfolio selection problems: uncertain mean-risk models and uncertain dominance. The former quantifies the problem with a trade-off analysis between two characteristics of the returns' uncertainty distributions, while the latter provides the decision making by point-wise comparing the returns' uncertainty distributions but lacking a convenient computational recipe. This paper addresses the consistency of uncertain mean-risk models with uncertain dominance. The analysis result shows that risk index as the risk measure makes the uncertain mean-risk model consistent with the second degree uncertain dominance. Risk index is defined according to investor's intuitive sense of risk. It measures the average loss relative to a reference return. Besides, similar results are obtained for semi-absolute deviation and absolute deviation (in the case of symmetric distributions for returns) as risk measures.

Authors: Tingting Yang, Xiaoxia Huang

High-Quality Credit Portfolios Under Multilevel Extreme Risks

Yunshen Yang (UNSW Sydney)

Consider a large investment portfolio that is crucially important for social and economic security and hence requires a prudent examination of the portfolio loss due to defaults. Suppose that the market is exposed to multilevel risks including idiosyncratic risk, systematic risk, and common shock. We argue that common shock and systematic risk may interplay with each other, form a causal loop, and exhibit a joint extreme scenario with strong tail dependence. Quantitatively, a static structural model is employed in which latent variables governing individual defaults follow a mixture structure integrating the multilevel risks. Under the bivariate regular variation framework, we carry out an asymptotic study of the portfolio loss as the portfolio size becomes large. Our main finding is that the tail dependence between common shock and systematic risk is another driver of large losses and ignoring it may lead to a disastrous consequence to portfolio management.

Authors: Qihe Tang, Yang Yang, Yunshen Yang

Optimal Dynamic Ruin Probabilities for Heavy-Tailed Losses Under Reinsurance Strategies

Bükre Yıldırım Külekci (TU Kaiserslautern)

In recent years, extreme events are appearing to increase both in frequency and severity in many different areas. Insurance mechanism provides safe protection for extreme losses in the frame of risk management solutions. Reinsurance agreements that insurance companies apply to manage heavy-tailed risks and create free capital are also directly affected by these extreme events. Therefore, we first model the heavy-tailed loss distributions by using the dynamic EVT-GARCH combined model to fit the specific features of heavy-tailed and skewed insurance data and provide more accurate estimates than the classical models considering the structural changes in data. Secondly, we examine the effects of reinsurance strategies on the asymptotic probability of ruin of the Cramér-Lundberg risk process. With numerical examples, we aim to illustrate the optimal reinsurance strategy for the insurer and the reinsurer. Additionally, we derive the corresponding expected value premiums and tail risk measure Value at Risk (VaR) which also allows us to compare these strategies.

Authors: Bükre Yıldırım Külekci, Ralf Korn, Sevtap Selcuk-Kestel

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Option Pricing in Emerging Markets Using Pure Jump Processes: Explicit Calibration

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Bilgi Yilmaz (TU Kaiserslautern)

This study investigates the VG and NIG models' option pricing performance by comparing with the BS option pricing model for emerging markets.The data consists of BIST30 index daily price and European options written on this index extend from 05 May 2018 to 05 May 2020 for given exercise prices with a maturity of 90 days. In this period, the European call options' strike prices range from 1200 to 1650, and the European put options' strike prices range from 1000 to 1400. To compare the models' efficiency, first we calibrate the models by minimizing the sum of squared deviations between the observed and theoretical option prices in the respective period. Second, we compute the option prices and compare the results with the observed option prices. We find that while the NIG process performs better than both VG and BS models, the BS model is the worst in option pricing.

Authors: Bilgi Yilmaz, Ali Alper Hekimogulu

Optimal Reinsurance Design with Model Uncertainty

Mingren Yin (University of Waterloo)

In the literature of reinsurance design problems, the distribution of the underlying risk is commonly assumed to be known. However, the estimation to the true distribution is prone to error. Thus, researchers are interested in the performance of reinsurance contracts in the worst-case scenario and designing the optimal contract with the consideration of distribution uncertainty. In this work, we first discuss the worst-case distributions from both perspectives of the insurer and the reinsurer, associated with a deductible insurance. Two parties of the reinsurance contract adopt general distortion risk measure to quantify their losses. We assume that an uncertainty sets includes all distributions having the same first two moments and being "close enough" from a given reference distribution. Depending on the insurer and reinsurer's choices of the reference distribution, mean and the variance, their uncertainty sets may be quite different. Furthermore, removing the distance constraint we can deduce closed-formed solutions of the worst-case distributions in a traditional two-moment uncertainty set with respect to VaR and TVaR. We also find Pareto optimal deductibles with respect to the both parties' worst-case scenarios.

Authors: Mingren Yin, Jun Cai, Fangda Liu

Credibility Theory for Mean-Variance Premium Principles

Yaodi Yong (The University of Hong Kong)

In the credibility theory, hypothetical mean and process variance are two quantities that convey crucial information to decision-makers when determining premiums. Enlightened by the mean-variance premium principle, we propose a credibility approach to estimate both hypothetical and process variance at one time. Our proposed estimator consists of linear observations and their quadratic terms. Several numerical illustrations are carried out to show the performance of the estimator. Meanwhile, a spin-off result is found and utilized to compare with the Bühlmann model and the q-credibility model.

Authors: Yaodi Yong, Yiying Zhang

Phase-Type Mixture-of-Experts Regression for Loss Severities

Jorge Yslas (Institute for Financial and Actuarial Mathematics)

The task of modeling claim severities is addressed when data is not consistent with the classical regression assumptions. This framework is common in several lines of business within insurance and reinsurance, where catastrophic losses or heterogeneous sub-populations result in data difficult to model. Their correct analysis is required for pricing insurance products, and some of the most prevalent recent specifications in this direction are mixture-of-experts models. This talk proposes a regression model that generalizes the latter approach to the phase-type distribution setting. More specifically, the concept of mixing is extended to the case where an entire Markov jump process is unobserved and where states can communicate with each other. The covariates then act on the initial probabilities of such underlying chain, which play the role of expert weights. The basic properties of such a model are computed in terms of matrix functionals, and denseness properties are derived, demonstrating their flexibility. An effective estimation procedure is proposed, based on the EM algorithm and multinomial logistic regression, and subsequently illustrated using simulated and real-world datasets.

Authors: Jorge Yslas, Martin Bladt

Will Claim Histories Become Deprecated Rating Factors? An Optimal Design Method on Real-Time Road Risk Model

Jiamin Yu (Shanghai Lixin University of Accounting and Finance)

With the popularity of the Telematics and Self-driving, more and more rating factors (such as mileage, route, driving behavior, etc.) are introduced into actuarial models. There are quite a few doubts and disputes on the rationality and accuracy of the selection of rating variable, but it does not involve the widely accepted historical claim records (in BMS or NCD systems). Recently, Tesla Insurance released its “Safety Score-based insurance”, irrespective of accident histories. Forward-looking experts and scholars began to discuss whether historical claims will disappear in the future auto insurance ratemaking system. Therefore, this paper proposes a new risk variable elimination method and a real-time road risk model design method, and concludes that the claim histories will be regarded as "noise" factors and deprecated in the Pay-How-You-Drive model.

Authors: Jiamin Yu

Research on the Impact of Earthquake Disaster Insurance Literacy on Public Service Satisfaction

Ruiting Sun (Institute of Disaster Prevention)

Providing public services for earthquake prevention and disaster reduction to the society is the core responsibility of the earthquake department. It also is an important part of earthquake prevention and disaster reduction cause in China. Currently, there is a gap between the public service level and service capability of the earthquake department and the demand of the society, and the satisfaction of the public needs to be improved, which is correlated with factors such as people's scientific literacy, service perception, and family income. From the perspective of catastrophe insurance, this paper uses AHP method to measure the level of people's earthquake disaster insurance literacy, and builds an Ordered Probit model to analyze the impact of people's earthquake disaster insurance literacy and public service perception on public service satisfaction. The results show that the level of earthquake disaster insurance literacy among Chinese residents is relatively low and the difference is large. Earthquake disaster insurance literacy and public service perception have a significant positive influence on public service satisfaction, while residents' family income level shows a negative influence on public service satisfaction, but its influence is not as great as that of earthquake disaster insurance literacy and public service perception. The earthquake prevention and disaster reduction department should further broaden the public service channels, focus on enhancing service quality, and improve the level of earthquake disaster insurance literacy and public service perception of the people; cooperate with insurance companies to develop multi-species and composite earthquake insurance products suitable for people of different income levels, so as to improve the satisfaction of the earthquake department's public services.

Authors: Qinglu Yuan, Ruiting Sun

Modelling the Mortality of China's Oldest-Old

Ho Yan Joey Yung (UNSW Sydney)

We develop a new modelling framework for the mortality of the oldest-old, the population aged 80 and over. We propose a multifactor model that combines a classic parametric oldest-old mortality model, such as the Kannisto model, with the survival tree. To improve the model accuracy, we implement the survival tree in the ensemble bagging technique. We formulate the framework to apply to left-truncated and right-censored data. To illustrate the use of the model, we apply the model to individual-level data for individuals aged 80 to 115 from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) from 1998 to 2018. Model comparisons show that our proposed model outperforms other candidate models in fitting and prediction based on the oldest-old sample from the CLHLS. We find that in the CLHLS sample, the rate of increase in the force of mortality decelerates with age at around age 105. In addition, we analyse the impact of different covariates on the oldest-old mortality rate. We report and visualise the new estimated force of mortality for a range of subgroups based on different covariates.

Authors: Ho Yan Joey Yung, Katja Hanewald, Andres Villegas

Optimal Price Structure of Cyber Insurance Policies with Risk Mitigation Services

Gabriela Zeller (Technical University of Munich)

In recent years, as the demand for cyber insurance has increased tremendously, cyber insurance markets around the world have been growing and the range of available cyber policies has been continuously expanding. Many cyber experts agree that pure risk transfer cannot be an optimal cyber risk management solution, and the beneficial potential of including pre-incident and post-incident services into cyber policies is being recognized by insurers and prospective insurance buyers alike.This talk addresses the question of pricing such services optimally from the insurer's viewpoint, i.e. under which conditions it makes economic sense for a profit-maximizing, risk-averse insurer to share the cost burden of providing such services. The interaction between buyer and insurer is modelled as a Stackelberg game, where both parties use distortion risk measures with concave distortion functions.After explaining how the notions of pre-incident and post-incident services map to the concepts of self-protection and self-insurance, we detail how in the considered set-up, in the univariate case the insurer will always shift the full cost of self-protection services to the insured. However, this does not generally hold for the pricing of self-insurance services or when taking a multivariate viewpoint, in which case it can be optimal (and even mandatory to find an acceptable contract for both parties) to share the cost of risk reduction between insurer and policyholder(s).

Authors: Gabriela Zeller, Matthias Scherer

Equilibrium Investment Strategy for a DC Pension Plan with the Return of Premiums Clause and Mispricing Under Imperfect Information

Ling Zhang (Guangdong University of Finance)

This paper investigates a time-consistent investment strategy under the mean-variance criterion for a DC pension plan. During the accumulation phase, members of the DC pension plan contribute a fixed proportion of their stochastic salary as premiums and the manager invests the premiums in a financial market to increase the fund value. The financial market contains a market index, a risk-free asset, and a pair of mispriced stocks, where the expected return rate of the stocks and mispricing follow mean reverting stochastic processes, but the expected return rate of the stocks is not directly observable. Moreover, to protect the rights of the members who die during the accumulation phase, the return of premiums clause is adopted. The objective of the manager is to maximize the expected terminal value and minimize the variance of terminal value for each surviving member. Then we formalize a continuous-time mean-variance optimization problem, which is time inconsistent, to seek a time-consistent investment strategy. The explicitly expressions of the equilibrium investment strategy and corresponding equilibrium value function are derived by adopting the filtering technique and solving an extended HJB system of equations. Furthermore, some numerical examples are presented to illustrate the sensitivity analysis of the equilibrium investment strategy and equilibrium efficient frontier.

Authors: Pei Wang, Ling Zhang, Yongzeng Lai

On the Equivalence Between Value-at-Risk- and Expected Shortfall-Based Risk Measures in Non-Concave Optimization

Fangyuan Zhang (EURECOM)

We study a non-concave optimization problem in which a financial company maximizes the expected utility of the surplus under a risk-based regulatory constraint. For this problem, we consider four different prevalent risk constraints (Expected Shortfall, Expected Discounted Shortfall, Value-at-Risk, and Average Value-at-Risk), and investigate their effects on the optimal solution. Our main contributions are in obtaining an analytical solution under each of the four risk constraints, in the form of the optimal terminal wealth. We show that the four risk constraints lead to the same optimal solution, which differs from previous conclusions obtained from the corresponding concave optimization problem under a risk constraint. Compared with the benchmark (unconstrained) non-concave utility maximization problem, all the four risk constraints effectively and equivalently reduce the set of zero terminal wealth, but do not fully eliminate this set, indicating the success and failure of the respective financial regulations.

Authors: Fangyuan Zhang, An Chen, Mitja Stadje

ESG Green Insurance Action from Underwriting - World's First E-6S (Re)Insurance U/W Model

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Fuwei Freeman Zhang (Thames Investment Limited)

In the context of climate change, insurers all over the world are using ESG thoughts and methodologies to re-examine themself, trying to help the global production mode and lifestyle reform and embark on the road of green sustainable developments by giving full play to the advantages of insurance.This paper analyzes the current situation of ESG insurance, finds the pain points of ESG actions in the insurance industry, expounds the natural mutual assistance relationship between ESG and insurance, puts forward the countermeasures for ESG development of insurance industry - the key to carry out ESG green insurance action is to start from underwriting via ESG underwriting model. It analyzes the world first (re)insurance underwriting model E-6S, and calls on insurance coleagues to actively participate in ESG green insurance action worldwide.

Authors: Fuwei Freeman Zhang

Pandemic Risk Management: Resources Contingency Planning and Allocation

Linfeng Zhang (University of Illinois at Urbana-Champaign)

Repeated history of pandemics, such as SARS, H1N1, Ebola, Zika, and COVID-19, has shown that pandemic risk is inevitable. Extraordinary shortages of medical resources have been observed in many parts of the world. Some attributing factors include the lack of sufficient stockpiles and the lack of coordinated efforts to deploy existing resources to the location of greatest needs.The paper investigates contingency planning and resources allocation from a risk management perspective, as opposed to the prevailing supply chain perspective. The key idea is that the competition of limited critical resources is not only present in different geographical locations but also at different stages of a pandemic. This paper draws on an analogy between risk aggregation and capital allocation infinance and pandemic resources planning and allocation for healthcare systems. The main contribution is to introduce new strategies for optimal stockpiling and allocation balancing spatio-temporal competitions of medical supply and demand.

Authors: Linfeng Zhang, Xiaowei Chen, Wing Fung Chong, Runhuan Feng

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Stochastic Control for Sub-Diffusions and Its Applications in Finance

Shuaiqi Zhang (China University of Mining and Technology)

This talk deals with optimal control for stochastic differential equation driven by non-Markov sub-diffusion, which moves slower than brownian motion. Becasue of the structure of sub-diffusion, the control is deterministic and stochastic anternatively, rather than purely stochastic one. Both the stochastic maximum principle and the HJB euqaiton are systems of equations. The HJB equation involes fractinal derivative. The regularity of value function is proved in order to study the HJB equation and its visicosity solution. At last, we use sub-diffusuion to model stock price in bear market since it characterizes the inactive trading and solve its optimal investment problem.

Authors: Shuaiqi Zhang

Modeling and Pricing the Cybersecurity Risks in Fog Computing Based Internet of Things Architectures

Xiaoyu Zhang (University of Science and Technology of China)

Research on cybersecurity risk modeling and pricing is becoming a spotlight in actuarial science. This paper pertains to the analysis of the cybersecurity risks involved in the fog computing technology which has been intensively deployed in assorted Internet of Things (IoT) applications. To this end, a class of structural models are established to cater the inherent cyber risk propagation process. We propose an interval approximation method to assess the compromise frequencies for the fog network’s elements, and under the smart home applications, the compromise probabilities are computed explicitly. Applications of the proposed structural models in the context of cyber insurance pricing are thoroughly explored.

Authors: Xiaoyu Zhang

Insurance Claim Frequency Analysis Using Bayesian CART Model

Yaojun Zhang (University of Leeds)

An insurance portfolio offers protection against a specified type of risk to a collection of policyholders 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. Both accuracy and interpretability of the model used are essential in (non-life) insurance pricing. Recently, tree-based methods have become popular; the classification and regression tree (CART) can sometimes give good performance and be easily interpretable. In this talk, we discuss a Bayesian approach applied to CART models. We shall focus on a claim frequency analysis. The two basic components of this approach consist of prior specification and stochastic search using MCMC. The basic idea is to have the prior induce a posterior distribution that will guide the stochastic search toward more promising CART models. Starting from the common Poisson distribution used for frequency analysis, we further implement the Zero-inflated Poisson distribution to address the difficulty arising from imbalanced insurance data. In addition to the statistical performance analysis of the proposed method, we present visualisation tools to obtain insights. Some simulation and real data examples will be discussed.This is a joint work with Georgios Aivaliotis, Lanpeng Ji and Charles Taylor (University of Leeds).

Authors: Yaojun Zhang, Lanpeng Ji, Georgios Aivaliotis, Charles Taylor

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Distortion Risk Contribution Ratio Measures: Definitions and Comparisons

Yiying Zhang (Southern University of Science and Technology)

Relative spillover effects play a key role in analyzing and comparing systemic risks. In this talk, we introduce the so-called distortion risk contribution ratio measures. Various types of contribution ratio measures are defined and their useful integral-based representations are provided. We establish comparison results between the proposed risk contribution ratio measures of two different bivariate random vectors with same or different copulas. Sufficient conditions are established in terms of stochastic orders, dependence structures, distortion functions and stress levels. We also study the ordering behavior of these measures on interaction between paired risks. Numerical examples are also presented as illustrations.

Authors: Yiying Zhang

The Identification of Systemically Important Banks Based on Tsallis Entropy with Application to Chinese Banks

Linhai Zhao (Huaqiao University)

The identification and supervision of systemically important banks is crucial for banking supervisors to address systemic risks to the financial system. The prevalent identification methods are biased due to the fact that less attention is paid to the indirect connections between banks, local topological information and global topological information of the bank network. This paper proposes a novel method based on Tsallis entropy for measuring the systemic importance of banks. Each bank is regarded as a node in the bank network and the influence of bank size will be excluded. The method integrates not only the influence of the nodes themselves and their neighborhood nodes, but also the local and global topological information of the network into account, which effectively improves the accuracy of identifying the systemic importance of banks. Granger causality test is used to construct the directed weighted graph of the bank network. and the influence of nodes with local and global topological information is measured through methods such as structural hole constraint coefficients and k-shell centrality. Then Tsallis entropy is adopted to calculate the complexity of the bank network, and the systemic importance of banks is identified. We conduct empirical analysis by employing the data of stock prices of 16 listed banks in the Chinese securities market with sample period from October 2007 to December 2020 and adopt the method presented in this paper to rank the systemic importance of these banks. The analysis shows that the ranking is in accordance with the reality and the method will promote the accuracy of identifying systemically important banks.

Authors: Linhai Zhao, Yajun Wang

Robust Credibility Based on Censored Data

Qian Zhao (Robert Morris University)

The Bühlmann model, a branch of classical credibility theory, has been successively applied at a premium estimation for group insurance contracts and other insurance specifications. In this paper we develop a robust Bühlmann credibility via the censored version of loss data, or the censored mean (a robust alternative of traditional individual mean). This framework yields explicit formulas of structure parameters in credibility for log-location-scale distribution families and their variants, which are commonly used to model the insurance risks. The asymptotic properties of the proposed method are provided and corroborated through simulations, and their performance is compared to that of credibility based on the trimmed mean. Besides, the sensitivity of the target premium is investigated by varying the censoring/trimming threshold level in several parametric distributions. And the non-parametric estimations in credibility are discussed using the theory of L-estimators. Finally, a numerical illustration indicates that the proposed robust credibility can prevent the effect caused by model mis-specification and capture the risk behavior of loss data in a broader viewpoint.

Authors: Qian Zhao, Chudamani Poudyal

A Volatility Model Based on Adaptive Expectations: An Improvement on the Rational Expectations Model

Yang Zhao (Henan University)

Investment expectations affect stock price volatility, making asset pricing more difficult. Correctly capturing investment expectations can help alleviate this problem. In this paper, we analyze the rational expectations properties of existing volatility models. Second, we explore a volatility model based on adaptive expectations by using mathematical methods and the applicable conditions and continuity feature of the adaptive expectations volatility model. Third, under the assumption of adaptive expectations, we construct adaptive expectations GARCH (ADGARCH) and LSTM-ADGARCH models. Using daily trading data from the Shanghai stock index and SPX500 for the period 2015-2021, we find that the volatility model based on adaptive expectations has more explanatory power than one based on rational expectations.

Authors: Yang Zhao, Yuan Yao, Lei Huang

Impact of Insurance on Capital-Constrained Supply Chain Finance Under Asymmetric Information

Yixing Zhao (Guangdong University of Foreign Studies)

We examine how the insurer improves the supplier's access to finance in a supply chain and alleviates the effect of information asymmetry. We develop an integrated supply chain model comprising of a capital-constrained supplier, a capital-constrained retailer, a loss-averse bank and an insurer. Supply chain participants have different beliefs of product demand and their operation and financing decisions are based on their beliefs. Our analytic and numerical results give the following three conclusions. First, the supplier should be responsible for the insurance premium. Higher premium proportion borne by the supplier can increase the order quantity and the total profit of the entire supply chain. Second, the performance of the entire supply chain improves as the insurance coverage ratio increases, especially under the case where the bank is loss-averse or the supplier is sufficiently capital-constrained. The purchase of insurance can effectively decrease the loan interest rate and improves the chance for the supplier to obtain a bank loan. Third, the supplier's and the retailer's profits are not maximized under supplier's belief of product demand because of information asymmetry. The use of insurance can mitigate the effect of information asymmetry. The supplier's and the retailer's decisions can approach the optimal decisions under full information if the insurer has more accurate information than the supplier and the bank.

Authors: Yixing Zhao, Yan Zeng

Inclusive Insurance and Residents' Consumption: Evidence from China

Lili Zheng (Central University of Finance and Economics)

With the transformation and upgrading of Chinese economic development structure, high-quality development became the core. As the "ballast stone" to promote the high-quality development of Chinese economy, the importance of consumption is self-evident. Comparing with other countries, Chinese consumption rate is in a relatively low position. In order to promote economic growth, it is very important to promote national consumption by expanding domestic demand. At present, as inclusive finance boosting, inclusive insurance has gradually entered people's view. Inclusive insurance provides insurance protection for a wider range of groups, realizes a wider range of risk sharing, and can provide bottom-up protection while facing risk, reduce income burdens, and reduce future income uncertainty, thereby promoting residents' consumption motivation.

The emergence of inclusive insurance is the result of adapting to changes in demand. Studying the impact of inclusive insurance on residents' consumption is of great significance for developing Chinese inclusive insurance and a long-term mechanism for further expanding residents' consumption.In order to explore the impact between inclusive insurance and residents' consumption, we use the provincial panel data of 30 provinces and regions in China from 2011 to 2019, calculates the index of inclusive insurance development (IID) in each province by the entropy weight method, and analyzed the development status and regional differences of IID in China. And then the panel threshold model is used to empirically test the relationship between the development level of inclusive insurance and residents' consumption, and conduct robustness tests. Finally, the following conclusions are drawn: First: The overall trend of Chinese inclusive insurance development is positive, but the problem of unbalanced regional development is prominent. The overall performance is eastern region>western region>central region. The problem of regional differences is also found through threshold regression. There are few provinces in the high-level range, and most provinces are in the low-level development range. Second, Chinese inclusive insurance has a promoting effect on residents' consumption, but this effect has an interval effect. Based on the threshold regression results, Chinese inclusive insurance can be divided into high development level and low development level. In the two ranges, there is a significant positive correlation between the development level of inclusive insurance and the level of residents' consumption. However, in the low development level range, the impact of the development level of inclusive insurance on household consumption is weaker than that in the high development level range.Based on the research conclusions, we put forward suggestions for the development of inclusive insurance, such as increasing government support, developing differentiated and diversified inclusive insurance, and promoting regional structural balance et al.

Authors: Lili Zheng, Wenxin Deng

Research on the Contagion and Impact of Reputational Risk --A Case Study of The Zhang Naidan Incident of China Life Insurance

Sujin Zheng (Central University of Finance and Economics)

Based on the idea of active learning, this paper constructs a two-layer corpus that can be modified and tested to analyze the emotional expression of public groups in the reputation risk events. Based on this corpus, this paper, in the perspective of risk contagion, uses the event research methodology to combine the public's sentimental expression, supervisor’s regulatory behavior and investors’ reaction in the event of China Life’s employee Zhang Naidan Report Violations, discusses the contagion path of reputational risk and the influence of public sentiments’ change in reputational risk event on the performance of the involved companies in the capital market. In this reputational risk event, public sentiment has an indirect impact on investors in the capital market by influencing the behavior of regulatory authorities, resulting in a negative impact on China Life's stock return compared with the industry return and the duration is 5 stock trading days. At the same time, the study found that this event that related to the company's internal operation and management did not form a risk contagion among the industries. This paper not only enriches the regulatory authorities' evaluation method of the company's handling of reputation risk event but also provides a quantitative basis for measuring reputation risk capital

Authors: Sujin Zheng, Hairuo Guo, Haitao Hu, Shuning Song

The Effect of Childhood Socioeconomic Status on Private Medical Insurance Demand: Evidence from China

Xiangwen Zheng (Central University of Finance and Economics)

A host of papers discussed the impact of childhood socioeconomic status (SES) on individual financial behavior, whereas few of them focused on the demand for insurance products. Our article contributes to the existing literature by testing the effect of childhood SES on private medical insurance (PMI) demand in China. Using CHARLS, we find that people who raised in poor families before age 17 are less likely to purchase PMI in later life. In addition, the impact of childhood SES is stronger for the middle-aged group than for the whole sample, yet we do not observe any statistically significant effect for the elderly. This paper emphasizes the importance of improving childhood living conditions in stimulating the insurance demand among the middle-aged and elderly.

Authors: Xiangwen Zheng

Efficient Valuation of GMMBs in Regime Switching Jump Diffusion Models with Surrender Risk

Wei Zhong (Chongqing university)

We present an efficient valuation approach for guaranteed minimum maturity benefits (GMMBs) embedded in variable annuity (VA) contracts in a regime-switching jump diffusion model. We allow early surrender of the VA contract and impose surrender charges, which are important in practice to discourage early termination/lapse of the contract. We consider both continuously-monitored and discretely-monitored surrender behaviors before maturity, and utilize an intensity-based framework. Based on the continuous-time Markov chain (CTMC) approximation combined with the Fourier cosine series expansion method, we find that the valuation problem can be solved under a regime-switching jump diffusion framework. Numerical experiments demonstrate the accuracy and efficiency of the proposed method.

Authors: Wei Zhong, Zhenyu Cui, Zhimin Zhang

Risk Sharing via Risk Budgeting

Feng Zhou (Bayes Business School)

Risk budgeting (RB) is an effective risk management that a decision-maker uses to create a risk portfolio with a pre-determined risk profile. We first revisit RB and Clustered RB for one risk holder setting for a risk portfolio with or without background risk, and we then extend these approaches to a two risk holders setting. Our methods are equally apply to investment portfolios, but also to insurance portfolios. We further compare the objectives of RB and Pareto Optimal decisions, and we numerically explain why RB approaches are appealing methods for risk mitigation in real-life financial and insurance risk sharing applications.

Authors: Feng Zhou, Vali Asimit, Wing Fung Chong, Radu Tunaru

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A Bayesian Generalized Additive Model Approach to Forecasting Mortality Improvement with Expert Judgment

Kenneth Zhou (Arizona State University)

In the midst of a global pandemic, modeling and forecasting future mortality dynam ics are hindered by the extensive discrepancy between recent excess deaths and long-term longevity momentum. To address this problem, this paper is set out to develop a Bayesian generalized additive model approach that incorporates external knowledge in projecting mortality improvement rates. The proposed model is constructed with a collection of spline functions over age, period and cohort dimensions. Our model has several novelties. First, we utilize an iterative Metropolis-Hastings-within-Gibbs algorithm to estimate the proposed model under the Bayesian paradigm with overdispersion. Second, we develop a predictive imputation method to facilitate a smooth transition of mortality improvement trends from recent mortality shocks to long-term rates. The predictive imputation can calibrated by either multiple expert opinions, external population data, or internal his torical data. Lastly, we illustrate the application of the proposed model with predictive imputation on populations with insuffiffifficient mortality data.

Authors: Xiaobai Zhu, Kenneth Zhou

Carbon Footprint and Carbon Risk Exposure of China's Social Security Fund

Qi Zhou (South China University of Technology)

Carbon risk caused by carbon activities such as carbon policy uncertainty and carbon price fluctuation has spread to the stock market. As the national social security reserve fund, the importance of the social security fund is self-evident. At present, China's social security fund's stock investment has more than 30%. Therefore, this paper studies the carbon footprint and carbon risk exposure level of China's Social Security fund by using the quarterly level data from 2004 to 2021. Specifically, we firstly construct the double round model to measure the impact of carbon risk, the first round is the direct impact of carbon risk on carbon prices, the second is indirect impact, which is based on the shares held by the fund's assets overlapping effect. Then, we take the social security fund as the node and the asset overlap relationship as the edge to construct the fund network, combined with the carbon risk measurement of the stock market, we analyze the carbon risk exposure level and carbon risk contagion type. Finally, we examine whether China's social security fund is divesting high-carbon-risk stocks through asset allocation to reduce carbon exposure. It is found that the carbon factor of China's stock market is significantly positive, and China's social security fund is exposed to a certain carbon risk, mainly concentrated in non-ferrous metals, manufacturing and other industries. As the asset allocation of the Social Security fund is highly dispersed and favors companies with high market value, the main type of carbon risk contagion is risk circulation. In addition, China's social security fund is actively decarbonizing its portfolio based on position data. The research of this paper can provide suggestions for the scientific allocation of the social security fund, and provide policy suggestions for the social security fund to promote the smooth completion of the "double carbon" goal.

Authors: Qi Zhou

Economic Scenario Generator in a Data-Rich Environment

Felix Zhu (UNSW Sydney)

Traditionally, Economic Scenario Generators (ESG) are developed using econometric models based on small datasets including only the target variables (usually around 4-6) and their lagged variables. With the advent of Big Data and machine learning/AI technologies, actuaries can now develop advanced models in the data-rich environment to achieve better forecasting performance and provide added values, which, however, has not been seen in the ESG literature. This paper bridges the gap by introducing a new ESG model using a big dataset (FRED Database) consisting of 121 economic variables and their lagged variables covering periods before, during and after GFC, and during COVID (2019-2021). Four target variables considered in this paper include inflation rate, interest rate, wage rate, and unemployment rate. The proposed ESG model combines dimension reduction and Neural Networks (including CNNs, LSTMs, and fully-connected layers) and is suitable for actuarial economic modelling in the data-rich environment. Using residual bootstrapping, this paper provides prediction intervals to quantify the prediction uncertainty. We find that the new ESG model's performance is consistently superior to the benchmark model, although the level of benefits varies across different economic variables and forecast horizons. The model performance is demonstrated using a social security fund forecasting application.

Authors: Felix Zhu, Fei Huang

The N-Player and Mean-Field Game of Optimal Reinsurance and Investment Strategy

Guanxia Zhu (Shanghai University of Finance and Economics)

We consider an insurance market with finite or infinite number of competitive insurers. Each insurer makes an optimal decision on reinsurance and investment to maximize her expected utility function that depends not only on her individual wealth but also the average wealth of other insurers. We study the problem by modeling the decision-making procedure as an N-player game and as a mean-field game for the limit case of infinite insurers. Using stochastic control techniques, we obtain the optimal reinsurance-investment strategies as the equilibrium solutions of the N-player game and the corresponding mean-field game.

Authors: Guanxia Zhu, Xudong Zeng

Optimal Consumption, Portfolio and Best Time for Health Investment

Shihao Zhu (Bielefeld University)

In this talk, we propose a tractable dynamic framework for the joint determination of optimal consumption, portfolio and the best time for health investment. Our model starts from a standard Merton portfolio and consumption choice problem, as well as a costly health investment decision in which health depreciates with age. Meanwhile, health---as a consumption commodity---directly enters the agent's utility and better health reduces the agent's mortality risk. The optimization problem is formulated as a stochastic control-stopping problem in a finite time horizon, which contains two state variables: wealth and health capital. We transform the original problem into its dual problem, which is a three-dimensional optimal stopping problem, together with interconnected dynamics. Due to the generic time and health dependence of the mortality force, we perform a detailed probabilistic study of the nonmonotonic optimal stopping surface. The boundary is characterized in terms of the family of unique continuous solutions to a nonlinear integral equation by studying its Lipschitz continuity property. We also provide comparative static analysis and economic implications. Our work seems the first one to integrate optimal time choice of health investment into the investment-consumption literature. The talk is based on joint work with Giorgio Ferrari (Bielefeld University).

Authors: Shihao Zhu, Giorgio Ferrari

Selection of Loss Averse Consumers in Life Insurance Market

Wei Zhu (University of International Business and Economics)

We study the equilibrium in insurance market where consumers have different degree of loss aversion and risk level. We show that the classical result that R-S equilibrium must be an adverse selection (if it exsits) and a pooling equilibrium cannot exist, may no longer hold true when insurance consumers' loss aversion is taken into account. Instead, the pooling equilibrium occurs under some conditions. In specific, the pooling equilibrium is determined by the loss aversion of both high-risk and low-risk consumers, where the pooling group has larger members when high-risk onsumers have higher loss aversion relative to low-risk consumers. As a result, consumers can achieve higher welfare in the pooling equilibrium. This result delivers an important economic implication that consumers' bias (loss aversion) can play a welfare-enhancing role or not, depending on whether the bias is more severe in high-risk or low-risk types. Our theoretical results highlight the potentially positive role of one type of behavioral bias in improving consumers' welfare in insurance market where adverse selection is always a concern and especially its worst case of death spiral can lead to extreme loss of consumers' welfare.

Authors: Wei Zhu

Raising the Normal Retirement Age Gradually

Xiaobai Zhu (Southwestern University of Finance and Economics)

Population aging has threatened the future fiscal balance of the public pension system in many countries. In response to this, parametric pension reforms are often undertaken to dampen the adverse effect of aging. Any reform will inevitably introduce intergenerational conflicts and thus needs always be implemented gradually over decades to enable individuals to adapt to their new retirement planning. In this paper, we study the optimal schedule for lifting the normal retirement age, using the calculus of variation approach. Given the aggregate actuarial loss of the pension system, our target is to distribute the deficit smoothly across different generations, subject to a fairness constraint that prohibits any cohorts from taking advantage of the reform. We further illustrate our theoretical study under different assumptions on the contribution and benefit calculation, and under different population structures.

Authors: Xiaobai Zhu, Jingong Zhang

Stackelberg Differential Game for Insurance Under Model Ambiguity

Bin Zou (University of Connecticut)

We study a dynamic Stackelberg differential game between a buyer and a seller of insurance policies in a spectrally negative Levy framework, in which both parties are ambiguous about the intensity and severity of insurable losses. Both the buyer and seller aim to maximize their expected wealth, plus a penalty term that re ects ambiguity, over an exogenous random horizon. Under a mean-variance premium principle and a quadratic penalty for ambiguity, we obtain the equilibrium in closed form. Our main results show that the buyer's robust optimal indemnity is a coinsurance with proportion less than one-half, which increases (resp. decreases) as the buyer (resp. seller) becomes more ambiguity averse. Also we show that the seller's robust optimal premium rule equals the net premium under the buyer's optimally distorted probability, which is the buyer's best hope, and it exceeds the actuarially fair premium under the seller's optimally distorted probability measure so is, thereby, acceptable to the seller.

Authors: Bin Zou, Jingyi Cao, Dongchen Li, Virginia Young
