Parallel Sessions

16th July 2018 Monday

8:00 - 9:00	Registration					
9:00 - 9:20	Opening ceremony					
9:20 - 10:20	in memoriam - Marc Goovaerts (in Colombo A)					
10:20 - 10:40	Coffee break					
Location	**Colombo A**	**Colombo LG01**	**Colombo LG02**	**Colombo C**	**Goldstein G03**	**Colombo B**
Session	**M1a**	**M1b**	**M1c**	**M1d**	**M1e**	**M1f**
	Ruin and Credit risk	**Micro-level reserving**	**Pension Schemes**	**Pension Investments**	**Reinsurance-investment Strategies**	**Pricing Annuities**
Chair	**Qihe Tang**	**Greg Taylor**	**Servaas van Bilsen**	**Yi Lu**	**Guohui Guan**	**Eric Ulm**
10:40 - 11:00	Jingchao Li	Alan Xian	Zhongfei Li	Rudi Zagst	Guohui Guan	Onofre Simões
11:00 - 11:20	Yasutaka Shimizu	Michal Pešta	Servaas van Bilsen	Ling Zhang	Bingyan Han	Bangwon Ko
11:20 - 11:40	Zhaofeng Tang	Xinda Yang	Zhaoxun Mei	Yan Zhang	Hui Zhao	Han Lin Shang
11:40 - 12:00	Zhiwei Tong			Yi Lu	Ming Cao	Eric R. Ulm
12:00 - 13:20	Lunch Colombo					
13:20 - 14:20	Plenary Annamaria Olivieri (in Colombo A)					
14:20 - 14:40	Coffee break					
Session	**M2a**	**M2b**	**M2c**	**M2d**	**M2e**	**M2f**
	Annuity Demand	**Reinsurance**	**Variable Annuities**	**Dividends I (in risk theory)**	**Finance I**	**Dependence Modelling I**
Chair	**Hazel Bateman**	**Ying Wang**	**Andrés M. Villegas**	**Eric Cheung**	**Chin-Wen Wu**	**Julien Trufin**
14:40 - 15:00	Xiaoqing Liang	Jingshu Luo	Samuel Thirurajah	Linlin Tian	Tzuling Lin	Yisub Kye
15:00 - 15:20	Lu Qian	Khadija Gasimova	Kevin Fergusson	Eric C.K. Cheung	Marco Guzzetti	Marek Arendarczyk
15:20 - 15:40	Hazel Bateman	Tianxiang Shi	Shuai Yang	Xiaowen Zhou	I-Chien Liu	Julien Trufin
15:40 - 16:00	Jinhui Zhang	Ying Wang	Xiao Xu	Kei Noba	Chin-Wen Wu	Wenjun Zhu
16:00 - 16:20	Coffee break					
Session	**M3a**	**M3b**	**M3c**	**M3d**	**M3e**	**M3f**
	Capital	**Bonus-Malus Systems**	**Option Pricing**	**Mortality Modelling I**	**Health Insurance**	**Life Insurance Products**
Chair	**Stéphane Loisel**	**Enrique Calderin**	**Otto Konstandatos**	**Linus Chan**	**Atsuyuki Kogure**	**Johnny Li**
16:20 - 16:40	Edward Furman	Enrique Calderín-Ojeda	Xiang Cheng	Adelaide Di Wu	Ghadir Mahdavi	Hamza Hanbali
16:40 - 17:00	Stéphane Loisel	Rosy Oh	Otto Konstandatos	Pintao Lyu	Shanshan Gu	Carol Troy
17:00 - 17:20	Xin Li	Jean Pinquet	Joanna Tumilewicz	Linus Fang-Shu Chan	Atsuyuki Kogure	Arezoo Fathieh
17:20 - 17:40		Wenyuan Zheng			Wanyu Yang	Johnny Siu-Hang Li

17th July 2018 Tuesday

8:00 - 9:00	Registration					
9:00 - 10:00	Plenary Sheldon Ross (in Colombo A)					
10:00 - 10:20	Coffee break					
Location	**Colombo A**	**Colombo LG01**	**Colombo LG02**	**Colombo C**	**Goldstein G03**	**Colombo B**
Session	**T1a**	**T1b**	**T1c**	**T1d**	**T1e**	**T1f**
	Retirement Income	**Dividends II (in risk theory)**	**Mortality Data**	**Non-life Insurance**	**Portfolio Management**	**Copulas**
Chair	**Hazel Bateman**	**Zbigniew Palmowski**	**Pintao Lyu**	**Greg Taylor**	**Jiaqin Wei**	**Hélène Cossette**
10:20 - 10:40	Katja Hanewald	Renata G. Alcoforado	Fei Huang	Yuan Yue	Yingxu Tian	A. Bugalho de Moura
10:40 - 11:00	Héloïse Labit Hardy	Zbigniew Palmowski	Sarah Krömer	Carol Troy	Chou-Wen Wang	Hélène Cossette
11:00 - 11:20	William Lim	Ran Xu	Yung-Tsung Lee	Grey Taylor	Jiaqin Wei	Jae Youn Ahn
11:20 - 11:40	Rui Zhou	Hayden Lau	Ahmad Salahnejhad Ghalehjooghi	Phuong Anh Vu	Rancy Chepchirchir	Etienne Marceau
11:40 - 13:20	Lunch Colombo (SC hosts IME Ed. Board - Faculty Lounge)					
Session	**T2a**	**T2b**	**T2c**	**T2d**	**T2e**	**T2f**
	Life-cycle Models	**Dependence Modelling II**	**Optimal Insurance**	**Mortality modelling II**	**Pricing Methods I**	**Finance II**
Chair	**Ralph Stevens**	**Félix Belzunce**	**Ambrose Lo**	**Cary Tsai**	**Petar Jevtic**	**Ruodu Wang**
13:20 - 13:40	Ralph Stevens	Félix Belzunce	Ambrose Lo	Yulong Li	Matúš Maciak	Nikolay Gudkov
13:40 - 14:00	Yike Wang	Jiajun Liu	Vali Asimit	Cary Chi-Liang Tsai	Petar Jevtić	Ruodu Wang
14:00 - 14:20	Garry Khemka	Siyang Tao	Wei Wei	Viktoriya Glushko	Ko-Lun Kung	Sarah Krömer
14:20 - 14:40	Wei Xiao	Wanyu Yang	Mario Ghossoub	Sarah Kaakai	B. A. Surya	Yunran Wei
14:40 - 15:00	Coffee break					
Session	**T3a**	**T3b**	**T3c**	**T3d**	**T3e**	**T3f**
	Analytics	**Life Insurance Valuation**	**Motor Insurance**	**Insurance Economics**	**Agriculture Insurance**	**Risk Theory**
Chair	**Arnold Shapiro**	**Chunli Cheng**	**David Rowell**	**Tim Boonen**	**Yang-Che Wu**	**JK Woo**
15:00 - 15:20	Min Ji	Enrico Ferri	Feiyan Yang	Haibo Liu	Endar H. Nugrahani	Yiqing Chen
15:40 - 16:00	Roel Henckaerts	Karim Barigou	David Rowell	Tim J. Boonen	Yang-Che Wu	Jae-Kyung Woo
16:00 - 16:20	Kyu Hyung Park	Monica Carvajal Pinto	David Rowell	Ning Wang	Hong Li	Kazutoshi Yamazaki
16:20 - 16:40	Arnold F. Shapiro	Chunli Cheng	Alfredo D. Egídio dos Reis	Nan Zhang		Jian Zhang
18:00 - 22:00	Gala dinner Doltone house (Special Guest Speaker: Hans Gerber on “R & D and IME”)					

18th July 2018 Wednesday

8:00 - 9:40	Registration		
Location	**Colombo A**	**Colombo B**	**Colombo C**
Session	**W1a**	**W1f**	**W1d**
	Mortality Forecasting	**Solvency**	**Pricing Methods II**
Chair	**Han Li**	**Runhuan Feng**	**Michel Vellekoop**
9:40 - 10:00	Michał Krawiec	Zhongyi Yuan	Shanshan Gu
10:00 - 10:20	Han Li	Mirko Kraft	Wing Fung Chong
10:20 - 10:40	Julien Tomas	Xavier Milhaud	Michel Vellekoop
10:40 - 11:00	Samuel Piveteau	Runhuan Feng	Gunardi
11:00 - 11:20	Coffee break		
11:20 - 12:20	Plenary Roger Laeven (in Colombo A)		
12:20 - 13:00	Closing ceremony		
13:00 - 14:00	Lunch box		

1 Colombo A

1.1 M1a Ruin and Credit Risk / Chair Qihe Tang

Some Ruin-related Probabilities in a Markov-modulated Risk Model

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Abstract

In this paper, we study some probabilities in a Markov-modulated risk process including:

- the probability that ruin occurs without the surplus visiting certain states;
- the probability that ruin occurs without a claim occurring in certain states;
- the probability that the surplus attains a target level without visiting certain states;
- the probability that the surplus attains a target level without a claim occurring in certain states.

These probabilities can be expressed in term of the modified matrix scale functions. The distribution of the duration that the surplus stays in certain states by the time of ruin is also investigated.

Keywords: Markov-modulated risk model; the duration in certain states; one-sided crossing probabilities; modified scale functions.

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Asymptotically Normal Estimators Of Ruin Probability Under Lévy Insurance Risks

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Abstract

A statistical inference for ruin probability from a certain discrete sample of the surplus is discussed under a Lévy insurance risk. The surplus model is a spectrally negative Lévy process with diffusion terms and possibly infinite activity jumps. We assume that the observations are consist of n-discrete records of the surplus every equi-distant time interval $h_n > 0$ in $[0, T_n]$, and "large" jumps, each of which corresponds to a claim size larger than a certain level $\epsilon_n > 0$.
We consider the Laguerre series expansion of the ruin probability proposed by Zhang and Su [2], and give an estimator of the partial sum, which is an approximation of the ruin probability in $L^2(\mathbb{R}_+)$-sense.
Under the asymptotics such that $h_n \to 0$; $T_n \to \infty$ and $\epsilon_n \to 0$ as $n \to \infty$, we show the asymptotic normality of the proposed estimator with the estimable asymptotic variance. The limit theorems for statistics used in this paper are mainly due to Shimizu [1]. This estimator enables not only a point estimation of ruin probability, but also an interval estimation and a testing hypothesis.

Keywords: Ruin probability, spectrally negative Lévy process, Laguerre polynomial, discrete observations, asymptotic normality.

MSC2010: **62M86**; 91B30, 60G44.

References

[1] Shimizu, Y. (2011). Estimation of the expected discounted penalty function for Lévy insurance risks, *Mathematical Methods of Statistics*, **20**, (2), 125–149.

[2] Zhang, Z. and Su, W. (2017). A new efficient method for estimating the Gerber-Shiu function in the classical risk model. Published online in *Scand. Actuarial J.*.

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Large Portfolio Losses from Defaults

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Abstract

Credit risk management has attracted much research attention in the current post financial crisis era. We study the asymptotic behavior of the loss from defaults of a large credit portfolio of defaultable obligors. Following the works of Bassamboo et al [1] and Tang and Yang [2], we propose a static structural model in which each individual default and the associated loss rate given default are separately governed by two correlated latent variables. Precise asymptotic formulas are derived by employing limit theorems such as the law of large numbers and the central limit theorem, and numerical studies are implemented to justify their accuracy.

Keywords: Common shock; credit risk; loss given default; portfolio loss.

References

[1] Achal Bassamboo, Sandeep Juneja and Assaf Zeevi (2008), "Portfolio credit risk with extremal dependence: Asymptotic analysis and efficient simulation." *Operations Research*, vol. **56**, pp. 593-606.

[2] Tang, Q. and Yang, Y. (2018), "Sharp asymptotics for large portfolio losses under extreme risks." *Working Paper*

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Large Credit Portfolio Losses Due to Default in a Multivariate Factor Model

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Abstract

In this talk, we aim at investigating large portfolio loss due to default. In our model, each obligor's credit quality process is modeled by a Itô process which captures both idiosyncratic and systematic risk. We establish a limit theorem for the aggregate loss when the default threshold is a constant for all the obligors in the portfolio. In the case of a varying default threshold, a precise asymptotic analysis for the tail probability of aggregate loss is developed.
The presenter will be a PhD student at the moment of the conference.

Keywords: credit portfolio losses, credit quality process, default, diffusion, law of large numbers, regular variation

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1.2 M2a Annuity demand / Chair Hazel Bateman

Annuitization and Asset Allocation Under Exponential Utility

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Abstract

We find the optimal investment, consumption, and annuitization strategies for a retiree who wishes to maximize her expected discounted utility of lifetime consumption. We assume that the retiree's preferences exhibit constant absolute risk aversion (CARA), that is, the retiree's utility function is exponential. The retiree invests in a financial market with one riskless and one risky asset, the so-called Black-Scholes market. Moreover, the retiree may purchase single-premium immediate life annuity income that is payable continuously, and she may purchase this life annuity income at any time and for any amount, subject to the limit of her available wealth.
Because maximizing exponential utility generally does not prevent wealth from dropping below 0, we restrict the investment, consumption, and annuitization strategies so that wealth remains non-negative. We solve the optimization problem via stochastic control and obtain semi-explicit solutions by using the Legendre dual. We prove that the optimal annuitization strategy is a barrier strategy. We also provide some numerical examples to illustrate our results and to analyze the sensitivity of the parameters.

Keywords: Life annuities; Optimal consumption; Optimal investment; Stochastic control; Free-boundary problem..

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Annuity Value and Longevity Risk in Chinese Market

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Abstract

Under the background of population ageing and public pension benefit decreasing, Chinese government strongly encourage the private annuity market to develop but there is almost no private annuity market. The main reasons are high annuity price from demand side and systematic longevity risk from supply side. In this paper, we first study on mortality modelling and forecasting for Chinese old age population and insured by comparing eight different mortality models which is commonly used in the literature and in practice. The study shows that Bayesian hierarchical model was best to capture the historical fluctuations of the data and the prediction intervals covered the true value of mortality. Then we measure the longevity risk using 99.5% Var for Chinese annuity market. Second, we study on the annuity value and try to answer why people don't like to annuitize their asset in the framework of consumption and investment based on Chinese market data. In the end, we give some suggestions for Chinese annuity market development. The presenter will be a PhD student at the moment of the conference.

Keywords: Old age mortality; Model selection; Annuity value; Demand and supply.

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Learning to Value Annuities: the Role Of Information and Engagement

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Abstract

Using an online experimental survey, we investigate perception and valuation of lifetime annuities relative to flexible drawdown products. Perception is defined in terms of participants understanding of the products, its riskiness and the sense of control, and valuation is elicited using iterative multiple price lists. Our findings highlight that, for participants who are engaged with the experimental tasks, information provision can substantially reduce or eliminate behavioural influences on the valuation of annuities. Providing balanced information and multiple opportunities to learn about the key features of the products, including potential income streams, narrows the gap between the "willingness to pay" and "willingness to accept" and, offsets the effects of financial capability, information framing and real world institutional settings.
However, we identify sizeable behavioural effects where participants have not fully benefited from the multiple opportunities of information provision - that is, for those participants with low engagement with the experimental task, and in our evaluation of perception of the retirement benefit products which is elicited prior to complete information provision. In both cases we observe that financial capabilities, information framing and real world institutional settings are important factors for explaining stated preferences.

Keywords: Information framing, experiments, annuity demand, cross-country analysis

Acknowledgements: We gratefully acknowledge funding from from the ARC Center of Excellence in Population Ageing Research (grant CE110001029) and ARC Linkage Grant 'Mandatory pre-funded retirement income schemes: Best policy and practice' (grant LP140100104).

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Optimal Life Insurance and Annuity Demand Under Hyperbolic Discounting When Bequests Are Luxury Goods

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Abstract

In this paper, an optimal portfolio management model with hyperbolic discounting is developed and analysed. Using the hyperbolic discounting factor, the model recognises the time-inconsistency of the strategies that an agent adopts in the case where there is no commit- ment. Under the framework of time-inconsistent preferences, agents can be categorised into two groups: "naïve", that is, agents who are not aware of the time inconsistency of their preferences; and "sophisticated", that is, agents who are aware of the time inconsistency of their preferences. For both the naïve and sophisticated cases, we modify Richard's model [1] of optimal life insurance, annuity purchase and investment over the life cycle by using hyperbolic discounting and allowing bequests to be luxury goods. The solution is obtained via numerical methods. We calibrate the model to Swiss data in presenting our results. We note this model contributes to explaining the annuity puzzle-observed low levels of purchases of voluntary life annuities.

Keywords: Finance, Annuity puzzle, Hyperbolic discounting, Luxury bequests, Dynamic programming.

References

[1] Richard, Scott F (1975). "Optimal consumption, portfolio and life insurance rules for an uncertain lived individual in a continuous time model. " *Journal of Financial Economics* 2(2), 187–203.

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1.3 M3a Capital / Chair Stéphane Loisel

Weighted Risk Capital Allocations in the Presence Of Systematic Risk

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Abstract

Determining aggregate risk capital is a fundamental problem of modern Enterprise Risk Management, and the determination process has been fairly well studied. The allocation problem, on the other hand, is generally much more involved even when a specific risk measure inducing the allocation rule is assumed, let alone the case when a class of risk measures is considered. In this talk I put forward arguments showing that the problems of determining and allocating the aggregate risk capital can often be viewed as being of similar complexity. In particular, I show that this is the case for the entire class of weighted risk capital allocations, as well as for risk portfolios that are exposed to systematic and specific risk factors. The talk is based on [1, 2].

Keywords: Weighted risk measure, Weighted risk capital allocation, Weighted insurance pricing model, Gini measure of variability, Systematic risk.

Acknowledgements: We thank the financial support of the Casualty Actuarial Society as well as of the Natural Sciences and Engineering Research Council of Canada.

References

[1] Furman, E., Kuznetsov, A., Zitikis, R. (2018), "Weighted risk capital allocations in the presence of systematic risk." *Insurance: Mathematics and Economics*, vol. **79**, pp. 75-81.

[2] Furman, E., Zitikis, R. (2017), "An Adaptation of the Classical CAPM to Insurance: The Weighted Insurance Pricing Model. " *Casualty Actuarial Society E-Forum*, Spring, 12 pages.

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Reevaluation Of the Capital Charge in Insurance After a Large Shock: Empirical and Theoretical Views

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Motivated by the recent introduction of regulatory stress tests in the Solvency II framework, we study the impact of the re-estimation of the tail risk and of loss absorbing capacities on post-stress solvency ratios. Our contribution is threefold. First, we build the first stylized model for re-estimated solvency ratio in insurance. Second, this leads us to solve a new theoretical problem in statistics: what is the asymptotic impact of a record on the re-estimation of tail quantiles and tail probabilities for classical extreme value estimators? Third, we quantify the impact of the re-estimation of tail quantiles and of loss absorbing capacities on real-world solvency ratios thanks to regulator data from *EIOPA*. Our analysis sheds a first light on the role of the loss absorbing capacity and its paramount importance in the Solvency II capital charge computations. We conclude with a number of policy recommendations for insurance regulators.

Keywords: Insurance, Extreme Value Theory, Financial Regulation, Solvency II, Solvency Capital Requirement, Loss Absorbing Capacities, Stress Tests, Enterprise Risk Management.

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Default and Liquidation Under the U.S. Bankruptcy Code

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[3] Department of Statistics and Actuarial Science, University of Iowa

Abstract

The procedures of default and liquidation as described in the U.S. bankruptcy code are rather complicated. In this paper, we follow the works of [1, 2, 3] to conduct a quantitative analysis of the default and liquidation risk of a firm under Chapter 7 and Chapter 11 of the U.S. bankruptcy code. Precisely, we study the probability of liquidation under a general time-homogeneous diffusion model. An explicit formula is established for the special case of a CEV model. A numerical study is implemented to check the impact of different parameters on the liquidation probability.
The presenter is still a PhD student at the moment of the conference.

Keywords: Default; liquidation; time-homogeneous diffusion; CEV model.

References

[1] Antill, S. and Grenadier, S.R. (2017), "Optimal capital structure and bankruptcy choice: Dynamic bargaining vs liquidation." Working Paper, Stanford University.

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1.4 T1a Retirement income / Chair Hazel Bateman

The Role Of Home Equity for Retirement Financial Planning in China

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Abstract

Reverse mortgages provide an alternative source of retirement funding by allowing older homeowners to borrow against the equity in their homes. We conduct and analyze two online surveys on the demand for reverse mortgage products in China. We test a flexible product design that overcomes shortcomings of an unsuccessful reverse mortgage product recently piloted in China. We find that interest in this new reverse mortgage product amongst older homeowners aged 45-69 years is high and that adult children aged 20-49 years would recommend such a reverse mortgage product to their parents. Participants mainly want to use reverse mortgage payments to live more comfortably in retirement and to pay for better medical treatments and aged care services. We identify individual covariates influencing the interest in the reverse mortgage product and the use of the product payments. Our results provide a new evidence base for the development of China?s reverse mortgage market.

Keywords: Reverse mortgage demand, Retirement income, Housing, China.

Acknowledgements: The authors acknowledge the financial support from the ARC Centre of Excellence in Population Ageing Research (CEPAR). We thank John Piggott, Thomas Post, Jennifer Alonso Garcia, and Ralph Stevens for valuable comments and suggestions.

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The Implications Of Mortality Heterogeneity on Longevity Sharing Retirement Income Products

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[2]School of Risk and Actuarial Studies, UNSW Australia, Australia

Abstract

In the context of population aging, various types of longevity sharing retirement income products have been recently proposed. Those alternative products enable individuals to insure their idiosyncratic mortality risk while pooling systematic mortality risk. Examples of this products include group self-annuitisation schemes, pooled annuity funds and retirement income tontines. However, mortality rates differ across sub-populations - for example, defined by gender, geographic area, or socio-economic variables - posing a challenge to the successful implementation of such mortality pooling arrangements. The impact of differential mortality on the redistribution properties of both defined benefit and defined contribution pension schemes has been widely studied. For instance, it has been shown that differential mortality can induce an undesirable transfer of wealth away from lower socio-economic groups with shorter life expectancy to higher socio-economic groups with above average longevity. In this paper, we analyse and contrast the redistribution properties of various longevity sharing retirement income products for pools with heterogeneous mortality.

Keywords: Longevity sharing retirement income products, group self-annuitisation, pooled annuity funds, mortality heterogeneity, wealth redistribution

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Investing for Retirement: How Cumulative Prospect Theory Naturally Leads to Greater Retirement Income Certainty

William Lim [§1], Catherine Donnelly [¶2], Gaurav Khemka [‖1]
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Abstract

Deciding how to invest savings during the pre-retirement phase is a critical decision for a comfortable retirement. We consider investors who intend to purchase a life annuity at retirement and need to decide how to invest their accumulated savings. The income to be obtained from the life annuity is expressed in real terms so that the investor understands the value of what they are targeting. Given an investor's ideal and minimum level of income in retirement, we determine the investment strategy so that the investor has a high chance of reaching their ideal income and is sure that their actual retirement income will not fall below the chosen minimum. We show that investors are better off investing without having to worry about guarantees or minimums under a cumulative prospect theory (CPT) framework. The conclusion is not as clear-cut under a constant relative risk aversion (CRRA) utility function.

To compare the investment strategies under CRRA and CPT framework, we maximise the expected value of the respective utility function, subject to the applicable constraints, on the level of retirement income. Our financial model is based on three assets: a nominal bond, an index-linked bond and a risky stock; all calibrated to historical UK market data. We use a realistic model of pension contributions, allowing for an expected salary path through life.

We find that under CRRA, the constrained investment strategy leads to greater certainty on the level of retirement income, reducing the risk of failing to attain the desired income. While this this may be attractive, it however, comes at a cost to the investor. The median of the possible retirement incomes is higher if the investor simply maximised the expected value of the CRRA utility function without imposing any constraints. Under CPT, we find that there is little benefit in constraining the retirement income. By an appropriate choice of the reference point, the CPT framework results in a strategy that naturally focuses on the desired income level and keeps the retirement income above the minimum in the vast majority of scenarios. It is only the most risk averse investor who would add constraints under CPT.

The presenter will be a PhD student at the moment of the conference.

Keywords: guarantee, portfolio optimisation, stochastic control, retirement planning, retirement wealth distribution

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The Impact Of Longevity Annuity Provision on Canadian Retirement Income Planning

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Abstract

Longevity annuity is a deferred annuity where payments start very late in life, i.e. well after the normal retirement age. By transferring the risk of outliving retirement savings at high ages to annuity providers, longevity annuity provides annuitants with enhanced later-life financial security. In this paper, we examine the impact of longevity annuity provision on retirement income planning based on Canadian tax rules and retirement system. A dynamic life cycle framework is developed to study welfare increase and consumption pattern changes resulting from the provision of longevity annuities to Canadian retirees. This framework is further applied to explore how individuals in different social classes respond to the access to longevity annuities and to determine if there exists a general rule about which percentage of retirement savings should be converted to longevity annuities. In addition, we incorporate bequest motive into the framework and measure the impact of bequest motive on the demand of longevity annuities.

Keywords: Longevity annuity, Life cycle, Retirement planning, Bequest motive.

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1.5 T2a Life-cycle models / Chair Ralph Stevens

Behavioral Economics and the Bequest Motive in Presence Of Illiquid Savings

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Abstract

This paper investigates the strength of the bequest motive using an experimental survey. In particular, we are show that it is influenced by behavior economical factors. The experimental survey is conducted in two countries, Australia and the Netherlands, with opposite retirement income policies. This provides insights the importance of institutional settings can play. In addition, by using between subject treatments, we let some participants be prone to narrow bracketing of mental accounts, while other subjects are induced to broad bracketing. This survey design has a substantial impact on the strength of the bequest motive of the participants.

Keywords: Mental accounting, peer effects, implied endorsement, bequest, illiquid savings, retirement savings, housing wealth.

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The Optimal Consumption, Portfolio and Insurance Problem With Habit Formation

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Abstract

We consider the optimal consumption, portfolio and insurance problem with habit formation. The objective is to optimize the expected discounted utility of consumption, heritage and terminal wealth. In this work, a generalized utility function is used. By dynamic programming, the problem is reduced to derive Hamilton-Jacobi-Bellman equation. Due to the non-negative constraint of insurance and consumption net of the habit index which presents the weighted average of past consumption, the HJB is difficult to solve. In this work, we take the convex dual with a well-defined generalized inverse function to rewrite the HJB equation. Then we obtain a HJB equation with a homogeneous form and linearize the PDE into a one-dimensional heat conduction equation. By generalized Fourier transformation, we derive an analytical solution. The solution is a convolution of the convex dual of the utility function and the Poisson kernel which happens to be the probability density function of a transition process including discounting, mortality, utility discounting, Radon-Nikodym derivative and premium rate of insurance. The convex dual of value function and its partial derivative also have a form of conditional expectation, completely corresponding to the result of martingale method. The presenter will be a postgraduate student at the moment of the conference.
Keywords: habit formation, consumption, portfolio, insurance, heritage, convex dual, generalized Fourier transformation.

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What Dividend Imputation Means for Retirement Savers

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Abstract

An outstanding feature of the Australian investment environment is its dividend imputation system, which provides full tax credits to Australian residents for the Australian corporate tax paid on the earnings from which dividends are distributed. An implication that investors on tax rates less than the corporate tax rate are able to claim an additional tax benefit, which boosts their net return above the sum of gross dividend plus capital gains generated in the market. This is particularly relevant for retirement savings within the Australian superannuation system, where income is taxed at 15% in accumulation and untaxed in retirement. At a corporate tax rate of 30%, imputation credits hence increase the after-tax value of a fully-franked dividend by 21.4% in accumulation, and 42.8% in retirement. This gives rise to two questions that we address in this research:

- How valuable are imputation tax credits to Australian retirement savers?
- How might this influence optimal portfolio formation?

We aim address the two questions in the context of a life-cycle model of retirement savings using a constant relative risk aversion (CRRA) and a reference dependent (cumulative prospect function) value functions. Our analysis shows that imputation is quite valuable to retirement savers; and can justify building portfolios with a significant home bias towards Australian equities. We find that, under the CRRA value function, the impact of dividend imputation is approximately 10% on starting wealth, and can increase lifetime utility by as much as 7%. The research also directly addresses potential implications for retirees of the Australian Labour Party proposal to remove the ability to claim cash refunds associated with imputation credits.

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The Effect Of Basic Medical Insurance System on the Saving Of the Middle-Aged and Old People

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Abstract

Since the reform and opening up, the per capita income level of Chinese residents has been continuously rising, and at the same time, the preventive saving rate has also been rising. The increase in the savings rate has hampered the pull of domestic consumption on economic growth, and high savings are considered to be an important factor in China's current account's long-term maintenance of a high surplus. The study found that domestic incentives for saving mainly stemmed from traditional consumption habits, liquidity constraints, and the impact of imperfect social security systems. In this paper, based on the precautionary saving theory ,we use the data from the Chinese Health and Pension Career Survey in 2011 and 2013 to apply the double-difference method and the fixed-effect model to explore whether the basic medical insurance can relieve the high savings status of the middle-aged and elderly population. The results of the econometric model show that, under the same conditions, the medical expenses for the residents participating in the basic medical insurance (experimental group) have been substantially reduced compared with the medical expenses for the residents who did not participate in the basic medical insurance (control group). The estimated results for each item of expenditure show that the uncertainty of medical expenditure has the greatest impact on household education expenditure, which is 21%, followed by daily consumption (15%). The results of the regression of households in different income groups show that as family income increases, the impact of enrolment on household non-medical expenditures gradually decreases. The presenter will be a graduate student at the moment of the conference.

Keywords: Basic Medical Insurance, Preventive Saving, Middle-aged

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1.6 T3a Analytics / Chair Arnold Shapiro

Predictive Analytics for Modeling Threshold Life Tables

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Abstract

Advances in health care and improved living standards have led to growing number of people beyond age 90. Accurate modeling of mortality at advanced ages is crucial to the valuation of pension plans and life annuities, especially longevity annuities where annuity payments start very late in life, say 85. Parametric regression models extrapolate lifetime distribution to the advanced ages but do not guarantee goodness-of-fit. Threshold life tables offer a promising solution to this problem using piecewise distribution via the peaks-over-threshold (POT) approach in the extreme value family. However, parameter estimation for a threshold life table is challenging and it does not guarantee a smooth life table. In this research, we impose parameter constraints to achieve a smooth threshold life table and propose a Bayesian approach to derive predictive density of lifetime distribution. We consider several parametric prior distributions as well as Jeffreys priors to derive an appropriate predictive density of lifetime random variable. The predictive density is used to compute life expectancy and other measures of interest in Bayesian framework. Simulations are also conducted to assess the accuracy of the estimates of interest based on the predictive density.

Keywords: Threshold life table; High age mortality; Longevity; Bayesian; Predictive modelling.

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Tree-based Machine Learning for Insurance Pricing

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Abstract

The goal of this paper is to apply machine learning techniques to insurance pricing, thereby leaving the actuarial comfort zone of generalized linear models (GLMs) and generalized additive models (GAMs). We focus on developing full tariff plans, built from both the frequency and severity of claims. We adapt the cost functions and performance measures used in the algorithms such that the specific characteristics of insurance data are carefully incorporated: highly unbalanced count data with excess zeros on the frequency side and scarce, but potentially heavy-tailed and right-censored data on the severity side. One of the key requirements is the need for transparent, interpretable pricing models which are easily explainable to all stakeholders. We therefore shy away from black box models such as neural networks and rather focus on tree-based machine learning models. Starting from single recursive trees we work towards more advanced ensembles such as bagged trees, random forests and boosted trees. We also present visualization tools to obtain insights from the models by assessing the importance of the different risk factors and their impact on the price of an insurance contract.
The presenter will be a PhD student at the moment of the conference.

Keywords: Insurance pricing, frequency, severity, machine learning, recursive trees, bagging, random forests, boosting.

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Analytics-assisted Triage Of Psychological Workers' Compensation Claims

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Abstract

Workers' compensation is a form of insurance for employers providing income replacement, medical benefits and rehabilitation support to eligible workers suffering a work-related injury or illness. The cost of work-related injuries and illnesses is significant, ranging between 1.8 and 6.0 percent of GDP by country in terms of total economic cost. Among all injuries, psychological injury is the most expensive form of workers' compensation claim due to its typically long duration. Despite the importance and cost of work-related psychological injury, the factors associated with prolonged claim duration are still not well understood. Using data provided by the workers' compensation agency in South Australia, this research identifies factors associated with the duration of workers' compensation claims for psychological injuries (psychological claims), and develops a practical and informative business model to aid the management of such claims by using modern analytics techniques including classification tree and association rule learning. We find that the factor most associated with duration of psychological claims is occupation, followed by bodily location of the most recent prior claim and age of injured worker. It is found that, among psychological claims, those made by claimants in high socio-economic occupations are at higher risk of prolonged claim duration. We finally develop a triage model that uses these factors to segment claims according to risk of prolonged duration. The model enables the focusing of efforts and resources on high-risk claims, thereby reducing the economic and societal burden of work-related injury.
The presenter will be a PhD student at the moment of the conference.

Keywords: Workers' compensation, psychological claims, mental health, data analytics

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Blockchains: What Are They, How Do They Work, and What Are Their Implications for the Insurance Industry?

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Abstract

In 2008, an elusive cryptologist named Satoshi Nakamoto proposed a peer-to-peer electronic cash system called bitcoin, which would allow online payments to be sent directly from one party to another without intervention. The underlying technology behind bitcoin was the blockchain, a decentralized transaction and data management technology. It featured a distributed, immutable digital record system that was shared among many independent parties and could be updated only by their consensus.
Although blockchain started off as a core technology of bitcoin, it has emerged as an innovative tool with the potential to impact the way we design a number of online applications. One of the most notable of which are full-fledged programs that are run on blockchains, called smart contracts, which are based on computerized transaction protocols that autonomously execute the terms of a contract. Smart contracts have been mentioned with respect to a number of insurance application areas, including contract enforcement, the streamlining of business transactions, customer engagement and satisfaction, fraud monitoring and detection, product development, and the handling of reinsurance contracts.
The purpose of this presentation is to provide an overview of blockchains, including what they are and how they work, their implications for the insurance industry, and research related thereto.

Keywords: insurance application areas, blockchain, peer-to-peer, smart contract

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1.7 W1a Mortality forecasting / Chair Han Li

Quickest Drift Change Detection in Lévy-type Force Of Mortality Model

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Abstract

Population longevity is a phenomenon widely observed in the world. It poses new challenges to various fields of economy. Among the others, it is strongly connected to the pension systems and insurance contracts. One of the key indicators of population lifetime is force of mortality which evolves in time. One can estimate general trend (drift) of this force analysing life tables. In other words, one can build up a statistical model to describe force of mortality and to forecast its future behaviour. But such model may become invalid over the years and there is an obvious need for actualisation of its parameters. In terms of our statistical model it means that its drift may change over the years of observations. Such changes cannot be ignored while forecasting future mortality of the society.
In the talk I will model force of mortality by a stochastic process, in which drift changes after some random time. Precisely, it will be a Lévy process consisting of both continuous and jump part. I will give solution to the quickest change-point detection problem for this model. I will consider Bayesian framework with exponential a priori distribution of the change point and an optimality criterion based on probability of false alarm and expected delay of the detection.
Our approach is based on optimal stopping theory and it is followed by numerical analysis. We will use this theoretical results to analyse Polish life tables and to model force of mortality in population with drift changing in time.
The talk is based on joint work with Zbigniew Palmowski and Łukasz Płociniczak.
The presenter will be a PhD student at the moment of the conference.

Keywords: force of mortality, Lévy process, quickest detection, optimal stopping, life tables.

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A Flexible Multi-factor Age-period-cohort Approach to Mortality Modeling With Forecast Reconciliation

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Abstract

Life expectancy has been increasing sharply in the U.S. since the second half of the 20th century. However, between 2014 and 2016, U.S. life expectancy has declined for two years in a row, for the first time since the early 1960's. This phenomenon has attracted a lot of attention in U.S. society. As argued by various academic researchers and medical experts, potential factors that contribute to the decreasing trend may include a high obesity rate and drug overdoses[§]. To gain better insights into the historical mortality patterns and to improve mortality forecasts, in this study, we analyze both aggregated national mortality data and cause-specific mortality data in the U.S. since 1950. First, we allocate cause-of-death mortality improvement into age, period, cohort, and residual components. Flexible multi-factor age-period-cohort models are proposed for a wide range of causes of death. We then link major causes of death back to extrinsic mortality drivers, such as anti-smoking campaigns, HIV/AIDS and pneumonia or influenza. Period effects that have been identified in the modeling process will be extrapolated to project future cause-specific mortality rates. It is expected that the aggregation of these individual cause-of-death forecasts will provide a more accurate projection for the national total death rate. In order to generate a set of coherent forecasts across all causes and make sure they add up to national level mortality rates, we apply several advanced forecast reconciliation techniques such as the "bottom up" method, as well as the more recent optimal combination method.

Keywords: Cause-of-death mortality modeling; flexible functional form approach; forecast reconciliation

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[§]See reports from the National Institutes of Health: https://www.nih.gov/news-events/news-releases/nih-study-finds-extreme-obesity-may-shorten-life-expectancy-14-years.

Mortality Forecasting by Cause Of Death and Basis Risk Modelling With Compositional Data

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Abstract

National demographic data are frequently used to predict future mortality improvements due to the homogeneity and robustness of the data. Inherent differences in the risk profile of an insured population from the general population create a basic risk. This basic risk is becoming increasingly important as the division of risk profiles influenced by socio-economic factors grows. In this paper, we develop an approach by cause of death to capture the basic risk assuming that the distribution and dynamic of cause-specific mortality differs between the general and insured population. Using the framework of the compositional data developed by Aitchison (1986), we obtain projections of the densities of mortality by cause of death for the general population based on two components: the density of mortality for a cause given the death by this cause and the vector of the proportions of deaths related to each cause. We are explicitly taking into account that mortality improvements are originating from: on the one hand, a delay of the age at death from the cause (for example due to the effectiveness of a treatment) and on the other hand a reduction in the number of deaths from the cause (due to the appearance of the vaccine or screening programs). We establish a deterministic relationship between the insured and general population and show how to integrate coherently expert opinions on long-term mortality dynamic, on future potential changes in the proportion of deaths, and on age at death distribution of cause-specific mortality. The model is compared with standard mortality forecasting approaches with an application to the United States population.

Keywords: Compositional Data Analysis; Mortality; Cause of death; Basis risk; Forecast; United-States; Lee-Carter; Expert judgements.

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Mortality by Cause Of Death and Forecasts by Compositional Time Series

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Abstract

In the context of mortality, studying the causes of death is useful for both understanding change point detection in mortality trends and for forecasting. Following the framework of the compositional data of Aitchison (1986), we abandon the conventional approach to use mortality rates and obtain predictions of the mortality densities by cause of death. We propose to decompose the density of mortality into two elements. The first component is the density of mortality for a cause conditional on the death by this cause, while the second is the vector of the proportions of deaths related to each cause. Such a decomposition is helpful in capturing the fundamental mortality dynamic between subpopulations. Following the model developed by Oeppen (2008), we apply the compositional Lee-Carter methodology on both components. Focusing on the later component, we propose an interpretation of Oeppen's approach based on compositional data analysis by rewriting the model as a dynamic system. This new form allows a better understanding of its essential parameters illustrating the dependence and the transfer of deaths between the different causes. We then study the stochastic behavior of the error term by introducing compositional data multivariate time series process. Two choices are considered: the multivariate random walk and the C-VARIMA.
This presenter will be a PhD student at the moment of the conference.

Keywords: Compositional Data Analysis; Mortality; Cause of death; Compositional Time Series; Differential System; Forecast; United-States; Lee-Carter.

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2.1 M1b Micro-level reserving / Chair Greg Taylor

Modelling Micro-level Insurance Claim Counts Using Markov-modulated Non-homogeneous Poisson Processes

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Abstract

The estimation of claim and premium reserves is a key component of an actuary's role and plays a vital part of any insurance company's operations. In practice, such calculations are complicated by the stochastic nature of claim arrivals and the impracticability of capturing all relevant drivers of the observed claims data. Further, past computation limitations have promoted the prevalence of simplified, but possibly sub-optimal, aggregate methodologies. However, in light of modern advances in processing power, it is viable to increase the granularity at which we analyse insurance datasets so that potentially useful information is not discarded.
In this paper, we propose a Markov-modulated non-homogeneous Poisson model to overcome issues involved in the practical implementation of micro-level claim count models. We incorporate a flexible exposure measure to explicitly allow for known claim count drivers while the hidden component of the model captures the impact of unobservable or practicably non-modellable information. Complications with the application of such models to real world insurance data are discussed and resolved. Finally, the theoretical findings are illustrated and validated in an empirical case study using Australian general insurance data to demonstrate the applicability of the proposed methodology.
The presenter will be a PhD student at the moment of the conference.

Keywords: Cox process, Markov-modulated non-homogeneous Poisson process, Micro-level insurance claim counts, Hidden Markov model, EM algorithm

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Dynamic and Granular Loss Reserving Embracing Dependencies

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Abstract

To meet all future claims rising from policies, it is requisite to quantify the outstanding loss liabilities. Loss reserving methods based on aggregated data from run-off triangles are predominantly used to calculate the claims reserves. Conventional reserving techniques have some disadvantages: loss of information from the policy and the claim's development due to the aggregation, zero or negative cells in the triangle; usually small number of observations in the triangle; only few observations for recent accident years; and sensitivity to the most recent paid claims, cf. [1].
To overcome these dilemmas, granular loss reserving methods for individual claim-by-claim data will be presented. Moreover, reserves' estimation is a crucial part of the risk valuation process, which is now a front burner in economics. Since there is a growing demand for prediction of total reserves for different types of claims or even multiple lines of business and there are possible structural breaks present in the historical data [3], time-varying frameworks embracing dependencies will be established.

Keywords: non-life insurance, loss reserving, granular reserving, individual claim development, dependence modeling, stochastic processes, dynamic models, time-varying models, panel data, bootstrap.

Acknowledgements: This research was supported by the Czech Science Foundation project GAČR No. 18-01781Y.

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A Multivariate Claim Counts Model

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Abstract

Dependencies between multiple Lines of Business have a material impact on the estimation of the diversification benefit when a risk margin of the aggregate loss is required. Current study of multivariate reserving requires focus on aggregate claims information, typically in the format of claim triangles. This presents serious limitations because of the small size of data and elimination of useful information.
In this paper, we extend the study of micro-level stochastic reserving models to the multivariate context. We develop a multivariate stochastic process model to allow for the dependency structure across multiple insurance claims processes. Furthermore, we develop algorithms to estimate the parameters.

Keywords: Dependency modelling, stochastic process, Insurance claims counts, Markov chain Monte Carlo.

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2.2 M2b Reinsurance / Chair Ying Wang

Peer Effects in Corporate Risk Management: Evidence from Reinsurance Utilization

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Abstract

In this paper we investigate the peer effects in corporate risk management, particularly reinsurance utilization, in the U.S. property-casualty insurance industry. We firstly build a simple theoretical model to explain two major mechanisms, learning motive and peer pressure, underlying peer effects in reinsurance utilization. Our model shows that, considering peer decisions can be a useful heuristic, helping insurers to capture unobservable common risks. Meanwhile, insurers whose reinsurance policies deviate too much from peers might be regarded as market outliers and will be subject to some revenue loss. We then use a spatial dynamic panel data (SDPD) model introduced by Qu, Lee, and Yu (2017) to empirically test the magnitude and significance of peer effects in reinsurance utilization. We find that peer firms' past and/or contemporary reinsurance utilization plays an important role in determining an insurer's reinsurance decision. Such peer effects are found among insurers in the same group or with a similar size, and are much stronger for insurers domiciled in the same state or with the same organizational form. Also, insurers are more sensitive to reinsurance decisions of larger peers, consistent with the learning motive of peer effects. Additionally, we find that an insurer's reinsurance decision is negatively associated with its own decision in the last year, indicating a partial adjustment in the reinsurance decision.
The presenter will be a PhD student at the moment of the conference.

Keywords: Peer Effects, Corporate Risk Management, Reinsurance Utilization, Spatial Dynamic Panel Model

Acknowledgements: This paper benefits greatly from the Matlab package written by Jihai Yu and J. Paul Elhorst in estimating spatial regression models. We appreciate their help.

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Optimal Reinsurance Strategies Under Solvency Ii Principles

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Abstract

Two approaches to the optimal reinsurance strategy under Solvency II principles are investi- gated in this paper. First approach demonstrates an optimal reinsurance model from the point of view of an insurer who wants to minimise the sum of its technical provisions and reinsurance premium. The second approach discusses an optimal reinsurance model using Pareto optimal- ity principle and aims to minimise the single-objective optimisation function of the liabilities of insurer and reinsurer. The number of claims in both methods is assumed to be random and individual claims are mutually independent. The resulting optimisation models are convex and Second Order Conic Programming is applied to solve them. Numerical examples demonstrate that different types of reinsurance models are optimal under expected value and standard devi- ation premium principles. Namely, quota-share reinsurance appears to be optimal for expected value premium principle and capped stop loss reinsurance is optimal when standard deviation premium principle is in place.
The presenter will be a PhD student at the moment of the conference.

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To Buyout or Not to Buyout?

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Abstract

In recent years, defined benefit (DB) plan sponsors have sought to reduce pension risk through strategies such as buyouts that involve the purchase of annuities from insurance companies. While pension buyouts can generally help employers reduce pension liabilities and related expenses and improve firm performance, little attention has been paid to the implications of pension risk transfer for employees. To fill this gap, we compare the total risks of employees with and without pension buyouts based on a model calibrated to market data in a stochastic framework. Our numerical examples show that whether pension risk transfer enhances or impairs the interests of employees greatly depends on the financial soundness of their employer and plan funding status. Meanwhile, both the buyout insurer's insolvency risk and the benefit protection provided by the Pension Benefit Guaranty Corporation (PBGC) relative to that of the State Life & Health Insurance Guaranty Association also play an important role in determining the extent to which a buyout will affect the welfare of employees. Our findings provide important insights for regulators and policymakers concerning best practices for pension de-risking through buyouts.

Keywords: defined benefit pension plan, pension default, plan participants, pension buyout.

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Reinsurance Premium Principles Based on Weighted Loss Functions

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Abstract

In this paper, we propose new reinsurance premium principles that will minimize the expected weighted loss functions, which balance the trade-off between the reinsuer's loss and the insurer's loss in a reinsurance contact. The random weighting factors based on risk measures are introduced for obtaining the optimal reinsurance premiums. The proposed premiums provide new ways for pricing reinsurance contacts and control the risks of reinsurance contacts. The resulting reinsurance premiums not only are more reasonable for both the reinsurer and the insurer, but also are competitive in the reinsurance market. As applications of the proposed principles, the modied expectile reinsurance principle and the modied quantile reinsurance principle are introduced and discussed in details. The properties of the new reinsurance premium principles are investigated. The comparisons between the new reinsurance premium principles and the classical expectile principle (Albrecher et al., 2017), the classical quantile principle (Heilmann, 1989), and the risk-adjusted principle (Heras et al., 2012) are provided.

Keywords: Reinsurance, ceded loss function, premium principle, expectile principle, quantile principle, risk-adjusted principle, expected value principle.

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2.3 M3b Bonus-Malus systems / Chair Enrique Calderin

Properties and Applications Of a New Generalised Poisson Distribution

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Abstract

In this work a new one-parameter version of the generalized Poisson distribution is introduced. This model is related to the Borel-Tanner family of probability distributions. This simple and flexible distribution satisfies many statistical properties which have not been included in the literature. As it is unimodal with zero vertex and overdispersed it is suitable to be applied in insurance settings as alternative to negative binomial, poisson-inverse gaussian, zero-inflated and hurdle models. A generalised linear model related to this distribution is also presented. For this regression model, parameters can be estimated by using a Fisher-Scoring algorithm. As an application, a dataset that explains the demand for health services among people 65 and over is considered.

Keywords: Generalised Poisson Distribution, Zero-Inflated models, Hurdle models,Generalised Linear Model, Fisher-Scoring, Health Services.

Acknowledgements: This work was partially funded by grant ECO2013–47092 (Ministerio de Economía y Competitividad, Spain and ECO2017–85577–P (Ministerio de Economía, Industria y Competitividad. Agencia Estatal de Investigación).

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Implementation Of Dependence Between Frequency and Severity in Bonus-malus System

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Abstract

A Bonus-Malus System (BMS) in auto insurance is a premium adjustment mechanism widely used in a posteriori ratemaking process to set the premium for the next time period based on the previous claim history of a driver. While independence between claim frequency and severity is key assumption in BMS, series of recent literature under various statistical models report the significant dependence between claim frequency and severity in auto insurance. In this paper, using the bivariate random effect model where the dependence between claim frequency and severity is introduced by copula based bivariate random effect, we illustrate how to combine the dependence structure into the current BMS and provide the analytical solution for the corresponding optimal relativities. The real data analysis and numerical examples are accompanied to assess the effect of dependence in BM system.
The presenter will be a PhD student at the moment of the conference.

Keywords: Dependence, Generalized linear model, Rate making, Dispersion parameter

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Credibility and Linear Filtering on Stationary Time Series

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Abstract

Users of generalized linear models software estimate correlation structures on Poisson mixtures when they study longitudinal count data. Linear prediction is a natural application of second-order semiparametric specifications on random effects. Linear credibility has obvious advantages in terms of readability and of simplicity in the derivations. This approach also has shortcomings that can be anticipated as the price to pay for the constraint on the shape of the predictor. This paper shows how to circumvent these weaknesses in the analysis of longitudinal count data. It represents a substantial improvement of previous publications ([1], [2]) by the author on this topic.

Keywords: Credibility and linear filtering; Generalized partial autocorrelation coefficients; Spectral measure of stationary random effects;

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Optimal Claim Behaviors in Automobile Insurance Under Bonus-malus System: from Mental Accounting Perspective

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Abstract

This paper aims to explain the optimal claim behaviors by policyholders in automobile insurance under the Bonus-Malus system. Typical behaviors include the "hunger for bonus"[1], "negative state dependence in claims"[2] and "nonstationarity of claim intensity"[2]. Previous studies focus on how the number of filed claims or the total amount of filed claims in a policy year determine the optimal claim behaviors[3],[4]. Our work develops a new decision-making framework utilizing the concept of "mental accounting"[5],"sunk cost"[5],"reference point"[6], and "loss aversion"[6] in Behavioural Economics, which better explains the optimal claim behaviors, and unifies the previous research results.
Specifically, according to the theory of "mental accounting", we split the cash flow into two accounts: the insurance account, and the automobile loss account. In the insurance account, policyholders always desire to gain back a "sunk cost" by the end of a policy year, where it is defined as the paid premium plus the un-filed claim amount, and minus the filed claim amount. This insurance account will be closed at the beginning of each policy year and the "sunk cost" will be resetted then. Particularly, according to the "loss aversion" theory, when the "sunk cost" hasn't been taken back, policyholders are risk-seeking. Main results include that the critical claim amount will increase at the beginning and fall near the end of a policy year; other results shed light on the mechanics of optimal claim behaviors as well.

Keywords: Automobile insurance Bonus-Malus system, Optimal claim behaviors, Mental accounting, Sunk cost, Loss aversion, Bellman equation

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2.4 T1b Dividends II (in risk theory) / Chair Zbigniew Palmowski

Ruin and Dividend Measures in the Renewal Dual Risk Model

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Abstract

We consider the dual risk model for financial application, where the random gains occur under a renewal process. We work some particular distributions for the inter-arrival times under the matrix-exponential family of distributions. Furthermore, we also consider randomized obser- vational periods, also under a renewal process and independent of the risk process. We will consider particular cases of this renewal process under the Phase-type family, such as Erlang and generalized Erlang distributions.
We work with the expected discounted penalty function, derive integro-differential equations and explicit solutions for special cases. We consider, in particular, quantities such as expected total discounted dividends, probability of getting a dividend, amount of a single dividend, expected discounted dividend, as well as ruin probabilities.
The presenter will be a PhD student at the moment of the conference.

Keywords: Dual risk model; Expected discounted penalty function; ruin probability; Expected discounted dividends; single dividend amount; dividend probability.

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Fluctuation Identities for Omega-killed Markov Additive Process: Bankruptcy Probability and Dividend Problem

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Abstract

Following [1, 2] in this talk we solve the exit problems for a one-sided Markov additive risk process (MAP) which is exponentially killed with a bivariate killing intensity $\omega(\cdot,\cdot)$ dependent on the present state of the process and its environment. Moreover, we analyze respective resolvents. All identities are given in terms of new generalizations of classical scale matrices for the MAP. We also remark on a number of applications of the obtained identities to (controlled) insurance risk processes. For example we show that our results can be applied to find the ruin probability in the so-called Omega model, where bankruptcy occurs at rate $\omega(\cdot,\cdot)$ when the surplus process becomes negative. We also solve dividend problem where discounting rate depends on the position of the risk process. Finally, we calculate few examples for the Markov modulated Brownian motion and particular choices of killing intensity $\omega(\cdot,\cdot)$.

Keywords: Markov modulation, Omega model, ruin probability, dividend, fluctuation theory.

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Optimal Dividend and Capital Injection Strategy With Penalty Payment at Ruin

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Abstract

In this paper, the optimal dividend and capital injection problem with penalty payment at ruin is studied . By taking into account the fixed and proportional transaction costs for capital injection and considering the surplus process killed at ruin, we transform the problem to a combined stochastic and impulse control up to ruin with free boundary at zero. We illustrate a different type of capital injection strategy comparing to the conventional results in the literature, where the capital injection is made before the time of ruin. We start with restricted dividend densities, under which we prove that the value function is the unique increasing, bounded, Lipschitz continuous and semi-continuous at zero viscosity solution to the corresponding Quasi-variational Hamilton-Jacobi-Bellman (HJB) equation. The uniqueness for such class of viscosity solutions is proved with the help of the boundary condition at infinity. Then we discuss the construction of the optimal strategy which is in turn a band-type strategy. Meanwhile, the result is extended to the scenario with unrestricted dividend rates. We show that the value function and corresponding Quasi-variational HJB equation is in turn the limiting situation to the restricted dividend densities case. However in the later case without the known boundary condition at infinity, we can only show that the value function is the smallest viscosity supersolution of the corresponding Quasi-variational HJB equation. Through a comparison principle, we are able to characterize the value function as the unique supersolution with smallest value at zero.
The presenter will be a PhD student at the moment of the conference.

Keywords: dividend and capital injection strategy, penalty at ruin, Quasi-variational HJB equation, stochastic and impulse control, viscosity solution, band strategy.

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On Optimal Periodic Dividend With Fixed Transaction Costs for Spectrally Positive Lévy Processes

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Abstract

In the literature of actuarial risk theory, stochastic processes are used to model risky business such as insurance companies. In particular, one important risk measure on stochastic processes is the maximised aggregate discounted dividends, which is often referred to "stability criterion", or the "optimal dividend problem", where finding an optimal strategy is of interest.
In this paper, we focus on the companies which face deterministic costs but stochastic gains. The suplus process are modelled as spectrally positive Lévy processes (the dual model). Motivated by the idea of periodic dividend strategies [1], which were introduced to capture the periodicity of dividend payments in real life, we incorporate fixed transaction costs in the periodic dividend payments to study the impact of such costs on the form of optimal strategies, for spectrally positive Lévy processes. In particular, dividends can only be paid at Poissonian times.
Inspired by the form of optimal strategies for dual model under different settings, we postulate that the optimal strategy is a periodic (b_u, b_l) strategy, where a dividend is paid whenever the surplus is above or equal to the upper barrier b_u at the Poissonian times (before ruin), such the surplus level is brought to a lower level/barrier b_l. Using exiting identities for Poissonian times [2], the value function of a general (b_u, b_l) strategy can be expressed concisely in terms of scale functions. Furthermore, when the barriers are chosen carefully and denoted as b_u^* and b_l^*, via a guess and verify approach the optimality of the (b_u^*, b_l^*) strategy is shown.
Results are illustrated.
The presenter will be a PhD student at the moment of the conference.

Keywords: SPLP, fixed transaction costs, periodic dividends, optimal strategy

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2.5 T2b Dependence modelling II / Chair Félix Belzunce

A New Criteria Of Stochastic Dominance for Dependent Random Variables

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Abstract

The ordering of risks are a very useful tool from a theoretical point of view and for solving insurance problems. Among the most common orderings, we have the stochastic order or the stochastic dominance criteria, which can be characterized by the comparison of increasing utility functions. However, this criteria only takes into account the marginal distributions of the two risks, and does not take into account their possible dependence. In this talk, we present from an applied point of view, a new criteria of stochastic dominance that takes into account the dependence structure of the two random variables involved in the comparison. Relationships with some existing criteria, closure properties and applications are also given.

Keywords: Stochastic dominance, dependent random variables, joint stochastic orders.

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Asymptotics for Systemic Risk With Dependent Heavy-tailed Losses

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Abstract

System risk is considered as the risk of collapse of an entire financial system, which has plays a significant role in explaining the recent financial turmoils from the insurance and financial industries. Although there exists a very large number of systemic risk measures in the literature on the Systemic risk (SR), the more simple SR definition from Acharya et al. (2012) is chosen to be discussed in this talk. We consider the tail behaviour of the SR for portfolio losses. We generalize the model to allow for heavy-tailed distribution of risk factors, which are equipped with a wide type of dependence structure. For various important cases, asymptotic formulas for the SR are derived. This risk model provides an ideal framework for modelling both heavy tails and dependence. As an extension, simulation experiments are conducted, comparing the asymptotic formulas with the traditional empirical estimates, which show that our approach is superior to a copula-based approach.

Keywords: asymptotics; dependence; heavy-tailed distribution; systemic risks

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Tail Dependence Structures from the Viewpoint Of Tail Dependence Matrices

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Abstract

The tail dependence coefficient is a bivariate measure of dependence in the tails, and the tail dependence matrix (TDM) is the array of such bivariate measures corresponding to a random vector. A TDM serves as a measure of multivariate tail dependence. It is known that the space of TDMs corresponding to d-dimensional random vectors is a polytope with exponential in d number of facets and vertices. In this talk, we will show that if we restrict attention to parametric classes, then the space of TDMs can have much simpler descriptions; this is encouraging as in higher dimensions imposing such restrictions is a common way to escape the curse of dimensionality. Also, we will discuss some results that describe the subset of TDMs generated by some popular family of copulas; in some cases this subset is shown to be a surprisingly small part of the whole space of TDMs. This suggests another dimension along which to evaluate copula families for practical use.
The presenter will be a PhD student at the moment of the conference.

Keywords: Tail Dependence Coefficient; Copula; Tail Correlation

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Analysis Of Systemic Risk Spillover Effect in China's Insurance Sector: Based on Covar Model Combined With Quantile Regression

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Abstract

With the rapid development of insurance industry in China, it has become an important part of China's financial markets so that it is necessary to study and manage the systemic risk of insurance industry scientifically. Taking weekly closing price of China's listed insurance companies from 2007 to 2017 as a sample, this paper establishes a CoVaR model combined with quantile regression method to investigate the systemic risk spillover effect of China's insurance industry. The result shows that systemic risk spillover effect among insurance companies is quiet significant, and different insurance company exhibits different intensity of risk spillover. Furthermore, there is significant risk spillover effect demonstrating bi-directional and asymmetric between insurance sector and other financial sector. Based on research results, this article points out the importance of reducing systemic risk of insurance industry and puts forward several policy recommendations.

Keywords: insurance; systemic risk spillover; CoVaR; quantile regression

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2.6 T3b Life insurance valuation / Chair Chunli Cheng

An Approach for Model Points Selection in Life Insurance

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Abstract

European insurance companies are required to assess the value of their portfolios by considering the cash flow projections on the basis of each policy, as well as to carry on the sensitivity analysis aimed at demonstrating the compliance of their models. Besides, according to Solvency capital requirements, they are allowed to compute these projections by replacing any homogeneous group of policies with some representative contracts, usually known as the related model points. This is so in order to speed up this process, that is usually carried out on a daily basis, since the complexity of the entire portfolio may lead to large computational times.
We assess the problem of defining the model points associated to a fixed homogeneous life insurance portfolio in presence of constraints, when the fluctuation of the interest rate term structure is considered as the main source of risk. For this purpose, we model the evolution of the price curve by a diffusive dynamics, the coefficients of which satisfy specific regularity conditions. The set of model points is thus defined as the portfolio verifying certain constraints that best replicates the original portfolio, by minimizing a specific risk functional. In this respect, some criteria of optimality are introduced by considering tools arising from the recent theory of the stochastic integration in UMD Banach spaces, with particular attention to the Malliavin calculus developed in such a framework. Several test examples illustrate the performance of the proposed method and its computational issues. This approach generalizes the standard portfolio immunization techniques based on the sensitivity analysis.
The presenter will be a Ph.D. student at the moment of the conference.

Keywords: Model Points, Life Insurance, Risk Management, Sensitivity Analysis, Malliavin Calculus.

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Dynamic Fair Valuations Of Insurance Liabilities: a Time-consistent Hedging Characterization

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Abstract

In this paper, we investigate the fair valuation of insurance liabilities in a dynamic multi-period setting. We define a dynamic fair valuation as a valuation which is market-consistent (mark-to-market for hedgeable claims), actuarial (mark-to-model for claims independent of financial market evolutions) and time-consistent, extending the work of [1] and [2]. We provide a complete hedging characterization for dynamic fair valuations. Moreover, we show how we can implement dynamic fair valuations through a backward iterations scheme combining risk minimization methods from mathematical finance with standard actuarial techniques based on risk measures. Compared to the work of [3] who characterize time-consistent and market-consistent valuations in a complete financial market by operator splitting, our framework is hedge-based and allows for financial market incompleteness.
The presenter will be a PhD student at the moment of the conference.

Keywords: Dynamic fair valuation, time-consistency, Solvency II, market-consistent valuation, actuarial valuation.

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Optimal Prediction Problems in Insurance

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Abstract

Optimal prediction problems are related to classic optimal stopping problems used, for instance, for option pricing in finance, however, optimal prediction problems allow for a non-adapted payoff process. This allows for instance to study the problem of prediction the time and value at which a financial price process attains its (global) maximum.
This work consists of formulating and studying optimal prediction problems driven by risk processes in insurance. The big difference with previous work in optimal prediction (see for example [2]) is the incorporation of jumps, i.e., discontinuities. We model the risk process as a Spectrally Negative Lévy process, allowing only negative jumps. This could be seen as an extension of the classic Cramer-Lundberg model. First we compare the recent result in [1], where the problem of stopping near the global supremum was studied in time-domain, with an approach in space-domain for the same problem, showing that the results are not equivalent. Then, we formulate a new problem changing the payoff for a more general function and find the optimal solution.
The presenter will be a PhD student at the moment of the conference.

Keywords: Optimal Prediction, Risk Process, Lévy Process, Stopping Times, Spectrally Negative Lévy Process.

Acknowledgements: We thank CONICYT-Chile for financial support.

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Surrender Contagion in Life Insurance: Modeling and Valuation

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Abstract

A mass surrender which imposes a significant risk to insurance companies has been taken into account for determining solvency capital in the insurance sector and the discussion on triggers of a mass surrender has attracted much attention in insurance literature. Undoubtedly, changes in financial conditions affect policyholders' surrender decision making, and by assuming that all or almost all policyholders can identify changes in the financial sector fast, are capable of analyzing those financial changes on their own and react to them by terminating their contract, a immediate mass surrender would result. However, it has been widely discussed in insurance literature that policyholders are not all timely reacting to changes in financial market, see [4] and [2]. This has also been emphasized by the CEIOPS¶: There is a difference in the surrender risk for different policyholders. Hence, given that institutional policyholders, assumed to surrender optimally, take up a small fraction of an insurance pool, occurrence of a mass surrender actually implies a surrender-mimicking behavior, namely surrender contagion.‖

However, surrender contagion has not attracted much attention in the literature of modeling surrender risk. To the best of our knowledge, the only work which intends to model contagious surrender behaviors of policyholders is [1]. They introduced a mathematical framework where both dependence of policyholder's surrender behavior on macroeconomic conditions and on other policyholders' surrender are integrated and embedded in a dynamic surrender intensity contagion process with external market-driven jumps and self-excited jumps, see [3]. Although modeling correlation and contagion among policyholders' behaviors, the approach by [1] has some limits. First, even though external macroeconomic conditions are modeled stochastically in their paper, adjustments in the policyholders' surrender behavior according to changes in macroeconomic conditions follow a given specific rule instead of by comparing their contract value and surrender value. Second, by considering policyholders' surrender likelihood changes after each single other policyholders' surrender [1] are analyzing policyholders' copycat behaviors in extreme situations, which are not common in reality. Third, [1] neither consider heterogeneous policyholders, nor structural changes of the pool of policyholders' over time, which is a crucial simplification of reality. Moreover, since the paper of [1] considers a risk management perspective and mainly focuses on estimating risk measures, it does not give any insight on valuation in life insurance with surrender contagion taken into account.

In the present paper, we introduce a pricing model for life insurance contracts which are sold to two types of policyholders, that is, professional policyholders, who can optimally surrender their contract, and non-professional policyholders, whose surrender behavior is affected by other policyholders' surrender decision. We model the surrender decisions of non-professional policyholders by a Poisson process with a dynamic surrender intensity contagion process with endogenous-excited jumps triggered by the number of accumulated surrenders. Surrenders are only contagious if they attract public attention causing further surrenders and, accordingly, the intensity's contagion component is enabled if and only if the recent surrenders reach a critical level. Further, the model allows for structural default, managed by a regulatory authority, which we include as a default barrier. This paper shows major implications for both the insurance company and its customers caused by surrender contagion. Professional policyholders terminate their policies at the expense of non-professionals, because their anticipation of gloomier prospects of the insurance company's investment performance implicitly makes their claims senior to their claims. The possibility of contagious behavior by non-professionals alters the surrender behavior of both professionals and non-professionals. First, it drives the professional policyholders to surrender earlier and more frequently. Second, the structure of non-professional surrenders changes due to the contagion effect temporarily speeds up their surrenders after the professionals surrender, concentrating surrenders in the period after professionals leave.

Keywords: Surrender Risk, Life Insurance, Contagion, Bounded Rationality, Regulation.

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¶The CEIOPS refers to the Committee of European Insurance and Occupational Pensions Supervisors.

‖Empirical evidence on herd behavior of policyholders in the insurance market can be found in [5].

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3.1 M1c Pension Schemes / Chair Servaas van Bilsen

Asset Allocation for a Dc Pension Plan With Inflation Risk and Learning About Return Predictability

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Abstract

This paper investigates an optimal asset allocation problem for a DC pension plan member under inflation risk and learning. The member aims to maximize the expected power utility from the real terminal wealth. The financial market consists of three assets: one risk-free asset (a bank account) and two risky assets (an inflation-indexed bond and a stock). We assume that the expected excess stock return is an affine function of two predictors. The two predictors are described by two mean-reverting processes. However, for these two stochastic processes, one can be directly observed by the member and the other one cannot be observed. This setting reflects two results of empirical research: stock returns seem to contain predictable components, and no observable predictor can fully explain the variations in the expected stock returns. Meanwhile, the stock and the predictors are correlated with the inflation-indexed bond. During the whole investment process, the member can use the observed information about the inflation level, the stock price and the observable predictor to estimate the unobservable predictor by adopting the Bayesian learning. Besides, the member is assumed to receive stochastic salary.
We derive the closed-form optimal investment strategy and the corresponding value function using the stochastic dynamic programming method. Furthermore, we measure the utility loss induced by ignoring learning about the unobservable predictor or not using the inflation-indexed bond to hedge against the stock return predictors. Finally, we present a numerical example to analyze economic implications of our theoretical results. The numerical example shows that using the inflation-indexed bond to learn about the unobservable predictor or hedge against the stock return predictors can lead to significant welfare improvements.

Keywords: Return predictability; DC pension plan; Inflation risk; Learning; Asset allocation

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How Costly Is It to Ignore Interest Rate Risk Management in Your 401(k) Plan?

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Abstract

This paper explicitly derives and explores optimal interest rate risk management for lifecycle investors in DC pension plans, and compares our results to the portfolio mix chosen in practice by Target-Date Fund (TDF) managers. We show that investments in long-term bonds play an important role in the portfolio of middle-aged individuals between ages 45 and 70. Our theoretical findings stand in sharp contrast with the investment choices made in practice; the role of long-term bonds is rather limited in the investment portfolios of 401(k) pension plan members in the US. Morningstar data on TDFs points out that the average bond duration is limited to five years and does not depend on age. We find that the absence of long-term bonds in the portfolio of a lifecycle investor can be costly, with the welfare loss peaking at 5 percent of consumption for middle-aged individuals.

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Return Smoothing Method in a Pension Contract: Risk Emerges

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Abstract

Smoothing mechanisms are widely used in with-profits contracts to provide smoothed returns to the customer. In this paper, we study a with-profits contract (or participating contract in the US) that is currently sold in the UK. A common smoothing method is applied in this contract. Under risk-neutral pricing, a closed form solution of pricing this contract is given in this paper. The results have shown that this smoothing method provides an unfair terminal value. It is overvalue to the insurer and undervalue to the customers. More importantly, a special kind of risk emerges because of the design of the smoothing method. This risk is caused by the speculating entry to the contract of the customer and it has not been discussed in previous literature. We carefully investigate this risk and show that this risk is of significance to the insurer.
The presenter will be a PhD student at the moment of the conference.

Keywords: With-profits contracts, Pension, Pricing, Risk management.

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3.2 M2c Variable annuities / Chair Andrés M. Villegas

Incorporating Taxation in the Valuation Of Variable Annuity Contracts: the Case Of the Guaranteed Minimum Accumulation Benefit

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Abstract

We study guaranteed minimum accumulation benefits (GMABs) guaranteeing the return of the premium paid by the policyholder, or a a higher stepped up value at the end of the accumulation period of the contract. GMAB riders have gained a lot of interest in the actuarial literature [1, 2, 3]. We present the valuation framework in partial differential equation form which is solved for fair fees with the aid of the computationally efficient method of lines algorithm and root finding methods. We incorporate tax, as recent literature shows that it reconciles fees with empirical observations [4]. We consider both the Australian and US tax systems in our valuation framework, as they differ into whether capital losses can be offset by capital gains. We find that, when capital losses cannot be offset by capital gains, the separation between the valuation curves increases as tax increases, reflective of the increasing value of the contract to the governments. If capital losses can be offset by capital gains, policyholder's optimal surrender behavior changes to the benefit of the insurer, reducing the insurer liabilities for any fee rate they choose to charge.

Keywords: Variable annuity, GMAB/GMMB, Method of lines, taxes, pricing

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Less Expensive Pricing and Hedging Of Long-dated Variable Annuities When Interest Rates and Mortality Rates Are Stochastic

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Abstract

Many providers of variable annuities such as pension funds and life insurers seek to hedge their exposure to embedded guarantees using long- dated derivatives. This paper extends the benchmark approach to price and hedge long-dated variable annuities using a combination of cash, bonds and equities under a variety of market models. The results show that when the discounted index is modelled as a time-transformed squared Bessel process less expensive hedging is achieved irrespective of the short rate model or the mortality model.

Keywords: Variable annuity, growth optimal portfolio, benchmark approach, long-dated equity index options, minimal market model, stochastic short rate, stochastic mortality rates.

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Fast Nested Simulation for Large Variable Annuity Portfolios: a Two-way Regression Based Approach

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Abstract

The nested simulation approach is one of the most widely used methods for the valuation and risk management of variable annuity (VA) portfolios. Due to the complexity of simulation algorithms (inner loop and outer loop simulations), large size (100K+) and inhomogeneity of a VA portfolio, running nested simulation for the entire portfolio is often computationally expensive and sometimes prohibitive. In this paper, we propose a regression-based nested simulation algorithm that can be used to effectively calculate/approximate the quantities of interest (e.g. predictive distribution of future liability, the total value of embedded guarantees, required capitals, etc.) for a large VA portfolio. An additive model based smoothing approach is proposed to reduce the number of inner-loops and the number of outer-loops for simulation. Further, we adapt a model-assisted population estimation framework to reduce the number of policies in use for calculation, the set of the representative policies is formed using the balanced sampling algorithm. Numerical studies show our proposed method performs well in accurately approximating the distribution of the future total liability.
The presenter will be a PhD student at the moment of the conference.

Keywords: Variable annuity portfolio, Nested simulation, Smoothing, Additive modeling, Model-assisted estimation, Balanced sampling.

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Pricing Variable Annuities With Guaranteed Minimum Benefits in a Time-changed Lévy Market With the Cos Method

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Abstract

This paper extends the valuation framework of variable annuities embedded with guaranteed minimum benefits (VA+GMBs) in a time-changed Lévy market and implements the Fourier-cosine (COS) method to price the contracts under various equity modeling frameworks. Numerical results are compared with those presented in [Kélani and Quittard-Pinon, 2017] for accuracy. With market parameters calibrated with S&P 500 index option prices in 2015, the fair guarantee charges are compared with those in a GBM, VG and CGMY framework. The results suggest that time-changed Lévy processes generally provide more flexibility in pricing by modeling the stochastic clock and the jump activities together in the unifying VA+GMBs valuations. Our suggested valuation method is efficient and generalizable to all types of guarantees under different equity processes and provides significance from a practical perspective.
The presenter will be a PhD student at the moment of the conference.

Keywords: Variable annuity, Time-changed Lévy process, COS method.

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3.3 M3c Option pricing / Chair Otto Konstandatos

Non-nested Upper Bounds for American Options

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Abstract

In this paper, we propose a new method to compute upper bound of American Options, which is based on approximating the martingale component of value process. Our method is much faster than existing methods, thus is of great practical use. The convergence and tightness of this upper bound are analyzed. In addition, the implementation details and enhancement techniques are discussed as well. Overall, our method makes a good trade-off between the time-efficiency of algorithm and the tightness of upper bound.

Keywords: Monte Carlo; Upper Bounds; American Options

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Analytical Valuation Of Performance-linked Executive Stock Options

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Abstract

Executive Stock Options represent major items of corporate liability requiring fast and objective actuarial evaluation for reporting purposes. In this work we present a closed form analytical valuation for the fair value of an Executive Stock Option structure with market-based performance conditions, consistent with the international accounting standard IFRS2 and its Australian equivalent AASB2, FAS 123 (R) and FRS 20. The need to align executive performance with employee reward, shareholder pressure and corporate governance issues have naturally led to the consideration of remuneration structures which incorporate performance conditions for the stock options granted to senior executives. Common market-based performance conditions require that total shareholder return of the company's stock exceed that of the company's peers, where 'peers' may be a competitor company, a small or large group of competitor companies or alternatively a broad market index. In this spirit we consider valuation with a very general performance-based vesting structure simultaneously incorporating a performance hurdle on the issuer's shareholder return, an out-performance of the return of a market competitor and the out-performance of a broad market index. We incorporate post-vesting voluntary early exercise using the Hull and White (2004) characterisation. Applying several lemmas we express our analytical results as highly symmetric portfolios of non-standard European instruments, simplifying numerical implementation. Death, disability or ill health usually lead to pre-vesting forfeiture or to post-vesting involuntary early exercise. Following AASB2 requirements we adjust for such attrition by constructing probability-weighted portfolios of our analytical result derived from empirically determined survival functions. Our numerical results illustrate the effect of performance hurdles and survival adjustment on the fair valuation.

Keywords: Executive stock options, Performance based vesting, Attrition, Corporate governance.

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The Double Continuation Region for One-sided Lévy American Options With Negative Discounting

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Abstract

We consider perpetual American call and put options in an exponential Lévy model. We assume a negative effective discount rate which arises in a number of financial applications including stock loans and real options, where the strike price can potentially grow at a higher rate than the original discount factor. We show that in this case a double continuation region arises and we identify the two critical prices. We also analyze a generalization of this result to multiple stopping problems of swing type, that is, when successive exercise opportunities are separated by i.i.d. random refraction times.
The talk is based on joint work with Marzia de Donno and Zbigniew Palmowski.
The presenter will be a PhD student at the moment of the conference.

Keywords: American option, negative rate, optimal stopping, Lévy processes

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3.4 T1c Mortality data / Chair Pintao Lyu

The Younger-older Dichotomy Of Mortality Patterns: Observations and Applications

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Abstract

In this paper, we propose and investigate a simple yet important observation on the age-sex-specific mortality data of many countries: the mortality data can be clustered into two groups along ages (i. e. above and below middle-ages), which have very different statistical patterns to each other. Firstly, we apply various statistical techniques to validate such differences. Then we show that by being age-group-aware, the performance of classical mortality prediction methods can be significantly improved, especially for the younger age groups. At last, we discuss the possible reasons causing such dichotomy of mortality patterns along ages.

Keywords: Time series clustering, Time series segmentation, Mortality forecasting

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A New Toolkit for Mortality Data Analytics

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Abstract

For the calculation of premiums, financial reserves, annuities, pension benefits, various benefits of social insurance programs, and many other quantities, a realistic representation of mortality rates is of fundamental essence. We achieve this by a new far-reaching and flexible approach for the smoothing and error-correcting of crude rates, based on the recently developed scaled Bregman distances of [2], [3], [1]. By means of several concrete data analyses, we show that our procedure can be superior to known graduation methods and that it can be applied very flexible.

The presenter will be a PhD student at the moment of the conference.

Keywords: Mortality; mortality rates; graduation; smoothing; scaled Bregman distances.

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The Goodness-of-fit and Predictability Of Modern Mortality Models in Taiwanese Data

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Abstract

This study investigates how recently developed mortality models perform in Taiwanese mortality data. In particular, we compare the Mitchell et al. model [1] with period effect that follows non-Gaussian distribution and two increasingly popular parametric models with cohort effect, Plat model [2] and O'Hare and Li model [3]. We apply the Taiwanese mortality data from 1970 to 2014 to examine the goodness-of-fit and show that the period effect in Taiwan in the Mitchell et al. model does exhibit non-Gaussian dynamic in both male and female population. We further divide the full sample into two parts, an in-sample period (1970-2004) and an out-of-sample period (2005-2014), to examine the predictability of these models on Taiwanese data. The root sum of squared errors is employed as the criterion. Our results suggest the Mitchell et al. model captures the male mortality rates better, while the O'Hare and Li model performs better in female mortality rates.

Keywords: Mortality models, non-Gaussian distributions, Period effects.

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Multi-population Socio-economic Differentiation in Experienced Mortality With Application to Portfolio-specific Mortality Data

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Abstract

Along with other developments in life insurance and pension, many insurers are getting interested in dynamic or flexible pricing based on the socio-economic attributes of the individuals on their mortality. Mortality differentiation is used to define a profiling framework on the level and trend of the mortality. Our study aims to make a bridge between the literature of the portfolio mortality studies with the mortality differentiation, and build a portfolio-specific mortality differentiation model with socio-economic differentiators. We look into the mortality in a multi-population (multi-class) framework and use a regression model to identify the socio-economic mortality differentiators from the individual-level (unbalanced) panel data and estimate the portfolio-specific mortality rates. As insurers use the experienced mortality in application, the differentiation model is adapted likewise to provide a portfolio-specific "differentiated experience factors" by re-scaling the population mortality rates to the experienced ones for each differentiation class. We use a time-specific model that gives room to study the trend of differentiated mortality over time and resonate the results with classic mortality trend models. Apart from the best-estimate mortality, a customized bootstrapping scheme is used to measure the uncertainty around the differentiated level and trend mortality for different classes.

Keywords: Mortality modeling; Multi-population mortality; Experienced mortality; Socio-economic differentiation

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3.5 T2c Optimal insurance / Chair Ambrose Lo

Universally Marketable Insurance in the Presence Of Multiple Risks

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Abstract

The study of desirable structural properties satisfied by marketable insurance contracts has been a recurring theme in insurance economics. We propose necessary and sufficient conditions for an insurance indemnity to be universally marketable in the sense that it appeals to both the policyholder and the insurer, irrespective of their risk preferences and risk profiles (see [1]). We begin with the univariate case when there is a single risk facing the policyholder, then extend our results to the case when multiple possibly dependent risks co-exist. Particular attention is paid to several important classes of dependent random variables.

Keywords: Insurance; indemnity; dependence; risks

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Optimal Robust Insurance With a Finite Uncertainty Set

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Abstract

Abstract Decision-makers who usually face model/parameter risk may prefer to act prudently by identifying optimal contracts that are robust to such sources of uncertainty. In this paper, we tackle this issue under a *finite uncertainty* set that contains a number of probability models that are candidates for the 'true', but unknown model. Various robust optimisation models are proposed, some of which are already known in the literature, and we show that all of them could be efficiently solved. The numerical experiments are run for various risk preference choices and it is found that for relatively large sample size, the modeler should focus on finding the best possible fit for the unknown probability model in order to achieve the most robust decision. If only small samples are available, then the modeler should consider two robust optimisation models, namely the Weighted Average Model or Weighted Worst-case Model, rather than focusing on statistical tools aiming to estimate the probability model. Amongst those two, the better choice of the robust optimisation model depends on how much interest the modeler puts on the tail risk when defining its objective function. These findings suggest that one should be very careful when robust optimal decisions are sought in the sense that the modeler should first understand the features of its objective function and the size of the available data, and then to decide whether robust optimisation or statistical inferences is the best practical approach.

Keywords: Optimal reinsurance, Risk measure, Robust optimisation, Second order conic programming, Uncertainty modelling.

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Optimal Insurance With Background Risk

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Abstract

When seeking for insurance, decision makers usually need to take multiple sources of risks into consideration. This raises the problem of how to design optimal insurance policy in the presence of background risk. In the study of this problem, the dependence structure between the insurable risk and background risk plays an important role and also brings the main challenge.
This talk consists of two parts. In the first part, we focus on a class of positive dependence structures characterized by high degree stochastic orders and investigate the optimal insurance strategy with respect to higher-order risk attitudes. Under those dependence structures, we prove that stop-loss insurance is optimal and find out the optimal retention level. Furthermore, we conduct comparative analysis and investigate how changes in utility function, initial wealth, and background risk affect the choice of optimal retention level. The second part concerns a more general setting about the dependence structure. For any background risk, we establish a sufficient and necessary condition for an insurance strategy to be optimal. The sufficient and necessary condition suggests that the optimal insurance strategy usually has a multiple-layer structure. We then study a few special cases of mixed dependence structures and explicitly derive the optimal insurance strategies.
This talk is based on the work of [1] and [2].

Keywords: Optimal insurance; background risk; positive dependence; mixed dependence structure; multiple layer insurance.

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Optimal Insurance With Belief Heterogeneity

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Abstract

In Arrow's classical problem of demand for insurance indemnification, a linear deductible schedule is optimal for an Expected-Utility (EU) maximizing decision maker (DM), if the premium depends on the indemnity's actuarial value, if the DM and the insurer share the same probabilistic beliefs about the realizations of the random loss, and if neither party experiences ambiguity (Knightian uncertainty) about the realizations of this loss.
Motivated by epistemic foundations and the decision-theoretic approach to subjective belief formation, we re-examine the problem of demand for insurance indemnification when the DM and the insurer disagree about the likelihoods associated with the realizations of the insurable loss. Unlike the existing (albeit narrow) literature on belief heterogeneity in optimal insurance design, we do not impose conditions on the type or level of disagreement about probabilities. Rather, we provide a closed-form characterization of the optimal indemnity for any type or level of belief heterogeneity, even allowing for disagreement about zero-probability events. We show that there exists an event A to which the insurer assigns full probability (but not necessarily the DM), such that the optimal indemnity for the DM is a state-contingent deductible over A and full insurance over the complement of A. We then recover several results from the existing litera ture as special cases.
Moreover, we introduce a measure of belief divergence and examine how the level of disagreement in beliefs affects the shape of the optimal indemnity. In particular, we show that the level of belief heterogeneity has an intuitive two-fold effect: the higher the level of divergence, the lower the DM's perception of the likelihood of the event A (and hence the higher her perception of the likelihood of full insurance), and the higher the level of the state-contingent deductible, *ceteris paribus*.
Finally, we show how our belief divergence measure leads to a belief divergence metric on the vector space of all probability measures defined on our initial measurable space. We study the topological properties of the hence defined metric space and their implications for our insurance problem.

Keywords: Optimal Insurance, State-Contingent Deductible, Heterogeneous Beliefs.

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3.6 T3c Motor insurance / Chair David Rowell

The Research on Consumer Welfare Of China's Compulsory Automobile Liability Insurance

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Abstract

The system of compulsory automobile liability insurance in China has been running smoothly for more than ten years since July 2006, but consumer welfare of the insurance has not been studied yet. This article first reviews overall development of China's compulsory automobile liability insurance by a total of 14 indicators fallen into two categories:1) business data including premium income, market share, expense ratio, claim payment, loss ratio, accident frequency, average cost per claim, etc.,2) performance data including return on investment and operating profit, in order to give a general conclusion. Then this paper discusses development differences of the insurance in China and suggests that its development varies distinctly by vehicle type and by region. With respect to loss ratio and profitability of the insurance, it is observed that consumers with low-risk vehicles subsidize those with high-risk vehicles, and consumers who live in less developed areas subsidize those in developed areas. Therefore, this article assumes that there are large differences between consumer welfare of different vehicle types, regions and companies in China. Based on the collected data of more than 15000 domestic consumer questionnaires in 2017, three indicators are used as a measure of consumer welfare, which are reasonability of premium, adequacy of guarantee, and satisfaction of claims, to test those assumptions by logit regression of generalized linear model. The results have confirmed our hypotheses at a significant level and with a good goodness of fit. From the point of premium reasonability, consumer welfare in middle and western areas of China is better than that in eastern areas, whereas in terms of claim satisfaction, the result is quite the opposite. Moreover, consumer welfare for low-risk vehicles exceeds that for high-risk vehicles from all three perspectives. And as for characteristics of insurance companies, consumer welfare is positively related to a company's age, number of branches, market share, claim payment, and negatively related to its expense. Also, factors such as whether a company is owned by a group and whether a customer has experienced a claim both have an effect on consumer welfare. This research can provide a certain reference for regional reform of premium rate as well as improvement of pricing policy by vehicle type in China. The presenter will be a PhD student at the moment of the conference.

Keywords: China's Compulsory Automobile Liability Insurance; Consumer Welfare; Development Differences

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Separating Equilibria: Some Theory and Evidence in Australian Market for Automobile Insurance

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Abstract

The objective of this paper is to prepare the theoretical ground for more ample research into the behaviour of consumers and insurance companies in the presence of adverse selection. As noted by Mimra and Wambach (2014), there has been little progress in testing the importance of adverse selection and the prevalence of separating vs. pooling equilibria. The proposed way forward is to model consumers in their search for maximum coverage at a given premium and insurers in their selection effort to stave off high risks (and attract low ones). Reaction functions are derived for the two players giving rise to Nash equilibria in efforts space, which typically are separating between high and low risks. These equilibria are then projected into the wealth level space of the Rothschild-Stiglitz (1976) model. Moreover, displacements of the Nash equilibria due to (i) community rating of premiums, (ii) provision of information to consumers free of charge, and (iii) learning from loss experience by insurers are used to extend the set of empirically testable predictions beyond conventional approaches.
Predictions derived from our theoretical models are tested with survey data collected from the Australian market for automobile insurance (4,006 vehicle owners & 61 insurers) and historical analyses of comprehensive automobile insurance policies published by *Choice Magazine*. First, our sample was partitioned, and proxies for insurer selection effort and consumer search effort are derived and our hypothesized policyholder-insurer interactions, in "efforts space", were tested. Second, tests for separating equilibria, (high-risks and low-risks), are conducted in "wealth space". The empirical models were estimated using bi-probit regressions and results are presented.
A one-period model of insurer-policyholder behaviour is unlikely to fully capture behaviors in an insurance market with adverse selection. While our results do offer some tentative evidence of a separating equilibria, further analysis with structural equation modeling for latent variables may sharpen our results.

Keywords: Adverse selection; Separating equilibria; Consumer search effort; Insurer selection effort; Automobile insurance

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Empirical Tests for Consumer-push and Producer-pull *ex Post* Moral Hazard in a Market for Automobile Insurance

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Abstract

In insurance markets, *ex post* moral hazard arises when the cost of a loss is affected by behaviour that occurs after the loss is incurred (Zweifel and Eisen, 2012). In the case of automobile insurance, when neither the policyholder nor the smash repairer bears the cost of a road traffic crash (RTC) repair, one or both parties may face incentives to inflate the loss size. Consumers, for instance, may face incentives to bring repairs that are not due to the event covered by the policy, into the scope of repairs. Producers, may face similar incentives to increase the size of the loss, by inflating the scope of the necessary repairs, or increasing the prices charged for "insurance jobs". The parties may face disincentives –including legal and financial sanctions– for engaging in such conduct. One reason to be interested in whether or not these two related, but distinct, forms of moral hazard –which we call "consumer-push" and "producer-pull" (*ex post*) moral hazard– is so that insurers are able to test for their presence or absence, and to develop targeted and optimal monitoring, detection and sanction strategies that reduce their magnitudes.
In this paper, we propose empirical tests for consumer-push and producer-pull moral hazard on the Australian auto (property) insurance market. To do this, we use a unique survey of 994 auto crashes. The information that was collected includes not only expenditures on crash repairs, but detailed information about the nature and scope of the repairs that were performed, vehicle and respondent characteristics, and indicators of the latent crash severity including attendance of emergency RTC services. Our empirical estimates suggest that ceteris paribus producer-pull added approximately 29.1 per cent to the cost of vehicle repairs. No evidence of consumer-push *ex post* moral hazard was found.

Keywords: *Ex post* moral hazard; Consumer-push; Producer-pull; Automobile insurance

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Estimation Of Foreseeable and Unforeseeable Risks in Motor Insurance

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Abstract

This project works with the risk model developed by [3] and quests modeling, estimating and pricing insurance for risks brought in by innovative technologies, or other emerging risks. The model considers together two diferent risk streams that arise together, however not clearly separated or observed. Specifically, we consider a risk surplus process where premiums are adjusted according to past claim records, like in a Bonus-Malus (BM) system, where we consider a *classical* or *historical risk* stream and an *unforeseeable risk* one. We can consider claim frequency adjustments as well as frequency and severity together. These are unknown risks which can be of high uncertainty that, when pricing insurance (ratemaking and experience rating), suggest a sensitive premium adjustment strategy. It is not clear for the Actuary to observe which claim comes from one or the other stream, when modelling such risks it is crucial to estimate the probability of the occurrence of such claims. Subsequently, premium calculation must fairly reflect these two risks and is not an easy task. Hence, we propose here an estimation procedure for this probability as well as the premium to be charged. We assume a Bayesian approach as used in credibility theory.

Keywords: Mixed Poisson processes; Foreseeable risks; Unforeseeable risks; Bayesian estimation; Ratemaking; Experience rating; Credibility; Bonus-malus.

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4.1 M1d Pension investments / Chair Yi Lu

Liability Driven Investments With a Link to Behavioral Finance

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Abstract

Liability driven investment (LDI) strategies that take stochastic liabilities into account have become increasingly important for insurance companies and pension funds due to market developments such as low interest rates, high volatility and changes in regulatory requirements. We consider stochastic liabilities in a portfolio optimization framework and include aspects from behavioral finance, in particular cumulative prospect theory (CPT). We study LDI strategies with extended preference structures and probability distortion and derive analytical solutions for a CPT portfolio optimization problem in an LDI context. Within a case study, we compare the optimal investment strategies to existing LDI approaches within traditional frameworks such as the surplus optimization presented in [1] and the funding ratio optimization in an expected utility framework as introduced in [2].

Keywords: Asset liability management, liability driven Investments, cumulative prospect theory.

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Optimal Investment Management for a Defined Contribution Pension Plan With Stochastic Interest Rate – a Hidden Markov Model

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Abstract

This paper considers a multi-period investment management problem for a DC pension plan with a stochastic interest rate, where the dynamics of the interest rate is modulated by the discrete-time Vasicek model. Meanwhile, the manager of DC pension plan can only obtain the partial information rather than the full information of the financial market. That is to say that there exist both observable and unobservable market state in the financial market. The state movement of the financial market is formulated by a discrete-time finite-state hidden Markov model. The return rate of risky asset depends on the observable and unobservable market. At the same time, the participant of the DC pension plan receives a stochastic salary and contributes some to the pension account at the beginning of each period. By adopting the sufficient statistics method, the optimization problem under incomplete information is converted into the one with complete. Furthermore, the optimal investment strategy and the efficient frontier are explicitly derived using the dynamic programming approach. Finally, some numerical results show the impact of the stochastic interest and the incomplete information on the optimal investment strategy and the efficient frontier.

Keywords: Stochastic interest rate; Incomplete information; DC pension plan; Investment management.

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Optimal Investment Asset Liability Management for Annuity Products With Multiscale Stochastic Volatility

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Abstract

This paper develops the annuity contract model in the presence of multiscale stochastic volatility (MSSV) for studying the optimal investment strategy before and after retirement in a defined contribution pension plan where benefits are paid under the form of annuities with a guaranteed payment for a predefined fixed period of time. Besides, we consider two types of volatility, including a fast-moving one and a slowly-moving one. By applying the maximum principle, Legendre transformation and dual theory we transform the complicated nonlinear partial differential equation (PDE) for the value function to a linear PDE. Then, we use the asymptotic approximation technique to derive the asymptotic solutions for the power (CRRA) and exponential (CARA) utility functions in two stages, i.e., before retirement and after retirement. We would emphases the key improvement of the optimization methodology. Finally we give an example of multiscale mean-reverting stochastic volatility and present results via advanced numerical techniques.

Keywords: Annuity; Multiscale Stochastic Volatility; Asymptotic Theory; HJB Equation; Stochastic Optimal Control.

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Optimal Investment Strategies and Risk-sharing Arrangements for a Hybrid Pension Plan

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Abstract

A continuous time stochastic model is used to study a hybrid pension plan, where both the contribution and benefit levels are adjusted depending on the performance of the fund, with risk sharing between different generations. The pension fund is invested in a risk-free asset and multiple risky assets. The objective is to seek an optimal investment strategy and optimal risk-sharing arrangements for plan sponsors and participants, which minimize the expected discount disutility of intermediate adjustment for both benefits and contributions and terminal wealth in finite time horizon. Using the stochastic optimal control approach, closed-form solutions are derived under quadratic loss function and exponential loss function. Numerical analysis is presented to illustrate the sensitivity of the optimal strategies to parameters of the financial market and how the optimal benefit changes with respect to different risk aversions.

Keywords: Hybrid pension plan; Intergenerational risk sharing; Hamilton-Jacobi-Bellman equation; Stochastic optimal control; Optimal investment.

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4.2 M2d Dividends I (in risk theory) / Chair Eric Cheung

Optimal Dividend Problem Under Sparre Anderson Model

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Abstract

We study the optimal dividend problem of Sparre Andersen model, which means, the claim frequency is a "renewal" process instead of a standard compound Poisson process. Since the reserve process is no longer Markovian, we expand dimensions to recast the problem in a Markovian framework. The expanded dimension means the the time elapsed after the last claim. We investigate the regularity of the value function and show that the value function is the unique constrained viscosity solution to the associated HJB equation. We explored the viscosity supersolution and subsolution of HJB equation and we obtain the viscosity solution via Perron's method.
The presenter will be a PhD student at the moment of the conference.

Keywords: Singular control, Optimal dividend, HJB equation, Viscosity solution, Comparison principle, Perron's method.

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Periodic Threshold-type Dividend Strategy in the Compound Poisson Risk Model

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Abstract

In this talk, the (baseline) surplus process is described by the classical compound Poisson model. Inspired by the idea of periodic dividend decisions in [1], we suppose that at the sequence of time points which are the arrival times of an independent Erlang(n) renewal process, the insurance company observes the surplus level to decide on dividend payments. If the observed surplus level is larger than the maximum of a threshold b and the last observed (post-dividend) level, then a fraction of the excess amount is paid as a lump sum dividend. In this proposed strategy, the surplus process can still have an upward trend with a ruin probability of less than one (as opposed to the barrier strategy in [1]). We are interested in the analysis of the expected discounted dividends before ruin (denoted by V). For general claim size distribution, the solution of V can be derived using defective renewal equations. More explicit result for V is presented when the claim size density has rational Laplace transform. Some numerical results are provided to illustrate the effect of randomized observation times on V and the optimization of V with respect to b under the periodic threshold-type dividend strategy. In particular, the optimal barrier generally depends on the initial surplus level. Convergence to the traditional threshold strategy is also shown as the inter-observation times tend to zero.

Keywords: Compound Poisson model; Expected discounted dividends; Threshold-type dividend strategy; Periodic dividends; Erlangization.

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How Long Does the Surplus Stay Close to Its Previous Maximum?

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Abstract

In this talk we find the Laplace transforms of weighted occupation times for a spectrally negative Lévy surplus process to spend below its running maximum up to the first exit times. The results are expressed in terms of generalized scale functions for the spectrally negative Lévy surplus process. For step weight functions, the Laplace transforms can be further expressed in term of scale functions.

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On Optimal Periodic Dividend and Capital Injection Strategies for Spectrally Negative Lévy Models

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Abstract

Our talk is based on [1]. De Finetti's optimal dividend problem has recently been extended to the case dividend payments can only be made at Poisson arrival times. Our talk considers the version with bail-outs where the surplus must be nonnegative uniformly in time. For a general spectrally negative Lévy model, we show the optimality of a Parisian-classical reflection strategy that pays the excess above a given barrier at each Poisson arrival times and also reflects from below at zero in the classical sense.
The presenter will be a PhD student at the moment of the conference.

Keywords: dividends; spectrally negative Lévy processes; scale functions; periodic barrier strategies; capital injection.

Acknowledgements: K. Noba and K. Yano were supported by JSPS-MAEDI Sakura program. K. Yano was supported by MEXT KAKENHI grant no.'s 26800058, 15H03624 and 16KT0020. J. L. Pérez was supported by CONACYT, project no. 241195. K. Yamazaki was supported by MEXT KAKENHI grant no. 17K05377.

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4.3 M3d Mortality modelling I / Chair Linus Chan

A Hierarchical Credibility Approach to Modeling Mortality Rates for Multi-country Populations

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Abstract

Hierarchical credibility model is a generalization of the Bühlmann credibility model and the Bühlmann-Straub credibility model with a tree structure of four or more levels. This paper aims to incorporate the hierarchical credibility theory, which is used in property and casualty insurance, to model multi-country mortality rates. The forecasting performances of the five/four/three-level hierarchical credibility mortality models are compared with those of the classical Lee-Carter model and its three extensions for multiple populations (joint-k, co-integrated and augmented common factor Lee-Carter models). Numerical illustrations based on mortality data for both genders of the U.S.A, the U.K. and Japan with a series of fitting year spans and three forecasting periods show that the hierarchical credibility approach contributes to more accurate forecasts measured by the AMAPE (average of mean absolute percentage errors). The proposed model is convenient to implement and the predicted multi-country mortality rates can be used to construct a mortality index for pricing mortality-indexed securities.

Keywords: Hierarchical Credibility Theory; Bühlmann Credibility Theory; Lee-Carter Model; Multi-population Mortality Model.

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Modeling and Forecasting Chinese Population Dynamics in a Multi-population Context

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Abstract

This paper proposes an innovative multi-population approach to modeling and forecasting China's mortality rates. Due to data quality and availability, mortality forecasts solely based on China's mortality data may lead to inaccurate and unreasonable results. In this paper, we incorporate mortality data from a group of more developed countries in an integrated framework, and use mortality patterns in these countries as a benchmark to improve mortality forecasts of China. In particular, our model allows China's systematic mortality patterns to gradually rotate to the benchmark values implied by the group of developed countries in the projection, and to reach the benchmark values in the long-run. In the empirical study, we combine the proposed approach and forecasts of China's age-specific fertility data to study China's population structure at different time horizons in various scenarios. The presenter will be a PhD student at the moment of the conference.
Keywords: Mortality modeling; Multiple populations; Population structure

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Cancer Incidence Rates Modeling and Risk Of Cancer Insurance

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Abstract

Modeling cancer incidence rates for evaluation of the price and reserve of cancer insurance is as vital as mortality rate modeling for life insurance and annuity products. However, there is a lack of researches about cancer incidence rates modeling in insurance and actuary literature. In this paper, we plan to construct an age-period model and an age-period-cohort model for cancer incidence rates by using complete database of National Health Insurance in Taiwan through 1996 to 2013. We analyze the robustness of the models by different age groups and periods on fitting and forecasting cancer incidence rates. Furthermore, we calculate the contract liability of a cancer insurance policy under IFRS 17 framework and analyze its best estimate of liability, risk adjustment, and contract service margin. Insurance risk capital from cancer insurance is also discussed by scenario analysis under our cancer incidence modeling.

Keywords: Cancer Incidence Rates, Age-Period-Cohort Model, IFRS 17.

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4.4 T1d Non-life insurance / Chair Greg Taylor

Insurance Fraud With Claim Buildup

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Abstract

The economic analysis of insurance fraud (ex post moral hazard) has failed to explain the prevalence of claim buildup in non-life insurance. In this paper, we introduce size-dependent litigation penalty in a costly state verification framework with a continuum of loss distribution and solve for an equilibrium where claim buildup exists in almost all loss types. We use a novel way of finding the binding incentive constraints when there are multiple agent types and the incentive compatibility constraint is not binding for all agents. The idea is that for a given claimed loss, the principal (insurer) will deter only those that are the most difficult to deter from fraudulently claiming this amount. The equilibrium condition determines that these are the cohort that will be indifferent between being honest and fraudulently filing said amount.
We also design an algorithm that, given a bounded loss distribution, retrieves the distribution of claims and probability of a claim being fraudulent using the Bayes' Theorem and the insurer's indifference condition in a Perfect Bayesian Nash Equilibrium.
Our findings are a considerable step forward to understanding the latent mechanism that drives insurance claims buildup and helps battle fraud in terms of mechanism design.
The presenter will be a PhD student at the moment of the conference.

Keywords: Insurance Fraud, Claim Buildup, Costly State Verification, Perfect Bayesian Nash Equilibrium, Incentive Compatibility.

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Self-selection Of Distribution System and Its Impact on the Property-liability Commission Rate

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Abstract

This paper examines the determinants of agent commission rates in the property-liability insurance industry. If insurers choose the distribution system that minimizes transaction costs(Regan, 1997), then the choice of distribution system could also affect the commission rate, suggesting that these two variables are determined simultaneously. This paper controls for the effects of chosen distribution system on the determinants of commission rate using a Heckman two-stage model. Our first stage binary model, an adaptation of Regan (1997), identifies the determinants of distribution system choice and derives the inverse Mills ratio. To control for selectivity bias, the second stage model incorporates the inverse Mills ratios among the determinants of commission rate. We employ distinct independent and exclusive agency rate specifications, thereby allowing the slope coefficients to vary, in keeping with empirical evidence that independent and exclusive insurers have different cost structures (Marvel, 1982).

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A Cape Cod model for the exponential dispersion family

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Abstract

The defining feature of the Cape Cod algorithm in current literature is its assumption of a constant loss ratio over accident periods. This is a highly simplifying assumption relative to the chain ladder model which, in effect, allows loss ratio to vary freely over accident period.
Much of the literature on Cape Cod reserving treats it as essentially just an algorithm. It does not posit a parametric model supporting the algorithm. There are one or two exceptions to this. The present paper extends them by introducing a more general stochastic model under which maximum likelihood estimation yields parameters estimates closely resembling those of the classical Cape Cod algorithm.
These estimators are shown to be minimum variance unbiased, and so are superior to the classical estimators, which rely on the chain ladder.

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On Unbalanced Data and Common Shock Models in Stochastic Loss Reserving

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Abstract

A common shock approach is a popular dependence modelling approach with some recent applications in loss reserving. The main advantage of this approach is the ability to capture structural dependence coming from known relationships. In addition, it provides a parsimonious construction of correlation matrix for a large dimension. However, the problem of unbalanced data can arise in the absence of careful modelling. This refers to a situation in which observations are of various magnitudes, and the same common shock affecting all these observations will have contributions in different proportions if adjustments are not considered. This is a typical issue in loss reserving data as claim cell values vary significantly across multiple dimensions within and also between loss triangles. In this paper, we formulate a solution to address this issue in the loss reserving context and illustrate it using a common shock Tweedie model. The results show that the solution does not only provide a much better balance in common shock proportions in unbalanced data, but also is parsimonious and provides distributional tractability for the multivariate Tweedie model.
The presenter will be a PhD student at the moment of the conference.

Keywords: Stochastic loss reserving; Dependence; Common shock; Unbalanced data; Negative claims; Multivariate Tweedie distribution; Bayesian estimation.

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4.5 T2d Mortality modelling II / Chair Cary Tsai

Health Status Mortality Modeling Based on a Multiple-state Markov Aging Model

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Abstract

Mortality heterogeneity is becoming increasingly important for the modeling of mortality risk. In this paper, we establish a finite-state time-inhomogeneous Markov ageing model with considering health status which is one of the key heterogeneity factors. We calibrate the model to both Australia cohort mortality data sourcing from Human Mortality Database (HMD) and health condition data of Australia collecting from National Health Survey (NHS) and WHO mortality database. With original health condition data being organised according to the International Classification of Diseases (ICD), we build our own health status classification by ranking health conditions and allocating them into four health status based on the severity of each condition (i.e. deadliness). The preliminary analysis shows that, while there is a certain improvement for the aggregated mortality rate, the rate of each health condition illustrates a more complex picture. We extend [1] to enable the model to capture the systematic mortality improvement by assuming that the mortality intensity of each health status follows an affine-type process, rather than using a subordinate time change process for the aggregated survival function. This permits us to directly model the stochastic development of aggregated mortality considering health status heterogeneity. And, compared to [1], our model enable us to capture the stochastic development of mortality risk in each health status at the same time. The model we developed will be compared with some other classical mortality heterogeneity models to test its efficiency in terms of annuity pricing and it will also be beneficial for future research focusing on retirement products innovation and post-retirement design.
The presenter will be a PhD student at the moment of the conference.

Keywords: Mortality Heterogeneity, Health Status, Markov Ageing Model

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A Bayesian Approach to Modeling Mortality Rates

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Abstract

Bayesian statistician specifies a prior probability, which is then updated to a posterior probability using past observed data. Statistical Bayesian theory provides a mathematical framework for performing inference or reasoning, using probability, and has numerous applications in many fields. This paper applies the statistical Bayesian theory to modeling of mortality rates. The forecasting performances of the proposed Bayesian approach and the classical Lee-Carter model are evaluated and compared in terms of the AMAPE (average of mean absolute percentage errors). Numerical illustrations based on mortality data from the Human Mortality Database for both genders of well developed countries demonstrate that the Bayesian approach outperforms the Lee-Carter model in mortality forecast.

Keywords: Bayesian Theory; Lee-Carter Model; Mortality Model; Mean Absolute Percentage Error.

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Short and Long-term Dynamics Of Cause-specific Mortality Rates Using the Cointegration Analysis

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Abstract

Historically actuaries used to work with the total mortality rates which encompassed all possible causes of death. Since the mortality rates differenced by causes of death do not have the same evolution, introducing mortality rates by cause of death brings new insight and helps to better understand the observed development of total mortality. Until recently, the common practice has been to assume the independence of difference causes of death, although the dependence between the causes clearly exists as we are in presence of competing risks. Cointegration and the related VECM (Vector Error Correction Models) methodology allow modeling the relation of two and more variables which while being subject to the different evolution patterns remain linked to each other in the long run. Using the data on main causes of death for 5 countries (USA, Japan, France, England & Wales and Australia) we apply the cointegration analysis to study the short and long-term dynamics of the cause-specific mortality rates. Impulse-response analysis is used to investigate the impact of an unexpected change in one cause-specific death rate, such as the impact of a new epidemic (sudden increase of mortality) or the discovery of a new cure for some diseases (sudden decrease of mortality).
The presenter will be a PhD student at the moment of the conference.

Keywords: mortality modelling, causes of death, cointegration, VECM, dependence, impulse-response analysis.

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How Can a Cause-of-death Reduction Be Compensated for in the Presence Of Heterogeneity? a Population Dynamics Approach Based on English Data by Deprivation

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Abstract

A growing number of studies indicate a widening of socioeconomic inequalities in mortality over the past decades. It has therefore become crucially important to understand the impact of heterogeneity and its evolution on the future mortality of heterogeneous populations. In particular, recent developments in multi-population mortality have raised a number of questions, among which are the issue of consistency between subnational and national forecasts, and the evaluation of cause-of-death reduction targets set by national and international institutions.
The aim of this paper is to show how the study of the population data and the population dynamics framework contribute to addressing these issues, by providing a new viewpoint on the evolution of aggregate mortality indicators in the presence of heterogeneity. Our findings rely on two unique datasets on the English population and cause-specific number of deaths by socioeconomic circumstances, over the period 1981-2015.
The analysis of the data first highlights the complexity of recent demographic developments, characterized by significant composition changes in the population, with considerable variations according to the age-class or cohort.
In a second part, we introduce a dynamic framework for studying the impact of composition changes on the mortality of the global population. In particular, we are interested in quantifying the impacts of cause-of-death mortality reduction in comparison with changes of composition in a heterogeneous population. We show how a cause of death reduction could be compensated for in the presence of heterogeneity, which could lead to misinterpretations when assessing public policies impacts and/or for the forecasting of future trends.

Keywords: Population Dynamics, Deprivation, Heterogeneity, Aggregate mortality, Cause-of-Death Mortality, Cohort Effect.

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4.6 T3d Insurance economics / Chair Tim Boonen

Indifference Pricing Of Bonds Linked to Actuarial and Interest Rate Risks

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Abstract

In this talk, we aim to use indifference pricing techniques to establish a general framework for agents trading risks in an incomplete market to price contingent claims that are possibly coupon bearing. While the literature mainly focuses on zero-coupon instruments or one-period models without intermediate payments, we employ a novel approach that works with the time 0 equivalent values to handle the intermediate coupon payments. Numerical illustrations involving the pricing of CAT bonds and ILWs are shown.
The presenter will be a PhD student at the moment of the conference.

Keywords: Catastrophe bond; contingent claim; incomplete market; indifference pricing; Industry Loss Warranty; time consistency.

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Optimal Reinsurance With Multiple Reinsurers: Competitive Pricing and Coalition Stability

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Abstract

We study economic pricing of reinsurance contracts via competition of an insurer with multiple reinsurers. All firms are endowed with distortion risk measures or expected exponential utilities. We require that contracts are Pareto optimal, individually rational, and satisfy a competition constraint that we call coalition stability. Indemnities are characterized by imposing Pareto optimality, as studied in the literature. In this paper, we characterize the corresponding premiums. There is a gain for the insurer due to the competition constraint. When the firms use distortion risk measures, this constraint yields stability for subcoalitions, which is a condition akin to the core in cooperative game theory. We show this gain for the insurer in closed form. Then, we derive that the premium is represented by a distortion premium function. If the firms use expected exponential utilities, the premium is represented by an exponential premium. We illustrate this premium function with the Mean Conditional Value-at-Risk.

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Robust Non-zero-sum Investment and Reinsurance Game With Default Risk

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Abstract

This paper investigates a non-zero-sum stochastic differential game between two competitive CARA insurers, who are concerned about the potential model ambiguity and aim to seek the robust optimal reinsurance and investment strategies. The ambiguity-averse insurers are allowed to purchase reinsurance to mitigate individual claim risks; and can invest in a financial market consisting of one risk-free asset, one risky asset and one defaultable corporate bond. The objective of each insurer is to maximize the expected exponential utility of his terminal surplus relative to that of his competitor under the worst-case scenario of the alternative measures. Applying the techniques of stochastic dynamic programming, we derive the robust Nash equilibrium reinsurance and investment policies explicitly and present the corresponding verification theorem. Finally, we perform some numerical examples to illustrate the influence of model parameters on the equilibrium reinsurance and investment strategies and draw some economic interpretations from these results.
The presenter will be a PhD student at the moment of the conference.

Keywords: Non-zero-sum stochastic differential game, relative performance, Nash equilibrium, model ambiguity, default risk.

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Stochastic Differential Reinsurance Games With Capital Injections

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Abstract

This paper investigates a class of reinsurance game problems between two insurance companies under the framework of non-zero sum stochastic differential games. Both insurers can purchase proportional reinsurance contracts from reinsurance markets and have the option of determining the time and amount of capital injections, which is described by impulse controls. We assume the reinsurance premium is calculated under the generalized variance premium principle. The objective of each insurer is to maximize the expected value that synthesizes the discounted utility of its surplus relative to a reference point, the penalties caused by its capital injection interventions, and the gains brought by capital injections of his competitors. We prove the verification theorem and derive explicit expressions of the Nash equilibrium strategy by solving the corresponding quasi-variational inequalities. Numerical examples are also conducted to illustrate our results.

Keywords: Stochastic differential game, Impluse control, Nash equilibrium, Quasi-variational inequality

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4.7 W1d Pricing methods II / Chair Michel Vellekoop

Construction and Examination on Risk Early Warning Model Of Property Insurance Company in China

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Abstract

In recent years, China's insurance industry has developed at a fast rate and the premium income of insurance companies has experienced a rapid growth. At the same time, with the deepening of mixed operation of financial business, the operating risk of insurance companies is also expanding. In order to protect the sustained and healthy development of the insurance industry, to ensure the role of the insurance industry to maintain economic and social stability, it is of great practical significance for us to establish a risk early warning model for insurance companies. As the operating difference between property insurance companies and life insurance companies is obvious, we only research on the construction and examination of the risk early warning model for property insurance companies to obtain more targeted results. This paper selects 15 typical property insurance companies that account for more than 85 percent of China's property insurance market share as the research objects, establishes a risk early warning model, and uses a fuzzy comprehensive evaluation method to perform empirical tests with panel data for a total of 10 years from 2008 to 2017. In this way, we finally get the company's annual warning results to analyze whether this risk early warning model is credible or not.

Keywords: property insurance, risk early warning model, fuzzy comprehensive evaluation.

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Pricing and Hedging Insurance Risks Using Principle Of Equivalent Forward Preferences

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Abstract

Since an indifference approach to value insurance risks has been adopted in [2], the actuarial pricing and hedging problem has been substantially revisited in the literature, by extending the underlying financial market, considering various insurance products, and generalizing to a portfolio of policies. All of these works used the classical expected utility preferences in their indifference arguments. Recently, a novel concept called forward investment performance process has been introduced in [1]. In this talk, we revisit the pricing and hedging problem for insurance risks using indifferent forward performance preferences to rectify a drawback in modeling under the classical expected utility framework. Instead of adopting the dynamic programming principle, we approach the problem via the tools of backward stochastic differential equations (BSDEs). Using the technique of enlargement of filtration, together with super-martingale sub-optimality and martingale optimality principles, we solve the problem by representing the prices and hedging strategies for insurance risks in terms of BSDEs.

Keywords: Indifference approach; Forward preferences; BSDEs; Enlargement of filtration; Martingale optimality principle.

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Exact Utility Indifference Pricing Methods for Incomplete Markets

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Abstract

We propose a method to determine optimal strategies for investment in markets which are incomplete. The choice of preferences and the discretization scheme for the stochastic dynamics of the risky assets allow us to prove a formal invariance result that can be exploited to find the exact optimal solution using a fast recursive algorithm.
We first illustrate our approach by comparing the known results for a number of very different optimization problems. These include the classical result for constant relative risk aversion preferences due to Merton [2], the exponential indifference pricing results of Musiela and Zariphopoulou [3] and Kraft's optimal investment strategy for equity prices that evolve according to Heston's stochastic volatility model [1].
We then use our method to define indifference pricing values for contingent claims which cannot be perfectly hedged and for preferences which need not be restricted to standard utility functions. This makes it possible to treat valuation problems which combine empirically observed preferences with risk management strategies that are not based on replication.

Keywords: Indifference pricing, Incomplete markets, Optimal investment strategies.

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The Pricing Of Deposit Insurance Under Non-black-scholes Option Theory Framework

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Abstract

Deposit insurance is used in many countries to prevent the bank from default and to hinder the country from systemic risk which can growth into economic or monetary crisis. Deposit insurance work by guarantee all saving in the bank (with several regulations), but it can cause a moral hazard when the bank take high-risk investment as the risk had been transferred to the deposit insurance. Fair pricing of a deposit insurance is needed to ensure the payment of all savings (in case of bank default) without give rise to moral hazard. Literature survey show that the price of a deposit insurance were determined based on option theory using Black-Scholes formula, which assuming that the bank asset data were fit to the lognormal distribution. Since this assumption is rarely being fulfilled, we develop a new deposit insurance pricing model which is not rely on lognormal distribution. Our approach provides an alternative framework to pricing the deposit insurance when the available data sets are not match with the Black-Scholes model assumption.

Keywords: Deposit insurance, pricing, option, Non-Black-Scholes model

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5 Goldstein G03

5.1 M1e Reinsurance-investment strategies / Chair Guohui Guan

Time-consistent Excess-of-loss Reinsurance and Investment Strategies for Insurer Under Smooth Ambiguity Utility

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Abstract

In this paper, we study the optimal excess-of-loss reinsurance and investment strategies for an insurer. The insurer is ambiguous towards the financial market. In the insurer's attitude, the rate parameter of the claim size and the market price of risk of a stock can not be estimated accurately. The insurer can purchase excess-of-loss reinsurance to hedge the insurance risk and invest in a financial market with three assets. We investigate the optimization goal under smooth ambiguity, which aims to search the optimal strategies on average. The extended HJB equation is introduced to solve this problem. Finally we derive the equilibrium strategies and present the sensitivity analysis to show the insurer's behavior. The final results show that the excess-of-loss reinsurance policy is not effected by ambiguity while the investment strategy is sensitive to ambiguity.

Keywords: Nash equilibrium; Time-consistent strategy; Excess-of-loss reinsurance; Investment; Smooth ambiguity.

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Time-consistent Mean-variance Reinsurance-investment Problems Under Unbounded Random Parameters: Bsde and Uniqueness

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Abstract

The open-loop time-consistent mean-variance (TCMV) reinsurance-investment problem is investigated when the parameters of the stochastic differential equations are stochastic and unbounded. The risk premium process of risky assets can be random and unbounded. Under an exponential integrability condition on the risk premium, we characterize the TCMV reinsurance-investment problem via a BSDE framework, adopted from [1] and [3]. An explicit solution to the equilibrium strategies is derived for a constant risk aversion under several popular financial models, including the constant elasticity of variance (CEV) and Ornstein-Uhlenbeck (OU) processes. For state-dependent risk aversion, a semi-closed form solution (up to the solutions to a pair of nonlinear PDEs) is obtained. Numerical results show that, under the CEV model, when stock price goes up, the equilibrium strategies suggest to invest more on the stock and less on the reinsurance protection. Under certain conditions, we prove the uniqueness of equilibrium strategies for constant and state-dependent risk aversion, inspired by [2]. It supplements results in the literature of using the HJB approach for the feedback controls.
The presenter will be a PhD student at the moment of the conference.

Keywords: Time-inconsistency, mean-variance, reinsurance-investment problem, backward stochastic differential equation, Ornstein-Uhlenbeck (OU) process, constant elasticity of variance (CEV) process.

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Robust Equilibrium Excess-of-loss Reinsurance and Cds Investment Strategies for a Mean-variance Insurer With Ambiguity Aversion

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Abstract

This paper considers the robust equilibrium excess-of-loss reinsurance and credit derivative swap investment strategies for an insurer. The insurer is assumed to be ambiguity aversion and to use the mean-variance criterion. She is allowed to purchase excess-of-loss reinsurance and invest in a financial market consisting of a risk-free asset and a credit default swap. Following a game theoretic approach, robust equilibrium strategies and equilibrium value functions in post-default case and pre-default case are derived, respectively. When the insurer is ambiguity aversion, the equilibrium strategies are characterized by unique solutions to some algebraic equations. For the degenerate case with an ambiguity-neutral insurer, closed-form expressions of equilibrium strategies and equilibrium value functions are obtained. Numerical examples lend support to the importance of model uncertainty and credit risk from the insurer's perspective.

Keywords: Credit default swap; Excess-of-loss reinsurance; Mean-variance criterion; Model uncertainty

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Stochastic Differential Game Formulation on Optimal Reinsurance and Investment Problem Under the Heston Model

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Abstract

This paper considers the non-zero sum stochastic differential game problem between two competitive insurers subject to the relative performance concerns. Each insurer can purchasing the proportional reinsurance to manager his own risks; and can invest in one risk-free asset and one risky asset whose price dynamics follows the Heston's stochastic volatility model. The main objective of each insurer is to maximizing the expected utility of his relative terminal surplus with respect to that of his competitor. The two insurers' decisions influence each other through the insurers' relative performance concerns and the correlation between their surplus processes. By applying the dynamic programming principle, a general framework of Nash equilibrium for the associated non-zero sum game is established. For the representative case of exponential utilities, we obtain explicit solutions for the equilibrium strategies and the equilibrium value functions, respectively. Finally, we provide some numerical studies and draw some economic interpretations.

Keywords: Non-zero sum stochastic differential game; proportional reinsurance; investment; Heston model; Nash equilibrium; Hamilton-Jacobi-Bellman (HJB) equation

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5.2 M2e Finance I / Chair Chin-Wen Wu

Do Population Demographics Predict Equity Premiums?

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Abstract

We examine the relation between demographic variables and equity premiums along with the components of equity premiums, capital gains and dividend yields. Using demographic and equity premium data for the sample period of 1933-2014 in the United States, we present evidence that population demographics predict equity premiums. The ratio of people age 0-24 to the total population predicts a decrease in equity premiums, whereas the ratio of people age 25-64 to the total population predicts an increase in equity premiums. Taking account of the effects of time and specific events, we find that the ratio of people age 65 and above to the total population significantly predicts an increase in equity premiums. The predictive power of demographic variables is even stronger after decomposing equity premiums into capital gains and dividend yields. Almost all the demographic variables studied significantly impact these components in the long term.

Keywords: demographic, equity premium, capital gain, and dividend yield.

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Approximating the True Time Weighted Return: an Optimal Approach in Terms Of Mean Square Error

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Abstract

It is a common practice to approximate the true time weighted return of a portfolio as a series of geometrically linked money weighted returns, among which the most popular is perhaps the so called Dietz return. The optimality of this procedure has never been formally proved, while a few empirical contributions questioned the accuracy of the results. We consider the best way in terms of mean square error to approximate the true time weighted return when a cash flow occurs at an unknown time during the estimation period. This condition typically occurs for a daily evaluation frequency. The main assumptions are: Gaussian, serially independent log returns; a single flow occurring at a uniformly distributed random time; independence between the amount of the flow and the returns of the period. We derive a closed-form formulation for high evaluation frequencies of an estimator that minimizes the MSE. With the further assumption of small flows we observe that the Original Dietz return can be derived as an approximation of our optimal estimator. This implies that under certain conditions the only way to improve the MSE of the Original Dietz return is to increase the information available, which in most cases means to further increase the estimation frequency.
The presenter will be a PhD student at the moment of the conference. Please do not consider me eligible for the prize reserved to students, as I'm 35 and my PhD is sponsored by my employer: let's make room for someone younger!

Keywords: performance measurement, time weighted, money weighted, approximation, mean square error

Acknowledgements: We thank Nextam Partners Sim for sponsoring the PhD as a part of its staff training program.

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Modeling and Valuation Of Reverse Mortgages in Taiwan

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Abstract

This study examines the increase of income for an elder by entering into a commercial reverse mortgage prevailed in Taiwan. The market loan to value ratio and interest rate are used to calculate the income supplement. In Taiwan, there is no insurance mechanism to protect banks and mitigate the crossover risk. Accordingly, one common contract clause in the commercial reverse mortgage is that banks have the right to terminate the contract once the value of the collateralized house is less than the loan balance. For borrowers who do not have other financial resources, they may become homeless after the property is auctioned. This study builds the cash flow model for Taiwan's commercial reverse mortgages and employs the geometric Brownian motion to simulate the future house value. We examine the probability that the bank terminates the contract early, i.e., the value of the collateralized house is insufficient. In addition, we calculate the profitability of the bank and the value of bank's early terminating option. Using a 65-year-old female borrower as an example, the effect of mortality is also reviewed.

Keywords: Reverse mortgage; Income supplement; Profitability analysis; Probability of early termination.

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Automatic Trading Strategies With Artificial Intelligence

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Abstract

Due to either declining fertility rates or mortality improvement, an aging society characterized by a growing proportion of the retired to the active working population has a great impact on the fiscal sustainability of pension funds. A partial solution to solve this problem is using automatic trading strategies to improve the performance of pension funds. Consequently, in this paper, focusing on building automatic trading strategies, we first provide a genetic algorithm, a particular class of evolutionary algorithms inspired by biological evolution,Â to learn the optimal buy and sell conditions according to the combinations of technical indicators and technical pattern characteristics. Using the trading records generated by genetic expression algorithm with the related characteristics such as technical indicators and technical pattern characteristics, we then employ deep learning to further improve the performance of automatic trading strategies. In empirical analysis, we apply this method to top 500 stocks in Shanghai and Shenzhen stock exchanges with a lengthy sample period running from 1990 to 2017 to evaluate the effectiveness of automatic trading strategies with genetic algorithm and deep learning. Our empirical evidence demonstrates that the automatic trading strategies could well prove to be profitable for the Shanghai and Shenzhen stocks after considering transaction cost with 50 basis points. Finally, the performance of automatic trading strategies is also robust to a variety of control variables.

Keywords: Automatic Trading Strategies, Technical Analysis, Artificial Intelligence, Genetic Expression Algorithm, Deep Learning.

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5.3 M3e Health insurance / Chair Atsuyuki Kogure

Adverse or Advantageous Selection in Iranian Supplementary Health Insurance Market

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Abstract

Existence of the type of selection in insurance market is of critical importance for insurers. Adverse selection leads to positive loading and higher than actuarial fair premium levels, and less than equilibrium amount of provision of insurance services. While propitious selection leads to negative loading in rate-making and sufficient amount of provision of insurance services. Existence of asymmetric information may cause adverse selection which means that individuals who are high risks purchase the insurance service more comparing to low-risk individuals. This article plans to investigate the type of selection, adverse or advantageous, in supplementary health insurance market in Iran.
We estimate two regression models in order to find the factors affecting decision to purchase health insurance coverage and the claim occurrence. We employ a dataset of an Iranian private insurance company survey. It contains information about individuals' behavior on demanding supplementary and their claim structure. The correlation between the decision to purchase health insurance coverage and the claim occurrence shows the type of selection. If the correlation is positive, it would suggest that adverse selection is predominant. Otherwise, the regime should be advantageous.
The advantageous selection regime would support the idea of setting negative loading on supplementary health insurance rates while the adverse selection regime requires positive loading.

Keywords: Supplementary health insurance, Adverse selection, Advantageous Selection, Asymmetric information

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Research on the Financing Mechanism Of Shanghai Resident Medical Insurance Under the Background Of Integration Of Urban and Rural Medical Insurance

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Abstract

Currently, China's medical security system is mainly composed of the basic medical insurance for urban employees, the basic medical insurance for urban residents and the new rural cooperative medical system. The establishment of the three systems has not only effectively alleviated the problem that it is difficult and expensive to see a doctor, but also improved the health needs and conditions of residents. With the development of economy, the separate basic medical insurance systems are hindering the effective allocation of medical and health resources, which may slow down the development of medical and health undertakings, hence exacerbate the unfairness of fund-raising and benefits among the insured groups. The government departments are actively promoting the integration of urban and rural resident medical insurance. The financing mechanism is the most important part of the medical insurance system, so this paper makes a research on the financing mechanism of resident medical insurance under the background of integration of urban and rural resident medical insurance. It takes Shanghai resident medical insurance system as an example, using empirical analysis and actuarial model to determine a unified urban and rural resident medical insurance funding standard, which will improve the resident medical insurance system in Shanghai to a great extent.

Keywords: resident medical insurance; integration of urban and rural resident medical insurance; financing mechanism.

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Predicting Health Care Costs With Covariate Shift Adaptation: an Application to Japanese Health Insurance Societies Data

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Abstract

The world is rapidly aging and the rising health care cost has been a major concern for many countries. Predicting health care costs is a significant first step toward addressing the issue. To make a prediction for the next year's cost Y_{t+1} in the current year t, it is usually the case that we construct a predictive model using the current year's cost Y_t as the response variable and the last year's covariates X_{t-1} as explanatory variables. Then we make the prediction for Y_{t+1} based on the constructed predictive model with the values of the explanatory variables replaced by those of X_t.
Underlying this methodology is the presumption that there is no change in the distribution between (X_{t-1}, Y_t) and (X_t, Y_{t+1}). However, in real-world applications we expect some form of shift in the distribution. The machine learning community has dealt with this problem under the name of dataset shift and proposed adaptation techniques to alleviate the problem.
In this paper, we consider the covariate shift, the most common case of the dataset shift. Our aim is to explore the possibility of the covariate adaptation technique for improving the accuracy to predict the health care cost at individual-level in real-life situations. In particular, we adopt a two-part model as the basic predictive model. The data we use are health care insurance claims data and health screening data of 10,000 individuals over the period from 2010 through 2012, which were randomly taken from health insurance societies of several Japanese companies.

Keywords: health care costs, predictive models, covariate shift, two-part model

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Ex-ante Moral Hazard and Its Heterogeneity Analysis in Social Medical Insurance: Evidence from Chinese Health and Nutritional Data

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Abstract

With the continuous expansion of social medical insurance coverage in China, it is important to identify and manage the moral hazard in medical services scientifically. Based on Chinese Health and Nutritional Data (CHNS), this article uses fixed effects model and propensity score matching difference in difference (PSMDID) model to investigate ex-ante moral hazard and its heterogeneity. The empirical results show that people participating in Urban and Rural Residents' Basics Medical Insurance (URRBMI) increase their tendency of smoking, drinking and other unhealthy behavior, implying the existence of ex-ante moral hazard. Moreover, there is heterogeneity between people with different qualities. Specifically, ex-ante moral hazard is significant for people with good health compared to people with poor health; People with lower education level have more ex-ante moral hazard than people with higher education level; And people with higher income is likely to have more ex-ante moral hazard than people with lower income. Based on these results, this paper proposes relevant policy recommendations for the construction of basic medical insurance system.

Keywords: ex-ante moral hazard; medical insurance; heterogeneity;

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5.4 T1e Portfolio management / Chair Jiaqin Wei

Optimal Mean-variance Problem in a Financial Market Driven by Ornstein-uhlenbeck Process

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Abstract

In this talk, we investigate the optimal investment-reinsurance strategy for a mean-variance problem when the surplus process is represented by a Cramér-Lundberg model. We incorporate the features of bull and bear markets into the stock price model, that is, the mean growth rate of the stock price is random and fluctuates around the target mean growth rate. Then the underlying asset in financial market is driven by a Ornstein-Uhlenbeck process. We adopt a backward stochastic differential equation (BSDE) approach to solve this problem. Explicit expressions for the efficient strategy and efficient frontier of the mean-variance problem are derived. Finally, numerical examples are presented to illustrate our results.
The presenter will be a PhD student at the moment of the conference.

Keywords: Mean-variance problem; Ornstein-Uhlenbeck process; Backward stochastic differential equation; Efficient strategy; Efficient frontier

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Empirical Analysis Of Index Tracking With Efficient Portfolio Dimension Reduction and Smart Beta Score

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Abstract

Using the efficient portfolio dimension reduction method proposed by Liu, Wang, and Tan[1],this paper combines the efficient portfolio dimension reduction with stock selection criterions of six smart-beta factors (profit, growth, safe, dividend, quality and momentum) to track the top 50 big cap equally-weighted stock index of Taiwan stock market. We adopt the rolling window method with month basis during the period from Jan, 2010 to Apr, 2017. The tracking stock index is composed of the top 50 big cap stocks and is renewed at first trade day at each month. Given appropriate in-sample periods and parameter, the empirical results show that the tracking EPDR portfolio rule outperforms the equally weighted stock index. Compared to the equally-weighted portfolio of top 50 big cap stocks, the EPDR portfolio rules only hold 10 to 20 assets on averages. In addition, the monthly returns of the EPDR portfolio rules are highly correlated with those of equally-weighted stock index of top 50 big cap stocks, which implies that the EPDR method may have good performance in index tracking.

Keywords: Efficient Portfolio Dimension Reduction, Smart Beta Scores, Tracking Portfolio Rules, Taiwan Top 50 Cap Index.

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Time-consistent Mean-variance Portfolio Selection With Margin Requirements

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Abstract

In this talk, I shall present some results on the time-consistent investment strategy under the mean-variance criterion. Short selling is assumed to be allowed, but accompanied by a certain percentage margin or collateral. If the margin rate is zero, then the there is no any constraints on short selling; if it is infinity, then short selling is prohibited. Under such an assumption, the state process for the mean-variance problem is nonlinear. An open-loop equilibrium strategy is obtained in explicit form by using backward stochastic differential equations.

Keywords: Mean-variance; Time-consistence; Short selling; Margin requirements; backward stochastic differential equations

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Currency Portfolio Optimization With an Innovative Covariance Matrix Estimator (qmle)

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Abstract

With the advent of high frequency data, the sum of squared returns between trades which is the most common estimator, is biased by microstructure effects like bid-ask bounce thus the need to drop most of the data. Nonetheless, a number of alternative estimators that make efficient use of the available data have been developed. However, choosing an estimator is not trivial since the study of their relative merits focuses on the speed of convergence to their asymptotic distributions. This in itself is not necessarily a reliable guide to finite sample performance, especially for cases when there is violation of assumptions on the price or noise process. Nonetheless, the covariation between asset returns plays a crucial role in modern finance in portfolio optimization, risk management and asset pricing. The paper is an effort towards estimating a covariance matrix using high-frequency data (quadratic covariation) from the portfolio selection perspective. Besides the significant increase in the sample size for estimation of the covariance matrix, use of HFD also enables for better adaptation to the local volatilities and correlations amongst a vast number of assets. This thus leads to an an improved estimation of portfolio variance. 1-minute, 5-minute, 30-minute and daily sampled forex data were used across the six major world currencies; i.e. EUR/USD, EUR/JPY, EUR/CHF, EUR/GBP, EUR/AUD and EUR/CAD. Covariance matrices based on intraday returns were constructed and evaluated.

Keywords: High Frequency Data, QMLE, Portfolio Optimization, Covariance Matrix

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5.5 T2e Pricing methods I / Chair Petar Jevtic

Structural Breaks in Dependent, Heteroscedastic, and Extremal Panel Data With Application to Non-life Insurance

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Abstract

New statistical procedures for a change in means—motivated by a non-life insurance problem—within a very general panel data structure are proposed. Unlike classical inference tools used for the changepoint problem in the panel data framework, we allow for mutually dependent panels, unequal variances across the panels, and possibly an extremely short follow up period [3]. Two competitive ratio type test statistics are introduced and their asymptotic properties are derived [1] for a large number of available panels. The proposed tests are proved to be consistent and their empirical properties are investigated in an extensive simulation study [2]. A practical application to non-life insurance is presented as well.

Keywords: non-life insurance, panel data, dependence within panels, dependence between panels, changepoint, short panels, heteroscedasticity, ratio type statistics, consistency.

Acknowledgements: This research was supported by the Czech Science Foundation project GAČR No. 18-00522Y.

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A Structural Model Of Cyber Risk Aggregate Loss Distribution Of Medium Size Enterprises

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Abstract

In a corporate and/or government domain, a cyber risk can be seen as a risk of a financial loss due to a breach of an institution's IT infrastructure by unauthorized parties and the exploitation, taking possession of, or disclosure of data assets, thus creating financial and/or reputational damage. In this paper, as a primary contribution to the existing body of actuarial literature, we propose a structural model of aggregate loss distribution for the cyber risk of medium-size enterprise. Up to our knowledge, no theoretical model of aggregate loss distribution for cyber risk exists in this setting. To achieve this, we contextualize the problem in the probabilistic graph-theoretical framework. Here, we assume the IT network topology to be represented by an appropriate (random) graph of finite (or infinite) size. We allow for heterogeneous node vulnerability and loss topology, and discuss the characteristic examples. Contagion is modelled using the framework of percolation theory. Finally, instructive numerical examples are provided.

Keywords: cyber risk, aggregate loss distribution, network topology, vulnerability

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A Macro Model Of Lapse Rate

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Abstract

Two macroeconomic variables, unemployment rate and interest rate, form competing hypotheses of policyholder's lapse behavior. We propose an empirical model to capture the impact of economic climate across policy years. We use a panel dataset of Taiwanese industry-wide lapse record that covers more than 26 million whole life and endowment insurance policies during 1981 - 2011. Preliminary analysis shows both the unemployment rate and interest rate explain the lapse rate trend but do not differ in capturing the cross-sectional variation. In the recession, the whole life policyholders are more likely to lapse early, but less likely to lapse when the policy is held longer. In contrast, endowment policyholder reacts consistently to economic change. We also find the lapse behavior of older policyholder is more sensitive to economic change than younger policyholder, which supports the conclusion in [1].

Keywords: Lapse rate model, Macroeconomic variables, Interest rate hypothesis, Emergency fund hypothesis.

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Competing Risks Under the Absorbing Markov Mixture Model

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Abstract

Competing risks play important role in censoring, which have found many applications across various fields including actuarial science. In this paper we present some new results on competing risks under the framework of absorbing Markov mixture model proposed in the recent work of Surya [1]. It is a mixture of continuous-time absorbing Markov chains moving at different speeds, where the mixture occurs at a random time. Identities concerning distributional properties of the process exit time due to a specific cause of exit are explicit in terms of the Bayesian update of switching probability and the intensity matrices of the underlying Markov chains, despite the fact that the mixture process is non Markovian. They form non-stationary of time and duration and have the ability to capture heterogeneity and past observation of the process, when conditioning on the available past information of the process up to current time. Following [1], we discuss forward intensity which corresponds to the likelihood of future events given past observation of the process. The results further extend that of given in [1] in the presence of censoring. Their availability in closed form offers promising features for applications, e.g. in actuarial science. We give some (numerical) examples to motivate the main results.

Keywords: Competing risks, Markov chains, Markov mixture processes, forward intensity.

Acknowledgements: The author is grateful for the GMS financial support # 218772 provided by Victoria University of Wellington.

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5.6 T3e Agriculture insurance / Chair Yang-Che Wu

Pricing Models Of Agriculture Insurance in Indonesia

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Abstract

Insurance on agricultural products has only been implemented in Indonesia as pilot projects [5]. There are several issues that need to be considered to make successful implementation of this project in the future. The fact that most of Indonesian farmers are in the lower level of economic status makes it a burden for the farmers to pay the insurance premium. If government can provide a significant support in this issue, it will certainly help the farmers. On the other hand, Indonesian farmers face a high level of farming risks with repect to weather uncertainty in tropical region that affect directly their crop yields. It has been studied empirically [4] that agricultural products have high volatility value. Based on this specific risk, a good model of premium pricing is needed, so that it doesn't give extra finacial burden for the farmers. A well defined crop insurance for rice production has been presented in [2]. This paper presents an alternative pricing model on agriculture insurane compared to the classical ones [1][3], considering the caracteristics of Indonesian farmers.

Keywords: agricultural products, insurance pricing

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The Effectiveness Of Agricultural Insurance and Policy Under Climate Forecasts and Different Production Stages

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Abstract

Climate-related risk has considerable effects on agriculture. When climate forecasts, agricultural insurance and government policy are combined, climate forecasts enabled farmers to prepare for upcoming weather challenges, and thus extreme weather events incur lower government bailouts and smaller farmer tax payments; agricultural insurance can further decrease the volatility of farmers' profits and stabilize agricultural production. These results suggest that government bailouts only help farmers in the convex stage of production avoid heavy financial burdens and encourage farmers to purchase agricultural insurance in the concave stage of production. Effective climate forecasts employed by governments assist farmers in production decision-making.

Keywords: agricultural insurance, agricultural production, government agricultural policy, climate forecast

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Improved Index Insurance Design and Yield Estimation Using a Dynamic Factor Forecasting Approach

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Abstract

Accurate crop yield forecasting is central to effective risk management for many stakeholders, including farmers, insurers, reinsurers and government. This is important for crop management, sales and marketing, designing insurance policies, setting premium rates, reserving, and other risk management purposes. The purpose of this paper is to investigate a new approach to forecast yields using a dynamic factor model. Then, based on the proposed approach a weather index-based insurance policy is designed with a focus on reducing basis risk, which has historically been a major limitation in the more wide-spread use of index-based approaches for agriculture. This dynamic factor approach is motivated by its ability to effectively summarize the information in a high-dimensional design matrix into lower-dimensional unobservable common factors. This makes it possible to consider an extensive set of variables that may be relevant to predicting crop yield, and in this paper 116 variables are considered, including 61 weather variables and 55 soil condition variables. Using county-level and state-level annual cropproduction experience from Illinois State, U.S., for three crop types, including corn, soybeans, and winter wheat, the empirical results show that the dynamic factor approach is capable of producing more accurate forecasting results compared to more popular statistical models.

Keywords: Crop Yield Forecasting; Factor Model; Index Insurance

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6 Colombo B

6.1 M1f Pricing annuities / Chair Eric Ulm

Pricing Impaired Life Annuities

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Abstract

The problem of the lack of annuitization (F. Modigliani's "annuitization puzzle"), continues to be widely discussed in the literature. A number of studies give a wide range of possible explanations, following two main approaches: the rational and the behavioral economics. Under the first approach, which will be embraced in this work, the adverse selection is one of the most popular explanations. Adverse selection in this context is the lack of actuarially fair supply of life annuities for those with an average or impaired life expectancy.
The ultimate purpose of this paper is to offer a contribution to partially solve the "annuitization puzzle", giving evidence that it is possible to fairly price life annuities for those lives that disease has diminished.
To accomplish the purpose in question, two steps are required. First it is necessary to assess the impact of some of the most serious and common medical conditions (cancer and some cardiovascular or respiratory diseases) over the survival curve, by using (1) net and (2) crude relative survival estimates, over a reference life table. Second, using the survival curves already adjusted taking in consideration each particular illness, proceed to calculate the life annuity premiums for the lives impaired due to that illness, and compare them with those of the general population in Portugal.
Although a few problems remain, mostly related with the quality and volume of available data, calling sometimes for precaution with respect to conclusions, some important results could be obtained. As expected, should impaired lives had access to a fair market, perhaps the Portuguese annuities business would increase.

Keywords: Life annuity, impaired life, net survival, crude probability of death, Portugal.

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On Valuing Equity-linked Annuities Embedded With Multiple Icicled Barrier Options

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Abstract

Motivated by the popularity of autocallable structured product, this paper proposes a new type of equity-linked annuity by embedding multiple icicled barrier options. The icicled barrier options, forming an extended class of partial barrier options, have been introduced by Lee and Ko (2018) to incorporate the concept of early redemption from the autocallable product into a unifying framework of barrier options. In this paper, we further develop their pricing methodology by considering multiple icicles and investigate the applicability to the equity-linked annuities. According to the multiple icicled barrier options, there may exist a variety of annuity payoff structures which increase the crediting rate or lock in the interest earned. Using the reflection principle of the Brownian motion and the actuarial method of Esscher transform, we derive various joint probabilities associated with the logarithmic returns at the multiple icicled times and the maturity, and obtain closed-form pricing formulas in terms of the multivariate normal distributions. The formulas are not only related to the pricing of the popular autocallable version, but can also be utilized for the risk management. The results are explored through numerical examples.

Keywords: Autocallable structured product, Black-Scholes model, Equity-linked annuity, Esscher transform, Icicled barrier option, Reflection principle

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Grouped Multivariate Functional Time Series Forecasting: an Application to Annuity Pricing

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Abstract

Age-specific mortality rates are often disaggregated by different attributes, such as sex, state, ethnic group, education and socioeconomic status. Forecasting age-specific mortality rates at the national and sub-national levels play a vital role in developing social policy and pricing annuity. However, the independent mortality forecasts at the sub-national levels may not add up to the forecasts at the national level. Further, the independent forecasts may not utilize correlation among sub-populations to improve forecast accuracy. To address these two issues, we modify and extend the grouped univariate functional time series to grouped multivariate functional time series forecasting. For quantifying forecast uncertainty, we utilize a nonparametric bootstrap method to reconcile interval forecasts. Using the regional age-specific mortality rates in Japan obtained from the Japanese Mortality Database, we investigate the one-step-ahead to 15-step-ahead forecast accuracy among the independent and grouped univariate and multivariate functional time series forecasting methods. The grouped multivariate functional time series forecasting methods are not only shown to be useful for reconciling forecasts of age-specific mortality rates at national and sub-national levels, but they also use multivariate functional principal component regression to jointly model sub-populations and enjoy potentially improved forecast accuracy averaged over different disaggregation factors. The improved forecast accuracy of mortality rates is of great interest to the insurance and pension industries for estimating annuity prices, in particular at the level of population sub-groups, defined by critical factors such as sex, region, and socioeconomic grouping.

Keywords: Forecast reconciliation; Hierarchical/grouped time series; Multivariate functional principal component analysis; Bottom-up method; Optimal-combination method; Japanese Mortality Database

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The Effect Of Retirement Taxation Rules on the Value Of Guaranteed Lifetime Withdrawal Benefits

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Abstract

We examine the value of GLWB options embedded in variable annuities in two different tax regimes. The New Zealand system taxes investment income when it is earned whereas the system in the US defers taxes on annuity investment income until it is paid out. We examine the effects of these tax differences on the charges collected by the issuer as well as on the value of the contract to the policyholder. We find that the issuer's charges are typically lower (higher) in the NZ tax regime when the expected fund earnings are low (high) or the fund volatility is high (low). On the other hand, the value to the policyholder is always lower in the NZ tax regime due to the earlier tax payments. We also find that the value of the GLWB in the NZ tax regime is nearly always below the value of an ordinary payout annuity with the same tax rules.

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6.2 M2f Dependence modelling I / Chair Julien Trufin

Gini-shortfall and a Risk Capital Allocation Rule Based on It for a Portfolio Of Dependent Risks

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Abstract

Assume a portfolio of n risk components having Archimedean dependence. Also, choose Gini-shortfall (GS) as the risk measure and consider the class of risk capital allocations that stems from GS(see, Furman, E., Wang, R., Zitikis, R. (2017). [1]). The determination of the aggregate and allocated risk capitals in the described set-up is not trivial at all, yet it is a pressing need for an insurer or a bank according to the new regulation rules. In this talk I will discuss a complete solution to the just-mentioned problem by showing how explicit expressions for the desired quantities can be obtained. Main machinery employed will be that of the weighted distributions as well as the phase-type or, more generally, matrix exponential distributions.
The presenter will be a PhD student at the moment of the conference

Keywords: s: risk measure, variability measure, Gini shortfall, Gini capital allocation, matrix exponential distribution, phase-type distribution.

References

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Multivariate Models Connected With Random Sums and Maxima

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Abstract

We present recent results concerning a stochastic model for the sum X and the maximum Y of dependent, heavy-tail Pareto components. Our results include explicit forms of the probability density and cumulative distribution functions, marginal and conditional distributions, moments and related parameters, parameter estimation, and stochastic representations. We also derive bivariate mixed tail conditional expectations, $\mathbb{E}(X|Y > y)$ and $\mathbb{E}(Y|X > x)$, which provide useful and practical risk measures in addition to the univariate TCEs recently derived for this model. Finally, we present real data examples from finance, illustrating the usefulness of the model.
The talk is based on a joint work with Tomasz J. Kozubowski and Anna K. Panorska (University of Nevada, Reno).

Keywords: Dependence by mixing; Generalized Pareto distribution; Lomax distribution; Extremes; Tail conditional expectation; Common background risk.

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Bounds on Multivariate Kendall's Tau and Spearman's Rho for Zero-inflated Continuous Variables

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Abstract

In this talk, we derive upper bounds on Kendall's tau and Spearman's rho for multivariate zero-inflated continuous variables. A lower bound for Spearman's rho is also established in the bivariate case. Zero-inflated distributions combine a continuous distribution on the positive real line and a point mass at zero. These distributions appear in numerous areas. For instance, in insurance studies, the total claim amount related to a given contract is often equal to zero, when no claims have been reported to the insurer, but may also by strictly positive when one or several accidents occurred. The bounds derived in this talk are easy to compute and can be estimated from a data set of zero-inflated random vectors. This provides analysts with the range of possible values for Kendall's tau and Spearman's rho, helping them to interpret the obtained results as shown in a numerical illustration.

Keywords: Kendall's tau, Spearman's rho, multivariate zero-inflated data, upper bounds.

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Modeling High Dimensional Systematic Risk

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Abstract

The Lévy Subordinated Hierarchical Copula Models (LSHAC) have been proved to be successful in modeling the dependence structure of finance and insurance processes[1]. One of the biggest challenges in efficiently apply the LSHAC model in the empirical modeling is that in high dimension cases (e.g., when dimension is higher than 100), it is almost impossible to obtain the expressions of their likelihood functions. As a result, the traditional maximum likelihood estimation (MLE) method is inapplicable in the very high dimensional cases. In this article, we estimate high-dimensional LSHAC with genetic algorithm (GA) and simulation method of moments (SMM). GA-SMM only depends on moment conditions instead of the whole likelihood. Another significant advantage of the proposed GA-SMM method is that it provides a good measure for evaluating and comparing hierarchical structures of the LSHAC. Empirical results show that GA-SMM provides accurate and efficient parameter estimation in a very high dimension setting. We apply the proposed estimating method to study systematic risk in the high dimensional financial market. In particular, we compare the CoVaR[2] of different LSHAC models and analyze the systematic risk of the financial market. More interestingly, we construct a market portfolio according to the optimal LSHAC estimated by GA-SMM with better performance.

Keywords: Levy Subordinated Hierarchical Copula, Genetic Algorithm, Simulation Method of Moments, Systematic Risk, Dependence Structure.

References

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6.3 M3f Life insurance products / Chair Johnny Li

Anticipating the New Life Market: Bounds for Longevity-linked Derivatives

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Abstract

We consider longevity trend bonds, of which a prime (and so far only) example is the Swiss Re Kortis bond written on the divergence between two populations, and thus, requires the use of a multi-population model. Using three different multi-population models (namely, the Li and Lee, the common-age-effect, and a copula-based model), we show that the assessment of the risk underlying the longevity trend bond is substantially different for each model. For this reason, we propose to use upper and lower bounds which rely on the existing and well developed single-population models only.
Taking into account the payoff structure of this bond, it is obvious that upper and lower bounds for spread options are our key tools. Upper and lower bounds for spread options has been derived in [1] and [2], respectively. Here, we provide an alternative proof for these bounds leading to expressions which are conveniently expressed as super- and sub-replicating strategies, with closed-form expression for the marginal strikes. In addition, we provide model-free closed-form expressions for the cumulative distribution functions (cdf) and probability distribution functions (pdf) of comonotonic and counter-monotonic differences. Finally, we derive super- and sub-replicating strategies for the payoff of the bond and show how the methodology can be applied to other mortality-linked securities.
These results allow to determine bounds for the time-t intrinsic value of the payoff, relying on the modelling of single population indices only. Thus, they can help to narrow the confidence intervals of (long-term) multi-population projections. On the other hand, the strategies could provide model-free upper and lower bounds, based on the observed market prices of longevity derivatives. Of course, the latter application implicitly assumes that such derivatives are standardized and openly traded in a liquid market.
The presenter will be a PhD student at the moment of the conference.

Keywords: Longevity trend bonds, spread options, comonotonicity.

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Participating Policies and Investment Incentives Of Life Insurers

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Abstract

A participating policy issued by a life insurer gives the policyholder a share of proceeds from the company's investments, subject to a guaranteed minimum rate of return. Using an extension of the theoretical model developed by [1], we show that the guaranteed return rate creates a conflict of interest between owners and policyholders. Our model assumes that the insurer allocates a fraction of its resources to a risky investment with high expected returns, and the rest to an interest-bearing money market account. Under the contingent pricing framework, the policy contains an embedded option that is of greater value to the policyholder than to the owners. For the policyholder, the optimal strategy is to invest all of the insurer's assets in the risky investment. However, the guaranteed minimum return creates an asymmetric payoff structure for the owners, and as a result the optimal owner strategy is to invest a fraction less than 1.0.
Through Monte Carlo simulation, the efficient frontiers of a participating policy are derived, both for the policyholder and for the insurer. Our simulation results show that as the policyholder's share increases, the insurer's payoff on the risky asset deteriorates. For this reason, the insurer may make its investment policy more conservative as the participation level rises.

Keywords: life insurance, participating policy, guaranteed return, contingent pricing, Monte Carlo simulation.

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Determinants Of Universal Life Insurance in Iran

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Abstract

Life insurance has a fundamental role in financial market and its significance is for the consumer services it provides, security it brings and investment it stimulates in the capital market. With Iran having low insurance penetration rate, we are motivated to investigate the elements that affect life insurance consumption in Iranian insurance market in order to suggest the ways to increase the purchase of life insurance.
In this study, we use an annual macroeconomic data and time series analyses to examine the effect of selected demographic and financial factors on the demand for universal life insurance in Iran. There will be two dependent variables, namely life insurance penetration rate and life insurance density, representing life insurance demand, and different independent variables such as income, inflation rate, interest rate, financial development index, dependency ratio, life expectancy, education, urbanization, and social security. We will use multiple regression (log-linear) models and lagged dependent variable models to estimate the attributed coefficients. Accordingly, changes in the demand of life insurance resulted by changes in independent variables can be measured.

Keywords: Universal life insurance, Penetration rate, Life insurance demand, and lagged dependent variable model.

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Constructing Out-of-the-money Longevity Hedges Using Parametric Mortality Indexes

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Abstract

Proposed by [1], parametric mortality indexes (i.e., indexes created using the time-varying parameters in a suitable stochastic mortality model) can be used to develop tradable mortality-linked derivatives such as K-forwards. Compared to existing indexes such as the LLMA's LifeMetrics, parametric mortality indexes are richer in information content, allowing the market to better concentrate liquidity. In this paper, we further study this concept in several aspects. First, we consider options written on parametric mortality indexes. Such options enable hedgers to create out-of-the-money longevity hedges, which, compared to at-the-money-hedges created with q-/K-forwards, may better meet hedgers' need for protection against downside risk. Second, using the properties of the time-series processes for the parametric mortality indexes, we derive analytical risk-neutral pricing formulas for K-forwards and options. In addition to convenience, the analytical pricing formulas remove the need for computationally intensive nested simulations that are entailed in, for example, the calculation of the hedging instruments' values when a dynamic hedge is adjusted. Finally, we construct static and dynamic Greek hedging strategies using K-forwards and options, and demonstrate empirically the conditions under which an out-of-the-money hedge is more economically justifiable than an at-the-money one.

Keywords: K-forwards; K-options; Longevity Greeks; Risk-neutral pricing; The CBD mortality indexes; Value-at-Risk.

References

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6.4 T1f Copulas / Chair Hélène Cossette

Reinsurance Of Dependent Risks

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Abstract

This work focuses on the optimal reinsurance problem for two dependent risks, from the point of view of the ceding insurance company. We assume that the two risks are dependent by means of a copula structure. By risk we mean a line of business, a portfolio of policies or a policy.
The problem consists in finding the optimal combination of quota-share and stop loss treaties, for each risk, that maximizes the expected utility or the adjustment coefficient of the total wealth of the insurer. It is known that these two criteria are connected and moreover the adjustment coefficient is related to the ultimate probability of ruin of the insurer through the Lundberg inequality. Results are obtained numerically, using the software *Mathematica*. Sensitivity of the optimal reinsurance strategy to several values of the dependence parameter, corresponding to different values of the tau, to different distributions of the underlying risks and to a variety of reinsurance premium calculation principles are performed in three families of copulas describing different tail behaviours of the joint distribution function.
Results show that dependencies alter the optimal treaty. Different dependence structures, *i.e.* different copulas, provide different values for the optimal retention levels. In the case of the expected value principle computed on the total ceded risk, the pure stop loss contract is always optimal, but that is not the case for the remaining premium computation principles. In general, the QS retention level decreases when dependence between the risks increases. For all cases considered, the maximum adjustment coefficient decreases when dependence increases.

Keywords: Reinsurance, Dependent Risks, Copulas, Premium Calculation Principles, Expected Utility, Adjustment Coefficient

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Hierarchical Archimedean Copulas Defined With Multivariate Compound Distributions: Properties and Estimation Procedure

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Abstract

In this talk, we discuss a new hierarchical Archimedean copula construction based on multivariate compound distributions. This new imbrication technique is derived via the construction of a multivariate exponential mixture distribution through compounding. The absence of nesting and marginal conditions, contrarily to the nested Archimedean copulas approach, leads to major advantages. A balance between flexibility and parsimony is targeted. After presenting the construction technique, properties of the proposed copulas are investigated. Assuming that the multivariate compound distributions are characterized by finite dimensional parameters, we propose an estimation procedure for these copulas.

Keywords: Hierarchical Archimedean Copulas; Hierarchical Compositive Likelihood Estimation Method; Tree Structure determination.

Acknowledgements: This work was partially supported by the Natural Sciences and Engineering Research Council of Canada (Cossette: 054993; Marceau: 053934) and by the Chaire d'actuariat de l'Université Laval (Cossette, Gadoury, Marceau, and Mtalai: FO502320).

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Modeling the Dependence in Compound Model Using Copula Representation

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Abstract

While the copula method is a popular choice in modelling the dependence, the choice of the proper copula family is much harder in general compared to the choice of the proper marginal distribution families. Especially, in the modelling of dependence between frequency and average severity, we show, by example, that classical copula approach may mislead the dependence between frequency and severity. Alternatively, in this presentation, we provide the copula method which can safely model the dependence among frequency and individual severities. Factor copula representation of the proposed model is also presented for the possible extension of the model.

Keywords: Dependence, Copula, Frequency-Severity, Compound model, Factor copula

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Collective Risk Models With Hierarchical Archimedean Copulas

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Abstract

In actuarial science, collective risk models, where the aggregate claim amount of a portfolio is defined in terms of random sums, play a crucial rule. In these models, it is common to assume that the number of claims and their amounts are independent, even if this might not always be the case. In this paper, we use Archimedean and hierarchical Archimedean copulas in collective risk models, to model the dependence between claim number random variables and the claim amounts involved in the random sum. Such dependence structures allow us to derive a computational methodology for the assessment of the aggregate claim amount. While being very flexible, this methodology is easy to implement, and can easily fit more complicated hierarchical structures. Using specific distributions for the number and the amounts of claims, we also derive explicit expressions for the aggregate claim amount and its related quantities.

Keywords: Random sums; Collective Risk Models; Archimedean Copulas; Hierarchical Archimedean Copulas.

Acknowledgements: This work was partially supported by the Natural Sciences and Engineering Research Council of Canada (Cossette: 054993; Marceau: 053934) and by the Chaire d'actuariat de l'Université Laval (Cossette, Marceau, and Mtalai: FO502320).

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6.5 T2f Finance II / Chair Ruodu Wang

Electricity Price Modelling With Stochastic Volatility and Jumps: an Empirical Investigation

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Abstract

The market of electricity derivatives has experienced a substantial growth in the volume of trade and the diversity of available products over the past few years. This leads to a rich data environment that requests more sophisticated and accurate modeling approaches for the spot electricity prices. This paper deals with the analysis of continuous-time stochastic volatility jump-diffusion processes in the context of pricing of futures contracts written on electricity spots. We formulate a model, which aims to capture the most prominent characteristics and stylized facts of the electricity spot market including mean reversion, seasonality, extreme volatility and spikes. The proposed modeling framework extends the existing techniques by incorporating mean reversion terms, stochastic volatility and jumps in both, the underlying spot process and its volatility. The model parameters are estimated using the Markov Chain Monte Carlo (MCMC) technique for the Australian electricity market, which has highly liquid futures trading that is relevant for the pricing application analysis. Using the market price of risk estimated from the futures market, we compute futures prices in a closed form and demonstrate that the model fits data well in-sample and out-of-sample.
The presenter will be a PhD student at the moment of the conference.

Keywords: Power markets; electricity modeling; energy derivatives; jump diffusion models; futures pricing.

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an Axiomatic Theory for Rating Structured Products

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Abstract

Credit rating is ubiquitous in all forms of financial products, and in particular structured products. In view of its fundamental importance, this paper proposes a set of axioms on a credit rating system for structured financial products. A desirable rating system, satisfying the axioms of scale invariance, no-structuring arbitrage, and scenario relevance, is called *coherent*. In addition, we study the consistency with pooling effect for rating systems. In our framework, the *probability of default* criterion used by Standard & Poor's and Fitch does not satisfy the no-structuring arbitrage axiom, and it also fails to be consistent with pooling effect. On the other hand, the *expected loss* criterion used by Moody's is a coherent rating system consistent with pooling effect, but fails to effectively reflect economic scenarios. As one of the main theoretical results, we show that a coherent rating system is characterized by a rating measure which admits a Choquet integral representation. Based on the theory, we propose some forms of coherent rating measures that can be used for practice. An empirical study on credit derivatives market data supports some of our theoretical considerations.

Keywords: credit rating, structured products, Choquet integrals, structuring arbitrage

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Renewable Energy Investments With Storage: a Risk-return Analysis

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Abstract

Purpose - The aim of this paper is to study investments in renewable energy projects which are jointly operated with an energy storage system, taking into account resource risk, energy price risk, inflation risk, and policy risk, with particular focus on risk-return characteristics from the perspective of private and institutional investors.
Design/methodology/approach - To this end, we present a stochastic discounted cash flow model and, via a numerical simulation analysis, apply this model to a wind farm with a pumped hydro storage system.
Findings - Our results show that energy storage systems have the potential to increase the expected present value of future investment cash flows and to hedge (downside) risk. However, in order to realize this potential, storage systems have to be cost-effective in terms of fixed operation, maintenance, staffing and insurance costs. We also identify several key factors which have a considerable influence on the performance of the operation strategy.
Originality/value - The paper contributes to the literature by conducting an analysis of (downside) risk and return of renewable energy investments with a storage system taking into account stochastic policy, resource, inflation, and energy price risk.
The presenter will be a PhD student at the moment of the conference.

Keywords: Renewable energy; wind farm; energy storage; policy risk; value at risk.

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Signed Choquet Integrals With the Cxls Property

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Abstract

In the past few years, elicitability has been considered as a desired property of risk functionals. The property of "convex level sets" (CxLS) is a necessary condition of elicitability. This article studies the CxLS property of a class of non-monotone law-inavriant risk functionals, the signed Choquet integrals, and we establish a characterization result in dimension one. We discuss higher dimensional signed Choquet integrals with the CxLS property and their applications in the statistical analysis of financial and insurance risks.
The presenter will be a PhD student at the moment of the conference.

Keywords: Convex level sets; Elicitability; Choquet integrals; Risk functionals

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6.6 T3f Risk theory / Chair JK Woo

Bivariate Regular Variation Among Randomly Weighted Sums in General Insurance

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Abstract

The tail behavior of randomly weighted sums has become an increasingly interesting topic in applied probability and this study has played an important role in a few problems in insurance, finances, and risk management. In this paper, we extend the study to the case of non-standard bivariate regular variation and, as applications, we interpret the study in terms of bivariate processes of aggregate claims (without discount, with discount according to either a constant force of interest or stochastic investment returns).

Keywords: bivariate regular variation, randomly weighted sums, asymptotics; limit measure, aggregate claims

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Joint Compound Discounted Renewal Sums With Emphasis on the Asymptotics Of Ibnr Claims in the Fractional Poisson Process

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Abstract

In this talk, we study the joint moments of a compound discounted renewal process observed at different times with each arrival removed from the system after a random delay. This process can be used to describe the aggregate (discounted) Incurred But Not Reported (IBNR) claims in insurance and also the total number of customers in an infinite server queue. It is shown that the joint moments can be obtained recursively in terms of the renewal density, from which the covariance and correlation structures are derived. In particular, the fractional Poisson process defined via the renewal approach is also considered. Furthermore, the asymptotic behaviour of covariance and correlation coefficient of the aforementioned quantities is analyzed as the time horizon goes to infinity. Special attention is paid to the cases of exponential and Pareto delays.

Keywords: Fractional Poisson process, Incurred But Not Reported (IBNR) claims, Infinite server queues, Joint moments.

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Fluctuation Theory for Level-dependent Lévy Risk Processes

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Abstract

A level-dependent Lévy process solves the stochastic differential equation

$$dU(t) = dX(t) - \phi(U(t))\,dt,$$

where X is a spectrally negative Lévy process. A special case is a multi-refracted Lévy process with $\phi_k(x) = \sum_{j=1}^{k} \delta_j 1_{\{x \geq b_j\}}$. A general rate function ϕ that is non-decreasing and continuously differentiable is also considered. We discuss solutions of the above stochastic differential equation and investigate the so-called scale functions, which are counterparts of the scale functions from the theory of Lévy processes. We show how fluctuation identities for U can be expressed via these scale functions. We demonstrate that the derivatives of the scale functions are solutions of Volterra integral equations.

Keywords: Refracted Lévy process, multi-refracted Lévy process, level-dependent Lévy process, Lévy process, Volterra equation, fluctuation theory.

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Insurance and Self-protection for Increased Risk Aversion

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Abstract

We investigate how increased risk aversion affects prevention activities of decision makers.By applying interval dominance order[], we find that an increased risk aversion induces higher level of protection if the value of hazard rate is higher than the 'boldness'coefficient[1]. Meanwhile, we try to show this new condition is effective with SICP model[2] and a general case model with continuous states of nature.
The presenter will be a PhD student at the moment of the conference.

Keywords: Risk aversion; Interval dominance order

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Insurers' Contingent Convertible With a Regulation Consistent Trigger

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Abstract

We study a Contingent Convertible (CoCo) bond issued by an insurer. We propose a new type of trigger for the CoCo based on the insurer's one-year probability of ruin. We argue that there are advantages of using such a trigger over many others currently in use and over some proposals that have appeared in the literature, and we note that such a proposal is consistent in spirit with the evolving prudential insurance regulations. It enables us to see why the capital ratio trigger widely used by banks may be ill-suited for insurance companies. We then develop a structural model for the CoCo bond issuer, and further propose a novel approach to pricing the CoCo. On the one hand, we use the canonical method to identify a risk-neutral pricing measure. On the other hand, to address the computational challenge arising from repeated assessments of the rare-event probability of ruin, we propose a Weighted Least Square Monte Carlo method used in combination with stratified sampling.

Numerical results are shown to illustrate the pricing approach, and also shed lights on the impact of some parameters on the design of the CoCo bond. In addition, they show the impact of the CoCo on the insolvency risk of the insurer, which provides important guidance as to whether the CoCo qualifies as risk capital for regulatory purpose.

Keywords: Contingent convertible; insurance regulation; least square Monte Carlo; trigger

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Group Solvency Calculations and Risk Measures: What Is Described Economically?

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Abstract

In this paper group solvency calculations under different risk measures are anlaysed taking into account different regulatory regimes. This is key to understand international insurance markets, because they are highly dominated by large insurance groups (or financial conglomerates). The Insurance Capital Standards (ICS 1.0) for Internationally Active Insurance Groups (IAIGs) were released in July 2017 by the International Association of Insurance Supervisors (IAIS) for extended field testing ([1]). We compare them in respect of efficient capital allocation with the Solvency II group solvency capital requirements (Group SCR), which came into effect from 1st January 2016 for EU based insurance groups ([2]). Other countries like China introduced solvency regimes with characteristics which are similar to Solvency II techniques (C-Ross). However, the ICS are expected to be the future risk-based global standard for group solvency calculations and the foundation of a Higher Loss Absorbency (HLA) for Globally Systemic Important Insurers (G-SIIs) ([3]).
The IAIS proposes to treat insurance groups for calculating their capital requirements as single economic entity and to start from consolidated data. However, legal structures and risk categories of insurance groups vary and the (pure) consolidated view might be not appropriate. As under Solvency II the Value-at-Risk (VaR) is proposed as risk measure. There are some known shortcomings of the VaR: e. g. it is not coherent. The Conditional Value-at-Risk (CVaR) fulfils the criteria of sub-additivity and allows therefore a more intuitive capital allocation within an insurance group. The scope of risk measures could be broadened by the class of spectral risk measures (see e. g. [4]). This might be helpful for a better understanding of the interplay of solo and group supervision in practice.
Research on groups-specific issues of financial institutions and especially insurance group is rare. In our paper we address also some special issues that have been experienced from the Solvency II group solvency calculations - taking into account the non-coherence of VaR (e. g. [5], [6]). After comparing the scope of consolidation we examine so-called horizontal groups (often mutuals). Additionally, we consider holding structures. Amongst other issues, we finally look at the availability and transferability of groups' capital resources bearing in mind diversification and consolidation effects ([7]). The contribution of this papper is to link group capital modelling with the legal requirements. It is worth to consider the legal constraints and the variety of legal structures in practice. However, this might complicate theoretical considerations. But the ambiguity caused be different perspectives (e. g. accounting, supervision and/or internal economic view) is the core of insurance group (risk) management.
It turns out that group solvency calculations under the proposed ICS will face challenges comparable to Solvency II group supervision because of the underlying correlation assumptions. As an outlook we consider some more detailed recommendations for the ICS to clarify a consistent risk-based treatment of insurance groups (also in in preparation for the development of ICS 2.0 for adoption in late 2019) and to contribute to further research on group risk assessments and systemic risk in the insurance sector ([8]). The ICS 2.0 will be developed for IAIGs and possibly extended to other groups (even to single entities).

Keywords: group solvency; ICS; Solvency II; risk measure; coherence; VaR; CVaR

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Operational Choices for Risk Aggregation in Insurance: Psdization and Scr Sensitivity

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Abstract

This paper answers crucial questions about the robustness of the *PSDization process* for applications in insurance. *PSDization* refers to the process that forces a matrix to become positive semi-definite. For companies using copulas to aggregate risks in their internal model, *PSDization* occurs when working with correlation matrices to compute the Solvency Capital Requirement (SCR). We study how classical operational choices concerning the modelling of risk dependence impacts the SCR during PSDization. These operations refer to permutations of risks (or business lines) in the correlation matrix, addition of a new risk, and introduction of confidence weights given to the correlation coefficients. Using genetic algorithms, it is shown that theoretically neutral transformations of the correlation matrix can surprisingly lead to significant sensitivities of the SCR (up to 6%). This highlights the need for a very strong internal control around the PSDization step.

Keywords: Solvency II, risk aggregation, positive semi-definite, Rebonato-Jäckel.

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Sample Recycling Method - New Technique for Efficient Nested Simulation

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Abstract

As more regulatory reporting requirements in the regulatory regimes around the world move towards dependence on stochastic approaches, insurance companies are experiencing increasing difficulty with detailed forecasting and more accurate valuation and risk assessment based on Monte Carlo simulations.
Stochastic modeling is commonly used by financial reporting actuaries whenever reporting procedures, such as reserving and capital requirement calculation, are performed under various economic scenarios, which are stochastically determined. Nested stochastic modeling is required whenever modeling components under each economic scenario are determined by stochastic scenarios in the further future.
Many existing techniques to speed up runtime of nested simulations is based on the reduction of inner loop calcuations by curve fitting techniques. The essence of these techniques is to develope a functional relationship between risk factors (equity values, interest rates, etc) and target features (insurance liability or their greeks) of inner loop calculations. Such functional relationship can be approximated by multivariate interpolation or smoothing techniques such as least squares Monte Carlo. Nonetheless, these techniques often require a large size of economic scenarios to develop accurate enough functional relationships, which could also be very costly to begin with. The proposed new technique is based on an entirely different strategy, which is to avoid “approximate" functional relationship but instead to save time by recycling a limited set of economic scenarios. We shall demonstrate with a variety of examples the efficiency and wide applicability of this new method.

Keywords: Nested stochastic modeling; nested simulation; financial reporting, least squares Monte Carlo; curve fitting; sample recycling.

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