

The 4th Workshop on Insurance Mathematics

with a special session on Longevity and Pension Risks

All the talks will be in Davis Center (DC) Room 1302 on the campus of the University of Waterloo.

Day 1: February 5th, 2016

8:30	Shuttle leaves from Delta Hotel
9:00 – 9:20	Registration (Davis Center 1301)
9:20 – 9:30	Opening remarks
Session 1	
9:30 – 10:30	Etienne Marceau (Université Laval)
10:30 – 11:00	Coffee break
Session 2	
11:00 – 11:30	Mélina Mailhot (Concordia University)
11:30 – 12:00	Dameng Tang (University of Toronto)
12:00 – 13:30	Lunch
Session 3	
13:30 – 14:00	Kristina Sendova (Western University)
14:00 – 14:30	Marie-Pier Côté (McGill University)
14:30- 15:00	Fan Yang (University of Waterloo)
15:00- 15:30	Coffee break
Session 4	
15:30 – 16:00	Clarence Simard (Université du Québec à Montréal)
16:00 – 16:30	Manuel Morales (Université de Montréal)
16:45	Shuttle leaves back to Delta Hotel
18:00 – 20:00	Reception and dinner

Day 2: February 6th, 2016 (special session on Longevity and Pension Risks)

8:30	Shuttle leaves from Delta Hotel
9:00 – 9:10	Opening remarks for the special session
Session 1	
9:10 – 10:10	Bruce Jones (Western University)
10:10 – 10:40	Hua Chen (Temple University)
10:40 – 11:00	Coffee break
Session 2	
11:00 – 11:30	Yongzeng Lai (Wilfrid Laurier University)
11:30 – 12:00	Torsten Kleinow (Heriot-Watt University)
12:00 – 12:30	Yijia Lin (University of Nebraska-Lincoln)
12:30 – 12:40	Closing remarks
12:40 – 2:00	Lunch

Abstracts on Day 1, February 5th

Keynote speaker: **Etienne Marceau** (Université Laval)

Time: 9:30 – 10:30

Title: *Models and Aggregation Methods for Portfolios of Dependent Risks*

In recent years, it has become crucial for insurers and financial institutions to develop efficient risk management tools to have an appropriate assessment of the global risk associated to a portfolio which may consist of a group of insurance policies, different lines of business or different risks of an investment institution. A fair quantification of this risk must be done to insure the company's solvability. Results related to the sum of dependent risks are of great interest notably in actuarial science, quantitative risk management, statistics and applied probability in general. For example, the calculation of the overall capital charge for a portfolio of risks require the knowledge of the cumulative distribution function (cdf) of the sum of dependent random variables (rvs). Risk measures, such as the Value-at-Risk (VaR) and the Tail-Value-at-Risk (TVaR), can be used to evaluate this total capital requirement. Over the last two decades, the study of the aggregation of dependent risks has attracted an increasing interest among researchers and practitioners in actuarial science.

In this talk, we will consider a portfolio of dependent risks represented by a vector of dependent random variables. In the first part, we will provide a brief review of the recent results about multivariate models and aggregation methods for dependent risks. In the second part, we present recent research results about three cases. In the first case, we assume the multivariate cdf is defined with an Archimedean copula. Archimedean copulas are very popular and their extensions, nested Archimedean copulas, are well suited for vector of rvs of high dimension. We propose a simple approach which allows the computation of the cdf of the sum or a variety of functions of those rvs. In particular, we derive the cdf and the TVaR of the sum of those risks using the Frank copula, Shifted Negative Binomial Copula, and the Ali-Mikhail-Haq (AMH) copula. The links between the Clayton copula, the Shifted Negative Binomial copula and the AMH copula are also discussed. In the second case, we examine the aggregation of pair of countermonotonic rvs. Notably, we derive closed-form expressions for the cdf of sum of two comonotonic positive rvs in specific cases. A general approach is also proposed to derive the VaR of the sum of two comonotonic positive rvs. In the third case, we propose an extension of the Farlie-Gumbel-Morgenstein copula, which is called Bladt-Nelsen copula. We present its properties such as the closed-for expressions for the Kendall's Tau and the Spearman's rho.

Speaker: **Mélina Mailhot** (Concordia University)

Time: 11:00 – 11:30

Title: *Multivariate TVaR-Based Risk Decomposition Techniques*

In insurance and in finance, regulators and management use capital allocation in order to protect stakeholders against adverse outcomes of risky businesses. From an enterprise risk management point of view, it has become important to calculate the contribution of each risk within a portfolio. In this presentation, multivariate Value-at-Risk and Tail-Value-at-Risk for $d \geq 2$ are presented, and we focus on three different methods to calculate optimal finite sets for the contribution of each risk within the sums of random vectors to the overall portfolio, which could particularly apply in actuarial science.

Speaker: **Dameng Tang** (University of Toronto)

Time: 11:30 – 12:00

Title: *A Marked Cox Model for IBNR Claims*

Predicting the loss reserve for incurred but not reported (IBNR) claims is an important yet challenging task for insurance companies. The traditional loss reserving methods and their stochastic versions have several deficiencies due to loss of information in using aggregate data. Recently, several papers have proposed the so called “micro-level reserving models”, which can enhance the predictive performance using policy-level claim data. However, almost all the loss reserving models neglect the temporal dependence possible existing in the claim arrival process. In this paper, we propose a marked Cox model for this process, which allows for an intuitive interpretation. While flexible in modeling temporal dependence, it also admits some analytical tractability. In particular, there exist closed-form expressions for both the autocorrelation function (ACF) and the number of IBNR claims under our model assumption. We also present an expectation-maximization (EM) algorithm for data fitting purpose and a simulation study is conducted to show its effectiveness. Finally, we examine the applicability of our model to a real data set in automobile insurance provided by an European insurance company. Our fitted model is compared with the popular overdispersed Poisson (ODP) aggregate model in terms of the number of IBNR claims from various perspectives. We conclude that our model produces a more realistic predictive distribution. In particular, its best estimate is both more accurate and precise than that of the chosen aggregate model.

Speaker: **Kristina Sendova** (Western University)

Time: 13:30 – 14:00

Title: *Dual surplus model -- risk measures, dependence, perturbation*

In the actuarial literature, the dual risk model is usually employed to describe the surplus of companies with occasional gains but continuous flow of expenses such as petroleum companies, pharmaceutical companies and brokerage firms (see Avanzi et al., 2007 or Albrecher et al., 2008). In this talk we focus on several extensions of the dual model and discuss relevant risk measures. Numerical examples are employed to illustrate the behaviour of the quantities that we study under various cash-flow options.

Speaker: **Marie-Pier Côté** (McGill University)

Time: 14:00 – 14:30

Title: *Rank-Based Methods for Modeling Dependence Between Loss Triangles*

In order to determine the risk capital for their aggregate portfolio, property and casualty insurance companies must fit a multivariate model to the loss-triangle data relating to each of their lines of business. As an inadequate choice of dependence structure may have an undesirable effect on reserve estimation, a two-stage inference strategy is proposed to assist with model selection and validation. Generalized linear models are first fitted to the margins. Standardized residuals from these models are then linked through a copula selected and validated using rank-based methods. The approach is illustrated with data for six lines of business from a large Canadian insurance company. This work is joint with Anas Abdallah and Christian Genest.

Speaker: **Fan Yang** (University of Waterloo)

Time: 14:30- 15:00

Title: *Optimal Portfolio Diversification*

Interconnectedness of risks may result in high systematic risk. When the number of risks are fixed, maximizing diversification benefits can lower the portfolio risk. In this work, the risk concentration is used to maximize diversification benefits, which is applied to portfolio selection. Since explicit solutions to such optimization problems are generally not available, asymptotic analysis is conducted as an alternative way to study them. A consistent and asymptotic normal estimator of the asymptotic solution is established as well.

Speaker: **Clarence Simard** (Université du Québec à Montréal)

Time: 15:30 – 16:00

Title: *Option pricing in a discrete time model for the limit order book*

We propose a discrete time model for the structure of the limit order book, so that the price per share depends on the size of the transaction. We deduce the value of a portfolio when the investor trades using market orders and a bank account with different interest rates for lending and borrowing. In this setting, we deduce conditions to rule out arbitrage and define a pricing method for European call and put options. We find explicit solutions for the price of European options with maturity one and study how the structure of the limit order book and the different interest rates affect the option prices.

Speaker: **Manuel Morales** (Université de Montréal)

Time: 16:00 – 16:30, February 5th, Friday

Title: *Applications of Levy processes in insurance and finance: New Developments and Future Challenges*

The last ten years have seen a large body of research on applications of Levy processes in insurance and finance have been. For instance, expressions for the expected discounted penalty function now exist for a wide range of models, in particular for a general class of Levy insurance risk processes. This leads to a theoretical treatment of certain types of options in finance and the analysis of richer ruin- and non-ruin related quantities in insurance. In this talk we start with a review of existing models and results while emphasizing the role of the theory of fluctuations in understanding the ruin problem. We then discuss new directions that can be studied with the ultimate aim of designing new path-dependent risk measures from the body of knowledge gathered over the years in Ruin Theory. More specifically, we will look at non-ruin quantities that contain relevant information about a Levy risk process. We will discuss various topics along these lines such as drawdowns and prediction of the ultimate deficit time. After discussing existing and potential applications that follow naturally on the steps of what has been done so far, we will venture on discussing the more existential question: Is there anything new under the horizon in terms of applications in the field? And how meaningful these applications are from a practical standpoint? As an illustration we will briefly discuss an interesting and unexplored direction for applications in quantitative finance.

Abstracts on Day 2, February 6th

Keynote speaker: **Bruce Jones** (Western University)

Time: 9:10 – 10:10

Title: *Health-linked Phase-Type Aging and Mortality Models*

Phase-type distributions have been used to model the distribution of human lifetimes. Such a model represents the lifetime as the time until absorption in a Markov chain involving a collection of transient states and a single absorbing state. This approach is appealing, as the model can be structured so that the states are interpretable. Specifically, each transient state may represent a physiological age of an individual.

This interpretation has no tangible meaning, however, unless physiological age can be connected with an observable health variable that is related to aging and mortality. Making this connection allows one to use health observations to adjust the distribution of physiological age and the resulting future lifetime distribution.

In this talk, I present simple and more complicated phase-type aging models and examine some of the considerations in using these models. I also discuss how a phase-type model can be extended to reflect health information and investigate the impact of doing so.

Speaker: **Hua Chen** (Temple University)

Time: 10:10 – 10:40

Title: *Mortality Dependence and Longevity Bond Pricing: A Dynamic Factor Copula Mortality Model with the GAS Structure*

Modeling mortality dependence for multiple populations has significant implications for mortality/longevity risk management. A natural way to assess multivariate dependence is to use copula models. The application of copula models in the multi-population mortality analysis, however, is still in its infancy. Only two studies, i.e., Chen et al. (2015) and Wang et al. (2015), develop multi-population copula models. Extending their work, we present a dynamic multi population mortality model based on a two-factor copula and capture the time-varying dependence using the generalized autoregressive score (GAS) framework. Our model is simple and flexible in terms of model specification and is widely applicable to high dimension data. Using the Swiss Re Kortis longevity trend bond as an example, we use our proposed model to estimate the probability distribution of principal reduction and some risk measures such as probability of first loss, conditional expected loss and expected loss. Our estimates are very close to those reported by Risk Management Solutions (RMS). Due to the similarity in the structure and design of CAT bonds and mortality/longevity bonds, we borrow CAT bond pricing techniques for mortality/longevity bond pricing. We find that our pricing model generates par spreads that are close to the actual spreads of previously issued mortality/longevity bonds.

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

Time: 11:00 – 11:30

Title: *Asset allocation for a DC pension fund with stochastic income and mortality risk: a multi-period mean-variance framework*

In this talk, I will present an asset allocation problem for defined contribution pension funds with stochastic income and mortality risk under a multi-period mean-variance framework. Different from studies in the literature where the expected utility was maximized or the risk measured by the quadratic mean deviation was minimized, we will try to enhance the return and to control the risk by the mean-variance criterion. First, we will obtain analytical expressions for the efficient investment strategy and the efficient frontier by applying the Lagrange dual theory, the state variable transformation technique and the stochastic optimal control method. Then, we will discuss some special cases under our model. Finally, a numerical example will be presented to illustrate the results.

Speaker: **Torsten Kleinow** (Heriot-Watt University)

Time: 11:30 – 12:00

Title: *Projecting Mortality with the Common Age Effect Model*

We review the Common Age Effect Model and compare it to the Li and Lee model for the mortality experience in six countries. In particular, we compare, both visually and numerically, the goodness of fit of those models and propose time series models for the relevant period effects for forecasting that produce non-diverging, joint future mortality scenarios. Model parameters are estimated using maximum likelihood, and, as in many mortality models, we find identifiability problems which complicate the estimation process. We discuss those identifiability problems and introduce constraints that result in a unique set of parameter estimates.

Speaker: **Yijia Lin** (University of Nebraska-Lincoln)

Time: 12:00 – 12:30

Title: *Pension Risk Management in the Enterprise Risk Management Framework*

This paper presents an enterprise risk management (ERM) model for a firm that is composed of a portfolio of capital investment projects and a defined benefit (DB) plan for its workforce. The firm faces the project, operational and hazard risks from its investment projects as well as the financial and longevity risks from its DB plan. The firm maximizes its capital market value net of pension contributions subject to constraints that control project, operational, hazard, financial and longevity risks as well as an overall risk constraint. By comparing values via ERM versus silo risk management, this analysis illustrates the importance of integrating pension risk in the firm's ERM program. The analysis also shows how hedging strategies can impact the firm's net value.

While the existing literature suggests that an excess-risk longevity hedging strategy such as a longevity swap is more attractive than a ground-up strategy such as a buy-out since the latter is more capital intensive and expensive, the analysis here shows that subject to the constraints, the excess-risk hedging strategy is less effective in improving firm value.