The first Waterloo Student Conference in

Statistics, Actuarial Science and Finance

WatSSAF 2019

October 18-19, 2019

STC 0040 & STC 0050

UNIVERSITY OF WATERLOO

Department of Statistics and Actuarial Science

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WELCOME

The first Waterloo Student Conference in

STATISTICS, ACTUARIAL SCIENCE and FINANCE

October 18-19, 2019

Science Teaching Complex (STC)

uwaterloo.ca/sas/student-conference

Department of Statistics and Actuarial Science

200 UNIVERSITY AVENUE WEST WATERLOO, ON, CANADA N2L 3G1

CONFERENCE OVERVIEW

ABOUT

The Waterloo Student Conference in Statistics, Actuarial Science and Finance is an annual student conference hosted by the Department of Statistics and Actuarial Science at the University of Waterloo. The aim of the conference is to provide a platform for graduate students in statistics, actuarial science and finance at the University of Waterloo, as well as other institutions in Ontario and Canada, to share their research results and experiences, discuss career opportunities, and network with prominent researchers and fellow graduate students.

The program of the conference features keynote presentations by leading researchers in selected areas and research talks and poster presentations by students. Special sessions for industry partners and sponsors of the conference are organized to present and explore research and career opportunities. There will be ample social and network opportunities through informal receptions, coffee breaks and lunches and at the formal banquet of the conference.

CONFERENCE ORGANIZING COMMITTEE

Kelly Ramsay, Co-Chair
Qihuang Zhang, Co-Chair
Gracia Dong
Maysum Panju
Chi-Kuang Yeh
Zijia Wang

Faculty Advisors:
Shoja'eddin Chenouri
Changbao Wu

About the Department of Statistics and Actuarial Science

The Department of Statistics and Actuarial Science is among the top academic units for statistical and actuarial science in the world and is home to more than 50 research active full-time faculty working in diverse and exciting areas. We offer bachelor's, master's and doctoral programs in Statistics and Actuarial Science and numerous joint programs with other Departments.

The Department offers a vibrant research environment for a wide range of areas including foundations of statistics, analysis of longitudinal and life history data, computational inference, finance, risk management, ruin theory, survey methods, industrial statistics, interdisciplinary collaborative work.

The Department benefits from close relationships with several research groups on campus including Waterloo Research Institute in Insurance, Securities and Quantitative Finance (WatRISQ), Business and Industrial Research Group (BISRG), Propel Centre for Population Health Impact (PROPEL), Centre for Computational Mathematics in Industry and Commerce (CCMIC), Survey Research Centre (SRC), and many others.

The Department is also home to over 1000 undergraduate students and about 150 graduate students in programs including Actuarial Science, Master of Actuarial Science (M.Act.Sc.) Program, Biostatistics, Master of Quantitative Finance (MQF), Statistics, and Statistics-Computing.

UNIVERSITY OF
WATERLOO

FACULTY OF MATHEMATICS
Department of Statistics and Actuarial Science

CONFERENCE SCHEDULE

FRIDAY, OCTOBER 18

8:00 - 8:40 a.m. Registration, Located in the STC Atrium outside of 0040

8:40 - 8:45 a.m. Opening remarks by Department Chair, Stefan Steiner
Room STC 0040

8:45 - 9:45 a.m. **KEYNOTE - XIAO-LI MENG**
ARTIFICIAL BAYESIAN MONTE CARLO INTEGRATION:
A PRACTICAL RESOLUTION TO THE BAYESIAN (NORMALIZING CONSTANT) PARADOX
Session Chair: Qihuang Zhang
Room STC 0040

9:45 - 10:05 a.m. Coffee Break

10:05 - 12:00 p.m. **SESSION 1A: Nonparametric and Computational Statistics**
Session Chair: Maysum Panju
Room STC 0040

10:05 - 10:28 a.m. NAM-HWUI KIM | Various Methods for Fitting a Finite Mixture of Sparse Factor Analyzers

10:28 - 10:51 a.m. SHAHAB PIRNIA | Detecting Change Points with Enhanced Backward Selection

10:51 - 11:14 a.m. HAOXIN ZHUANG | Grouping Dependence Structure and Selection of Copula-Based Models Using a Bayesian Nonparametric Method

11:14 - 11:37 a.m. KELLY RAMSAY | Nonparametric Multiple Change-point Detection for Covariance Matrices

11:37 - 12:00 p.m. GRACIA DONG | Variance Estimation of Quasi-Monte Carlo Integration without Replication

10:05 - 12:00 p.m. **SESSION 1 B: Forecasting and Risk Measure**
Session Chair: Qihuang Zhang
Room STC 0050

10:05 - 10:28 a.m. YECHAO MENG | DSA Algorithms for Mortality Forecasting

10:28 - 10:51 a.m. RUIHONG JIANG | Stock Return Forecasting Power of the Actuaries Climate Index

10:51 - 11:14 a.m. HUAMENG JIA | Multivariate Geometric CVaR

11:14 - 11:37 a.m. LIUYAN JI | Asymptotic Properties of the Generalized Bivariate CTE

11:37 - 12:00 p.m. PENG LIU | Distributional transforms, Probability Distortions and their Applications

12:00 - 1:30 p.m. Lunch

1:30 - 2:30 p.m. **KEYNOTE - SEBASTIAN JAIMUNGAL**

MEAN-FIELD GAMES AND DIFFERING BELIEFS

Session Chair: Kelly Ramsay
Room STC 0040

2:30 - 2:50 p.m. Coffee Break

2:50 - 4:45 p.m. **SESSION 2A: Biostatistics**

Session Chair: Chi-Kwuang Yeh
Room STC 0040

2:50 - 3:13 p.m. CE YANG | Regression Trees with Interval-censored Failure Time Data

3:13 - 3:36 p.m. BINGFENG XIE | Dependent Observation Schemes of Marker Processes in Cox Regression

3:36 - 3:59 p.m. FANGYA MAO | Two-Phase Response-dependent Sampling with Current Status Data

3:59 - 4:22 p.m GABRIELA G. MARTINEZ | Bandwidth Selection for the Effective Dose Problem

4:22 - 4:45 p.m. OMID AGHABABAEI | Joint Modeling for Longitudinal Data with Irregular and Outcome-dependent Follow-up

2:50 - 4:45 p.m. **SESSION 2B : Pobability and Analysis**

Session Chair: Kelly Ramsay
Room STC 0050

2:50 - 3:13 p.m. FEIYU ZHU | Particle Physics Representation of a Continuous Stationary Gaussian Process

3:13 - 3:36 p.m. ZHENYUAN ZHANG | On Discrete-time Self-similar Processes with Stationary increments

3:36 - 3:59 p.m. AARON JANEIRO STONE | Mean Field Behaviour of Queueing Systems with Job Redundancy

3:59 - 4:22 p.m. XIYUE HAN | On the Extrema of Functions in the Takagi Class

4:22 - 4:45 p.m. BANAFSHEH LASHKARI | Statistical Tools for Analysis of Functional Data

5:00 - 6:00 p.m. Cocktail Reception at FED Hall

6:00 - 10:00 p.m. Banquet Dinner at FED Hall

CONFERENCE SCHEDULE

SATURDAY, OCTOBER 19

8:45 - 9:45 a.m. **KEYNOTE - MARY THOMPSON**
THE STATISTICAL SCIENCES AND SOCIETY
Session Chair: Kelly Ramsay
Room STC 0040

9:45 - 10:05 a.m. Coffee Break

10:05 - 12:00 p.m. **SESSION 3A : Survey Sampling and Design**
Session Chair: Wenlin Zhang
Room STC 0040

10:05 - 10:28 a.m. MENGLU CHE | Improving Estimation Efficiency for Regression with MNAR Covariates

10:28 - 10:51 a.m. HON YIU SO | Correlated and Misclassified Binary Observations in Complex Surveys

10:51 - 11:14 a.m. YILIN CHEN | Doubly Robust Inference with Non-probability Survey Samples

11:14 - 11:37 a.m. MENG YUAN | Semiparametric Empirical Likelihood Inference with General Estimating Equations under Density Ratio Models

11:37 - 12:00 p.m. CHI-KUANG YEH | Properties of Optimal Regression Designs under Second-Order Least Squares Estimator

10:05 - 12:00 p.m. **SESSION 3B : Finance**
Session Chair: Junhan Fang
Room STC 0050

10:05 - 10:28 a.m. W. S. AVUSUGLO | Treatise of PD-LGD Correlations in a Portfolio Setting

10:28 - 10:51 a.m. TOLULOPE FADINA | Default Ambiguity

10:51 - 11:14 a.m. YANG LIU | Central-planned Portfolio Selection and Pareto Frontier

11:14 - 11:37 a.m. XIAOLE XUE | Protecting Target Zone Currency Market from the Central Bank

11:37 - 12:00 p.m. FRANÇOIS-MICHEL BOIRE | Distributional Response to Fiscal Stimulus

12:00 - 1:30 p.m. Lunch

1:30 - 3:25 p.m. **SESSION 4A : Statistical and Casual Inference**

Session Chair: Gracia Dong
Room STC 0040

1:30 - 1:53 p.m. ZHAOYANG TIAN | A Powerful Procedure that Controls the False Discovery Rate with Directional Information

1:53 - 2:16 p.m. ZHAOHAN SUN | Semiparametric Inference of Causal Effect with Nonignorable Missing Confounders

2:16 - 2:39 p.m. CONG JIANG | Dynamic Treatment Regimes with Interference

2:39 - 3:02 p.m. TUGBA AKKAYA-HOCAGIL | The Use of Propensity Scores with a Semi-Continuous Exposure Variable

3:02 - 3:25 p.m. CHRISTOPHER SALAHUB | Seen to Be Done: A Graphical Investigation of Peremptory Challenge

1:30 - 3:25 p.m. **SESSION 4B : Risk Aggregation and Allocation**

Session Chair: Yechao Meng
Room STC 0050

1:30 - 1:53 p.m. ZIJIA WANG | Joint Densities in the Renewal Risk model with Generalized Random Income

1:53 - 2:16 p.m. NAWAF MOHAMMED | Allocation of Compositions vs Composition of Allocations under CTE rule

2:16 - 2:39 p.m. YISUB KYE | A Reconciliation of the Top-down and Bottom-up Approaches to Risk Capital Allocations: Proportional Allocations Revisited

2:39 - 3:02 p.m. ANDREW FLECK | Risk Aggregation and Allocation in the Presence of Systematic Risk via Stable Laws

3:02 - 3:25 p.m. QIUQI WANG | A Signaling Game of Debt Financing Using Equity Guarantee Swaps

3:25 - 3:35 p.m. **Closing Remarks by Conference Committee members**
Room STC 0040

KEYNOTE SPEAKERS

DR. SEBASTIAN JAIMUNGAL

UNIVERSITY OF TORONTO

Director of the professional Masters of Financial Insurance Program in the Department of Statistical Sciences at the University of Toronto, and Chair for the SIAM activity group in Financial Mathematics and Engineering (SIAG/FM&E).

MEAN-FIELD GAMES AND DIFFERING BELIEFS

Even when confronted with the same data, agents often disagree on a model of the real-world. Here, we address the question of how interacting heterogenous agents, who disagree on what model the real-world follows, optimize their trading actions. The market has latent factors that drive prices, and agents account for the permanent impact they have on prices. This leads to a large stochastic game, where each agents' performance criteria is computed under a different probability measure. We analyse the mean-field game (MFG) limit of the stochastic game and show that the Nash equilibria is given by the solution to a non-standard vector-valued forward-backward stochastic differential equation. Under some mild assumptions, we construct the solution in terms of expectations of the filtered states. We prove the MFG strategy forms an \epsilon-Nash equilibrium for the finite player game. Lastly, we present a least-squares Monte Carlo based algorithm for computing the optimal control and illustrate the results through simulation in market where agents disagree on the model. Time permitting, this talk will also introduce some notions of Nash deep Q-learning related for model free approach to solving this and related problems.

DR. XIAO-LI MENG

HARVARD UNIVERSITY

Whipple V. N. Jones Professor of Statistics at Harvard University, Dean of Harvard Graduate School of Arts and Sciences (2012-2018) and recipient of the COPSS President's Award in 2001.

Artificial Bayesian Monte Carlo Integration: A Practical Resolution to the Bayesian (Normalizing Constant) Paradox

Advances in Markov Chain Monte Carlo in the past 30 years have made Bayesian analysis a routine practice. However, there is virtually no practice of performing Monte Carlo integration from the Bayesian perspective; indeed, this problem has earned the "paradox" label in the context of computing normalizing constants (Wasserman, 2013). We first use the modeling-what-we-ignore idea of Kong et al. (2003) to explain that the crux of the paradox is not with the likelihood theory, which is essentially the same as for a standard non-parametric probability/density estimation (Vardi, 1985); though via using group theory, it provides a richer framework for modeling the trade-off between statistical efficiency and computational efficiency. But there is a real Bayesian paradox: Bayesian analysis cannot be applied exactly for solving Bayesian computation, because to perform the exact Bayesian Monte Carlo integration would require more computation than needed to solve the original Monte Carlo problem. We then show that there is a practical resolution to this paradox using the profile likelihood obtained in Kong et al. (2006) and that this approximation is second-order valid asymptotically. We also investigate a more computationally efficient approximation via an artificial likelihood of Geyer (1994). This artificial likelihood approach is only first-order valid, but there is a computationally trivial adjustment to render its second-order validity. We demonstrate empirically the efficiency of these approximated Bayesian estimators, compared to the usual frequentist-based Monte Carlo estimators, such as bridge sampling estimators (Meng and Wong, 1996).

[This is a joint work with Masatoshi Uehara.]

DR. MARY THOMPSON

UNIVERSITY OF WATERLOO

Distinguished Professor Emerita in the Department of Statistics and Actuarial Science at the University of Waterloo, first Scientific Director of the Canadian Statistical sciences Institute (CANSSI), and recipient of the SSC Gold Medal in 2003.

THE STATISTICAL SCIENCES AND SOCIETY

This talk will look at developments in statistics, data science and related disciplines through the lens of some of the most important issues facing societyin the twentieth and twenty-first centuries: armed conflicts; human rights abuses; economic inequality; climate change; technological challenges in communication; the management of risk; combatting disease. We will explore international and Canadian examples of how these priorities have influenced the direction of research, and discuss the role of the statistical sciences in addressing the priorities of today.

STUDENT SPEAKERS

Joint Modeling for Longitudinal Data with Irregular and Outcome-dependent Follow-up

Omid Aghababaei
Child Health Evaluative Sciences, The Hospital for Sick Children, Toronto
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An important problem in longitudinal studies is that subject follow-up times are irregular and may depend on past outcomes and their associated factors that are not included in the regression model. The standard inferential procedures in this situation can lead to biased estimates for parameters in the outcome model. We first discuss the general estimation approaches in the literature and then propose a joint model for the observation times and the outcome model to estimate the regression coefficients and predicte future outcomes and visit times. We also apply the proposed procedure to a real dataset. This is joint work with Eleanor Pullenayegum.

The Use of Propensity Scores with a Semi-continuous Exposure Variable

Tugba Akkaua Hocagil
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Propensity score methodology has become increasingly popular in recent years as a tool for estimating causal effects of treatment or exposure using data from observational studies.

For the most part, discussion has been restricted to binary and continuous exposure variables but often in environmental epidemiology the exposure variable has a mass at zero for non-exposed individuals, and long tails reflecting the variation in the extent of exposure among those who are exposed. We develop a propensity score methodology based on a two-part model and show how this can be used to more reliably estimate the causal effects of a semi- continuous exposure variable. We compare and evaluate the performance of our proposed method relative to the generalized propensity score method and direct covariate adjustment through simulation studies. We find that when the outcome can be modeled by linear regression, all three methods yield unbiased results. However, when the effects of confounders are more complex, the proposed methods can outperform both direct covariate adjustment and methods based on the generalized propensity score. We illustrate our method using data from the Detroit Longitudinal Cohort Study where the exposure variable is based on prenatal alcohol exposure and cognitive measures for the child are the outcomes of interest.

Treatise of PD-LGD Correlations in a Portfolio Setting

W. S. Avusuglo
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The provision in Paragraph 468 [1] for calculating Loss Given Default (LGD) requires that parameters used in Pillar I of Basel II capital estimations must be reflective of economic downturn conditions so that relevant risks are accounted for. This provision is based on the fact that the probability of default (PD) and LGD correlations are not captured in the proposed formula for estimating economic capital. To help quantify economic downturn LGD, the Basel Committee proposed establishing a functional relationship between long-run and downturn LGD.

To the best of our knowledge, the current proposed models that map out this relationship have the same under- lying framework — account-level LGD generally (examples, [2, 3]) takes the form

$$\text{LGD} = H(\text{loss driver})$$

We highlight a mistake that is frequently made in specifying H (.) — current studies ignore the difference between potential loss and LGD at the account lev ́el . By effecting this mistake, we present qualitative analysis on the underlying parameters in the model. This is joint work with A. Metzler and R. M. Reesor.

Distributional Response to Fiscal Stimulus*

François-Michel Boire
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We incorporate Quantile Regressions into a structural Vector Auto-Regression model to investigate how fiscal and monetary policies influence the distribution of GDP forecasts in developed countries. We find that both policy instruments affect the location of the distribution of GDP growth, whereas fiscal expenditure shocks also impact the shape of the distribution. In normal times, fiscal policy does not significantly change GDP growth, but if monetary policy is constrained by the zero-lower bound, fiscal expansion improves the lower tail of the distribution. Conversely, fiscal contraction at the zero-lower bound exacerbates GDP tail risk. This is joint work with Thibaut Duprey and Alexander Ueberfeldt.

*The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank of Canada.

Improving Estimation Efficiency for Regression with MNAR Covariates

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For regression with covariates missing not at random (MNAR) where the missingness depends on the missing covariate values, the complete-case analysis leads to consistent estimation when the missingness is independent of the response given all covariates, but it may not have the desired level of efficiency. We propose a general empirical likelihood framework to improve estimation efficiency over the complete-case analysis. Different from existing methods in Bartlett et al. (2014) and Xie and Zhang (2017) that improve the efficiency by modeling the missingness probability conditional on the response and fully observed covariates, we allow the possibility of modeling other data distribution related quantities, and thus the proposed framework is more flexible in dealing with MNAR covariates. We also give guidelines on what quantities to model to potentially have better efficiency improvement. Simulation studies are conducted to investigate the numerical performance and an application to data collected from the US National Health and Nutrition Examination Survey (NHANES) is carried out. This is joint work with Peisong Han and Jerald F. Lawless.

Doubly Robust Inference with Non-probability Survey Samples

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We establish a general framework for statistical inferences with non-probability survey samples when relevant auxiliary information is available from a probability survey sample. We develop a rigorous procedure for estimating the propensity scores for units in the non-probability sample, and construct doubly robust estimators for the finite population mean. Variance estimation is discussed under the proposed framework. Results from simulation studies show the robustness and the efficiency of our proposed estimators as compared to existing methods. The pro- posed method is used to analyze a non-probability survey sample collected by the Pew Research Center with auxiliary information from the Behavioral Risk Factor Surveillance System and the Current Population Survey. Our results illustrate a general approach to inference with non-probability samples and highlight the importance and usefulness of auxiliary information from probability survey samples. This is joint work with Pengfei Li and Changbao Wu.

KEY WORDS Design-based inference, inclusion probability, missing at random, probability sampling, propensity score, regression modeling, variance estimation.

On Empirical Approach for Optimal-- Reinsurance with CVaR

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The quest for optimal reinsurance has remained a fascinating area of research and it has drawn significant interests from both academicians and practitioners. In determining the optimal reinsurance treaties, most of the existing literature assume the explicit distribution of the underlying risk is available. In reality, however, its distribution is usually estimated from empirical data, and such an estimation procedure will definitely involve some error risk. Motivated by this observation, Tan and Weng (2014) Proposed the so-called *empirical approach,* where the optimal reinsurance models are formulated directly based on the empirical data and the resulting models are called *empirical reinsurance models.* The empirical approach has many advantages compared with the traditional formulation. First, as just mentioned, it incorporates the uncertainty on the distribution of the underlying risk into the reinsurance model directly. Second, the empirical reinsurance model can be solved efficiently by using programming techniques, such as linear programming and Second-Order-Conic programming, for a variety of optimality criteria and reinsurance premium principles.

In our paper, we focus on the CVaR minimization model. We illustrated the existence of optimal solutions of both the theoretical reinsurance model and the empirical models. Furthermore, we established the probability convergence of the optimal objective functions of the empirical reinsurance models to the counterpart in a theoretical model. A numerical example is given to demonstrate the efficiency of the empirical approach.

Variance estimation of quasi-Monte Carlo integration without replication

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The usual variance estimate of a quasi-Monte Carlo (QMC) estimator requires creating a random sample of quasi-random estimators, each based on an independent low-discrepancy point set.

This is because the points are not independent within each point set, and thus the assumptions for using the regular Monte Carlo variance estimator do not hold. Using (t,m,s)-nets, which have a specified joint probability density function, we investigate the performance of various unbiased variance estimators that only require 2 to 3 point sets instead of needing to create multiple copies of the QMC estimate by directly calculating the covariance between pairs of points. We benchmark the accuracy of the proposed estimators against the usual QMC variance estimator.

Default Ambiguity

Tolulope Fadina
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In this talk, we will discuss ambiguity in the context of single-name credit risk. We focus on uncertainty in the default intensity. This approach is a first step towards integrating uncertainty in credit-risky term structure models and can profit from its simplicity. We derive drift conditions in a Heath-Jarrow-Morton forward rate setting in the case of ambiguous default intensity in combination with zero recovery.

Risk Aggregation and Allocation in the Presence of Systematic Risk via Stable Laws

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In order to properly manage risk, practitioners must understand the aggregate risks they are exposed to. Additionally, in order to, e.g., properly price policies and calculate bonuses the relative riskiness of individual business units must be well understood. Certainly Insurers and Financiers are interested in the properties of the sums of the risks they are exposed to and the dependence of risks therein. Realistic risk models however must account for a variety of phenomena: ill-defined moments, lack of elliptical dependence structures, excess kurtosis and highly heterogeneous marginals. Equally important is the concern over industry-wide systematic risks that can affect multiple business lines at once. Many techniques of varying sophistication have been developed with all or some of these problems in mind. We propose a modification to the classical individual risk model that allows us to model companywide losses via the class of Multivariate Stable Distributions. Stable Distributions incorporate many of the unpleasant features required for a realistic risk model while maintaining tractable aggregation and dependence results. We additionally compute the Tail Conditional Expectation of aggregate risks within the model and the corresponding allocations.

Bandwidth selection for the effective dose problem

Gabriela Gonzalez Martinez
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When administering a drug, a key question is to figure out which drug concentration yields the desired result. One approach is to use generalized linear models, where the drug concentration is modelled as a covariate. The amount of drug that will safely produce a positive effect in a specific pro- portion of the population under study is commonly referred as the effective dose.

In a parametric setting, the problem becomes trivial for a one dimensional covariate. However, a fully parametric approach can fall short when the relation between the drug and the response is more complex. Under this framework, a more robust method is needed.
If a non-parametric approach is preferred, a popular tool that a practitioner would typically use is a kernel smoother.

Choosing to work with kernels implies selecting a smoothing parameter commonly referred to as the bandwidth. Traditional methods for bandwidth selection involve minimizing an integral on the L2 distance between the true function and its estimator. However, if one's goal is to estimate the effective dose using a plug-in estimator, typical bandwidth selection techniques become suboptimal. The reason being is that the L2 norm is a global optimization tool, while the effective dose is a very local problem.

Therefore, a different approach is required. My goal in this project is to study how to optimally select the bandwidth for kernel smoothing plug-in estimators of the effective dose. In this talk we will discuss my current progress towards a solution.

On the Extrema of Functions in the Takagi Class

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The Takagi class is a class of fractal functions on the unit interval generalizing the celebrated Takagi function. In this presentation, we study the extrema of these functions. This is a problem that goes back to J.-P. Kahane. We characterize the set of all extrema of a given function in the Takagi class by means of a “step condition” on their Rademacher expansions. This step condition allows us to compute the extrema and their locations for a large class of explicit examples and to deduce a number of qualitative properties of the sets of extreme points. Particularly strong results are obtained for functions in the so-called exponential Takagi class by studying a special type Littlewood Polynomials and their “step roots”. For example, the exponential Takagi function with parameter $\alpha\in(-2,2)$ has exactly two maximizers if $ \alpha$ is not the “step root” of a Littlewood polynomial. Furthermore, we show that there exist Littlewood polynomials such that, if α is a corresponding root in $(-2,2)$, the set of maximizers is a Cantor-type set with Hausdorff dimension $1/n$, where n is the degree of the polynomial. On the other hand, we prove the location of maximum for the exponential Takagi function with parameter $\alpha < 0$ behaves ‘step-wisely’. Feasible application and possible further topics on the Takagi function will be also included in this presentation. This presentation is based on a joint work with Professor Alexander Schied from the University of Waterloo.

Asymptotic Properties of the Generalized Bivariate CTE

Liuyan Ji
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In this project, we investigate the limiting behavior of a bivariate conditional tail expectation (CTE) modeled by copula and marginal risk distributions belonging to the Maximum Domain of Attraction (MDA). Specifically, with the help of general notions of Extreme value theory (EVT) and an integrated study of tail dependences of copula, we find the aforementioned bivariate CTE is asymptotically proportional to the corresponding Value-at-Risk (VaR) risk measure for the marginal distributions belonging to MDAs and for copula families with various tail behaviors. In addition, our results show that the asymptotic bivariate CTE sends people a warning message of worrying situations in contrast to the asymptotic univariate CTE.

Multivariate geometric CVaR

Huameng Jia
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The modern risk management started between 1955 and 1964. Currently, the most commonly used risk measures are univariate such as Value at Risk, Expected Shortfall, expectile, and so on. Although the traditional univariate risk measure is easier to be implemented, it is hard to incorporate the correlation between risks. As such a reason, multivariate risk measures are developed.

In this presentation, we will discuss the a new multivariate risk measure that is inspired by multivariate geometric quantile by Chaudhuri (1996), and multivariate geometric expectiles by Herrmann et al. (2018). The new multivariate risk measure is called generalized geometric CVaR which extend the univariate CVaR to multivariate risk measure for any dimension d.

The content of presentation is ordered as following. First we start with some background information. We revisit the univariate model that are closely connected to multivariate geometric risk measures and then followed by existing multivariate geometric risk measure that includes multivariate geometric VaR and expectile and the strategy they use to extend the univariate risk measure to multivariate geometric risk measure. Then, we introduce our newly defined multivariate geometric CVaR and provide an interpretation of how to understand this risk measure. After that, we discuss how this risk measure can be obtained and the properties of the loss function, expected loss function that can guarantee the existence and uniqueness of the solution, and then follow by the risk measure properties that makes this risk measure a desirable one in risk management. At the end, we provide numerical illustration with multivariate Pareto distribution and multivariate Normal distribution to examine how the parameters and covariance between random variables in the model will affect the risk measure. We also provide a comparison between multivariate CVaR and other multivariate risk measures. This is joint work with Jun Cai.

Dynamic Treatment Regimes with Interference

Cong Jiang
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Personalized Medicine refers to the principle of tailoring treatments to individual patient characteristics in order to optimize care. In other words, the treatment is individual-oriented rather than symptom-oriented because of the patient heterogeneity. This approach is formalized by Dynamic Treatment Regimes (DTRs). In the context of multi-stage treatment decisions, a DTR is a sequence of decision rules which at each stage takes patient information (such as age) as input, and outputs a treatment recommendation. As in the wider causal inference literature, DTR estimation relies upon the key assumption of no interference: that the outcome of one individual is unaffected by the treatment assignment of others; however, in many social network contexts (such as friendship networks or family networks), this assumption is questionable. In the presentation, I will discuss some causal inference assumptions under network interference. Building on this interference causal framework, then I will present a generalization of two main DTR estimation approaches, which are Q-learning and Dynamic Weighted Ordinary Least Squares (dWOLS), in the presence of interference; and show a very important property - double robustness - of dWOLS.

Stock Return Forecasting Power of the Actuaries Climate Index

Ruihong Jiang
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The Actuaries Climate Index (ACI) is the newly released index by actuarial professional associations to measure climate risk. Composite with elements including temperature, precipitation, wind power, and sea level, it reflects extreme climate changes in Canada and the United States. In this paper, we investigate the forecasting power of the ACI to stock returns in relevant sectors. We find that less ACI time trends predict higher returns in agriculture-related portfolios and that the portfolio return is amplified for a more extended holding period. We also test the efficiency of the stock market with respect to the ACI. In light of the relative strength trading strategy, we invest in stocks with less climate risk and sell stocks with more climate risk. The outperformance of the “buy winner and sell loser” strategy in agriculture-related industries implies the inefficiency of the stock market. We find that the food and beverages sector contributes most to the outperformance. Our results shed a useful insight into how the stock market can be used to mitigate the adverse effect of the climate risk on the profitability of a company. This is joint work with Chengguo Weng.

Various Methods for Fitting a Finite Mixture of Sparse Factor Analyzers

Nam-Hwui Kim
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A finite mixture of factor analyzers is an effective method for achieving parsimony in model- based clustering, as a sparse factor loading matrix can result in a highly interpretable model and a sparse covariance estimate. However, in pursuit of such sparsity, one can end up with rank-deficient solutions regardless of the number of factors assumed. In light of this issue, we develop various penalty-based methods that can fit a finite mixture of sparse factor analyzers with full-rank factor loading estimates. This is joint work with Ryan P. Browne

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A reconciliation of the top-down and bottom-up approaches to risk capital allocations: Proportional allocations revisited

Yisub Kye
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In the nowadays reality of prudent risk management, the problem of determining aggregate risk capital in financial entities has been intensively studied for quite long. As a result, canonical methods have been developed and even embedded in regulatory accords. While applauded by some and questioned by others, these methods provide a much desired standard benchmark for everyone. The situation is very different when the aggregate risk capital needs to be allocated to the business units of a financial entity. That is, there are overwhelmingly many ways to conduct the allocation exercise, and there is arguably no standard method to do so on the horizon.

Two overarching approaches to allocate the aggregate risk capital stand out. These are the top-down approach that entails that the allocation exercise is imposed by the corporate centre, and the bottom-up approach that implies that the allocation of the aggregate risk to business units is informed by these units. Briefly, the top- down allocations start with the aggregate risk capital that is then replenished among business units according to the views of the \textit{centre}, thus limiting the inputs from the business units. The bottom-up approach does start with the business units, but it is, as a rule, too granular, and so may lead to missing the wood for the trees.

In this presentation, I connect the bottom-up approach to allocate the aggregate risk capital to a general class of Dirichlet distributions defined on the n- dimensional simplex. The mixed-scaled Dirichlet distributions proposed herein contain the classical Dirichlet distribution as a special case, exhibit a multitude of desirable closure properties, and emerge naturally within the multivariate risk analysis context. As a by-product, our invention revisits the proportional allocation rule that is often used in applications, and by doing so, unifies the top-down and the bottom-up approaches to allocating the aggregate risk capital into one encompassing method.

Statistical tools for analysis of functional data

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In many applications, individual data samples are in the form of functions and objects, sharing some common shape features. The intensity and location of these features vary from sample to sample. Faced with such data, the interest might be whether or not two populations of functions are different. Another question of interest is how much of the variation in the observed functional data is due to the measurement device. We will discuss about the statistical tools to answer these and similar questions.

Central-planned Portfolio Selection and Pareto Frontier

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In delegated portfolio management, we stand at a perspective of a central planner to study Pareto portfolio selection and compare different contracts. We formulate the Pareto problem of utilities of the manager and the investor by multi-objective programming. First, we solve out two cases of the closed-form Pareto optimal portfolio based on non-smooth and non-concave utility optimization. One case of the optimal portfolio has a novel two-peak pattern and the other case has a one- peak pattern. We divide the optimal portfolio into three terms (Merton term, Aggressive term and Conservative term) to explain the patterns and conduct asymptotic analysis to illustrate economic insights. Second, we establish a Pareto frontier of the optimal portfolio, which is proved to be decreasing and concave. We use Pareto frontiers to compare different contracts, showing that among first-loss contracts, the investor benefits from the one with a smaller incentive rate and a smaller managerial ownership proportion.

Two-Phase Response-dependent Sampling with Current Status Data

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Two-phase epidemiological designs involve the collection of a Phase I sample in which the response and inexpensive covariates are available. A Phase II sub-sample is then created where an expensive exposure variable of interest is also measured. In this presentation we consider different frameworks for analysis of current status data on a failure time process with incomplete covariates, along with associated selection models for the creation of the Phase II sample. Specifically, we consider Phase II samples based on simple random sampling, balanced sampling, and optimal stratified sampling schemes based on a selection model designed to minimize the variance of a parameter of interest. Since the optimal design requires knowledge of parameters which are unknown in practice, we extend this work to develop an adaptive Phase II selection process to approximate the optimal Phase II selection model. Simulation studies are conducted which demonstrate that the adaptive approximately optimal design is practical and superior to alternative Phase II designs and achieves efficiency close to the optimal design.

DSA Algorithms for Mortality Forecasting

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It has been well recognized that borrowing information from populations with similar structural mortality patterns and trajectories is helpful to the mortality forecasting of a target population. One crucial step to gain an enhanced forecasting accuracy lies in the selection of a proper group of populations. To the best of our knowledge, however, no structured method exists to select the group flexibly and effectively. In our paper, we consider the mortality forecasting for a general target population from the Human Mortality Database (HMD). We develop an effective procedure to select a group of populations from the HMD to enhance the mortality prediction of the target population. Instead of grouping populations according to geographical or socioeconomic information, we obtain the group from the mortality data themselves via some machine learning methods. We design a DSA (deletion-substitution-addition) algorithm to choose the “best” grouping, which has both reliable explanatory power for current mortality patterns and superior performance in terms of forecasting accuracy for each target country. This is joint work with Liqun Diao and Chengguo Weng

Allocation of Compositions vs Composition of Allocations under CTE rule

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The allocation exercise is a natural cascade after capital determination. Throughout the literature the prominent allocation rules are expressed as a separate composition of the BUs and the aggregate allocations (composition of allocation). It is, however, more intrinsic to consider the allocation of compositions I.e. the allocation of the BU's percentage contribution. In this paper, we consider the CTE allocation rule and we aim to examine under which class of probability distributions does allocation of compositions coincide with composition of allocations.

Detecting Change Points with Enhanced Backward Selection

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Change points detection is an important problem in many fields such as engineering, economics, finance, climatology and bioscience. It has attracted a lot of attention in statistics, and several solutions have been proposed and implemented in the literature. For multiple change point detection, one of the most popular method is binary segmentation. Binary segmentation starts with recovering a single change point and dividing the data into two segments. For each segment, the existence and location of a new change point is decided. This process continues until no new change points can be found. Binary segmentation is easy to understand and is efficient computationally, but it has some drawbacks. To overcome these drawbacks, the method of wild binary segmentation was proposed in (Fryzlewicz, 2014). In this talk, we introduce a new approach for change point detection and present the performance of our method in comparison to standard binary segmentation and wild binary segmentation.

Nonparametric multiple change-point detection for covariance matrices

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New methods for multiple change-point detection in the multivariate setting will be presented. The goal is to detect sudden expansions and/or contractions of the underlying covariance matrix of a multivariate time series. Presented methods first use data depth to transform the problem into a univariate change- point problem. One method then optimizes an objective function based on the classic Kruskal–Wallis one way ANOVA to choose the best set of change-points. PELT is used to optimize the objective function. The second method applies wild binary segmentation to a rank-based CUSUM statistic. Note both methods are fully parametric. Some simulation and theoretical results will be discussed.

Seen to Be Done: A Graphical Investigation of Peremptory Challenge

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The obscure legal practice of peremptory challenge has recently come under increased scrutiny in Canada due to its relevance in a number of high profile cases with racial aspects, chiefly the Gerald Stanley murder trial. In order to better understand the place of this challenge in the modern legal system, its history, controversies, and modern defenses are presented. The key modern arguments are analyzed using novel visual tools – the “mobile plot” and “positional boxplot” – applied to three data sets. A series of multinomial regression models motivated by these visualizations are then fit in order to generate precise parameter estimates. Throughout this analysis, the importance of race in the exercise of peremptory challenges is readily apparent. The implications of this finding to the future of the peremptory challenge are discussed.

Correlated and Misclassified Binary Observations in Complex Surveys

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Misclassifications in binary responses have long been a common problem in medical and health surveys. One way to handle misclassifications in clustered or longitudinal data is to incorporate the misclassification model through the generalized estimating equations approach. However, existing methods are developed under a non- survey setting and cannot be used directly for complex survey data. We propose a pseudo-GEE method for the analysis of binary survey responses with misclassifications. We focus on cluster sampling and develop analysis strategies for analyzing binary survey responses with different forms of additional information for the misclassification process. The proposed methodology has several attractive features, including simultaneous inferences for both the response model and the association parameters. Finite sample performance of the proposed estimators is evaluated through simulation studies and an application using a real dataset from the Canadian Longitudinal Study on Aging (CLSA). This is joint work with Mary E. Thompson and Changbao Wu.

Key words and phrases Complex sampling design; generalized estimating equations; super-population model; variance estimation; clustered data; repeated measurements.

Mean Field Behaviour of Queueing Systems with Job Redundancy

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Technological advancement in cloud computing has resulted in the viability of a new class of routing algorithm, the so-called redundancy models which are able to replicate jobs for processing on different servers. An asymptotic amount of queue-endowed servers could in this way employ their plentiful, otherwise idle servers towards processing. Research on the behaviour of such systems, however, have only conjectured the asymptotic independence of queues (Gardner, Harchol-Balter, & Scheller-Wolf, 2016; Hellemans, Bodas, & Van Houdt, 2019). To this end, we construct a non-matrix representable state space reflecting job dependency and construct a piecewise-deterministic Markov process with an associated metric space to describe the time-evolution of such systems. Such will be demonstrated to be sufficient in order to prove the stationarity and asymptotic independence of queues in the case of decreasing hazard rate service times.

Semiparametric Inference of Causal Effect with Nonignorable Missing Confounders

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We consider the estimation of causal effect when con- founders are subject to missingness. We allow the missingness of confounders to be nonignorable, that is, the missingness may depend on the missing confounders conditional on the observed data. The identification has been discussed in the literature; however, limited effort has been devoted into making semiparametric causal inference with nonignorably missing confounders. To address this, we propose three semiparametric estimators: the inverse probability weighting (IPW), the regression, and the doubly robust (DR) estimators. The IPW and the regression estimators require the correct specification of the propensity scores and the regression models for confounders and outcome, respectively. Assuming the selection bias odds ratio function is always correctly specified, the DR estimator utilizes both sets of models and is consistent if either set of models, but not necessarily both, is correctly specified. We investigate the finite sample performance of our proposed semiparametric estimators in the simulation studies and apply our estimators to the SO2 emissions data.

Key words and phrases: Causal inference, doubly robustness, outcome-independent missingness, nonignorable missing, shadow variable

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A powerful procedure that controls the false discovery rate with directional information

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In many multiple testing applications in genetics, the signs of test statistics provide useful directional information, such as whether genes are potentially up- or down-regulated between two experimental conditions. However, most existing procedures that control the false discovery rate (FDR) are p-value based and ignore such directional information. We introduce a novel procedure, the signed-knockoff procedure, to utilize the directional information and control the FDR in finite samples. We demonstrate the power advantage of our procedure through simulation studies and two real applications.

A Signaling Game of Debt Financing Using Equity Guarantee Swaps

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We analyze the real option signaling game models of debt financing of a risky project under information asymmetry, where the firm quality is only known to the firm management but not outsiders. The firm decides on the optimal investment timing of the risky project that requires upfront fixed funding cost and subsequent operating costs. The fixed funding cost is financed via either direct bank loan or entering into a three-party equity guarantee swap (EGS) that involves a bank granting the loan and third party guarantor. Under the EGS agreement, the guarantor is obligated to pay all the future coupon stream to the bank upon default of the firm. In return for the provision of the guarantee, the guarantor obtains certain proportional share of equity of the firm at the time when the swap agreement is signed. The share of equity demanded by the guarantor depends on the outside investors' belief on the firm quality. The low-type firm has the incentive to mimic the investment strategy of being high-type in terms of investment timing and share of equity. The high-type firm may adopt the appropriate separating strategy by speeding up investment or choosing an alternative financing choice. The resulting loss of the real option value of the investment opportunity represents the information cost under separating strategies. We examine the incentive compatibility constraints faced by the firm under different quality types and discuss characterization of the separating and pooling equilibriums. Unlike the usual assumption of perpetuity of investment opportunity, our real option model assumes the time window of the investment opportunity to be finite. We explore how the information cost and nature of separating and pooling equilibriums evolves over the finite time span of the investment opportunity. The information costs and investment thresholds exhibit interesting time dependent behaviors. We examine the firm's investment and financing choice between EGS and the direct bank loan against time and other parameters via comparison of the corresponding information costs and investment thresholds.

Joint Densities in the Renewal Risk model with Generalized Random Income

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In risk theory, premiums are usually assumed to be collected by insurers at a constant rate over time. However, for those smaller insurance companies which have relatively volatile premium incomes or premiums that are paid in lump sums, a generalized risk model with a random income component may be of practical interest. In this paper, our aim is to analyze the distributions of ruin related quantities in a generalized renewal risk model. We use probabilistic arguments and the Lagrange expansion theorem to obtain explicit expressions for joint densities involving the time to ruin, the number of claims until ruin, the surplus prior to ruin and the deficit at ruin. Numerical examples will be used to illustrate behavior of some ruin related quantities in renewal risk models with random incomes.

Dependent observation schemes of marker processes in Cox regression

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Cohorts of patients registered in clinics are routinely followed over time to collect information on time-varying markers, to learn about their disease course, and to evaluate the effects of interventions in routine care. We consider the setting where interest lies in modeling the effect of a marker on the survival time via a Cox regression model. Marker processes evolve in continuous time but measurements of markers are typically only available when individuals attend a clinic or give serum samples, so the true marker values is unobserved. Moreover the occasions when markers are measured are often related to the state of health of the individual and often the marker value itself. The convention is to use the most recently recorded marker value in Cox modeling of a survival time subject to right- censoring. We formulate a class of joint models for the marker process, visit process and survival time to investigate the large and finite sample properties of the estimator of marker effect in a Cox model for the survival time under this observation scheme. We also discuss approaches for mitigating the resulting bias through joint modelling to yield valid inferences. This is joint work with Richard Cook.

Protecting target zone currency market from the central bank

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We consider a stochastic control problem of the central bank on target zone markets. In this type of markets the price process is modelled as a diffusion which is reflected at two barriers. Such model arises when a currency exchange rate is kept in a domain due to central bank intervention. The central bank, who wishes to keep the currency exchange rate in this domain when a trader liquidates a certain amount of currency, therefore needs to buy its own currency. The permanent price impact, which is created by the transactions of both sides turns the optimal trading problem of the central bank into a blow-up elliptic ordinary differential equation (ODE) with a quadratic gradient term. We solve the central bank's control problem by means of Hamilton-Jacobi-Bellman (HJB) equation and application of nonlinear elliptic partial differential equation results. This is joint work with Eyal Neuman, Alexander Schied and Chengguo Weng.

Regression trees with interval-censored failure time data

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Interval-censored failure time data arise when the precise time of an event of interest is unobservable, but the status of an individual is determined at periodic assessment times. We consider the development of predictive models for failure times as well as the failure status of individuals at a particular time horizon. We use the theory of censoring unbiased transformations (CUT) to construct appropriate observed-data loss functions for the interval- censored event times. We further demonstrate that the regression trees built from the observed-data loss functions are equivalent to the ones using the imputation techniques, which apply the CUT to interval-censored failure times. These methods enable one to build regression trees to reveal an underlying dependence structure on covariates and show how these methods can be used effectively to make predictions. The proposed methods are evaluated via detailed simulation studies in which performance is compared to the conditional inference tree approach of Fu and Simonoff (2017). An application is given to a motivating study aiming to identify biomarkers associated with disease progression in rheumatic disease.

Properties of Optimal Regression Designs under Second-Order Least Squares Estimator

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We will talk about optimal regression designs under second-order least squares estimator
(SLSE). The SLSE, proposed by Wang and Leblanc (2008), is asymptotically more efficient than the least squares estimator when the error distribution is asymmetric. We first review the design properties under SLSE in the literature, including convexity, transformation and scale invariance, and optimization algorithms. Then we propose a new formulation for the design problems under A-optimal criterion for which can be applied to c-optimal criterion under the SLSE. We also derive the number of support points of the optimal designs by applying equivalence theorem. Several examples will be presented.

Semiparametric empirical likelihood inference with general estimating equations under density ratio models

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Density ratio models (DRMs) have been proved to be a powerful statistical tool to link two or more related samples. In this presentation, we consider statistical inferences under two-sample DRMs with additional auxiliary information incorporated through estimating equations. We examine the asymptotic properties of the maximum empirical likelihood estimators of the unknown parameters in the DRMs and/or defined through estimation equations, and further establish the chi-square limiting distributions for the empirical likelihood ratio statistics of these parameters. We also propose an empirical likelihood ratio test for the validity and usefulness of the auxiliary information. Simulation studies show that correctly specified estimating equations for the auxiliary information will result in more efficient estimators and more powerful statistical tests.

On discrete-time self-similar processes with stationary increments

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A stochastic process is self-similar if it is invariant under suitable scaling in both time and space. In this talk, we consider discrete-time self-similar processes with stationary increments. Different from the continuous-time case, the scaling function of such a process may not take the form of a power function $b(a) = a^H$. More precisely, it has an Ostrowski-type classification. It is shown that the new type of processes with the scaling function $b(a) = (a_p)^H$ has a special spectral representation. We also construct examples of such processes and discuss its interplay with other self-similar objects in pure mathematics, e.g. self-similar measures and self-similar automorphisms. This is joint work with Yi Shen.

Particle Physics Representation of a Continuous Stationary Gaussian Process

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The Generalized Langevin Equation (GLE) is a fundamental result in statistical mechanics describing the stochastic evolution of observables in interacting-particle systems. In the linear case, the GLE corresponds to a continuous stationary Gaussian process, a particularly useful first-order approximation in many single-molecule bio-physical experiments. However, dynamics of the observed particle position process must be deconvoluted from those of a latent force, rendering statistical modeling and parameter estimation typically in- tractable. Here, we prove that any continuous stationary Gaussian process can be expressed as a GLE, providing an explicit inverse representation of the force in terms of position. In addition to the immediate upshot of straightforward linear GLE modeling directly in the observable domain, the result provides insights for modeling nonlinear stationary physical processes as well. This is joint work with Martin Lysy.

Keywords and phrases: Generalized Langevin equation, continuous stationary Gaussian processes, Hamiltonian fields, projection operator, fluctuation-dissipation theorem, Laplace transform, power spectral density, autocorrelation function

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Grouping Dependence Structure and Selection of Copula-Based Models Using a Bayesian Nonparametric Method

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When analyzing dependent data, an insufficient sample size can lead to inaccurate model selection of dependence structure and estimation of the dependence parameters. Dependent data that arises from multiple sources may share the same dependence structure, thus grouping the data according to the similarity in their dependence structure is a necessary way to increase sample size and carry out valid and efficient inference. In this paper, we introduce a copula- based model and develop a Bayesian nonparametric method, called the DPM copula model (CM), with copula selection indicators and dependence parameters, whose prior distributions follow a Dirichlet Process (DP). We apply a Gibbs sampler with augmented parameter values to conduct inferences. Extensive simulation studies show that our proposed DPMCM can recover the true grouping structure and achieve high accuracy in copula model selection under various finite sample settings. We apply the DPMCM to analyze real data sets. This is joint work with Grace Y. Yi and Liqun Diao.

Distributional transforms, probability distortions and their applications

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In this presentation we provide a general mathematical framework for distributional transforms, which allows for many examples that are used extensively in the literature of finance, economics and optimization. We put a special focus on the class of probability distortions, which is a fundamental tool in decision theory. As our main results, we characterize distributional transforms satisfying various properties and this includes an equivalent set of conditions which forces a distributional transform to be a probability distortion.

In the application, we introduce a new method for sensitivity analysis of risk measures based on composition groups of probability distortions.

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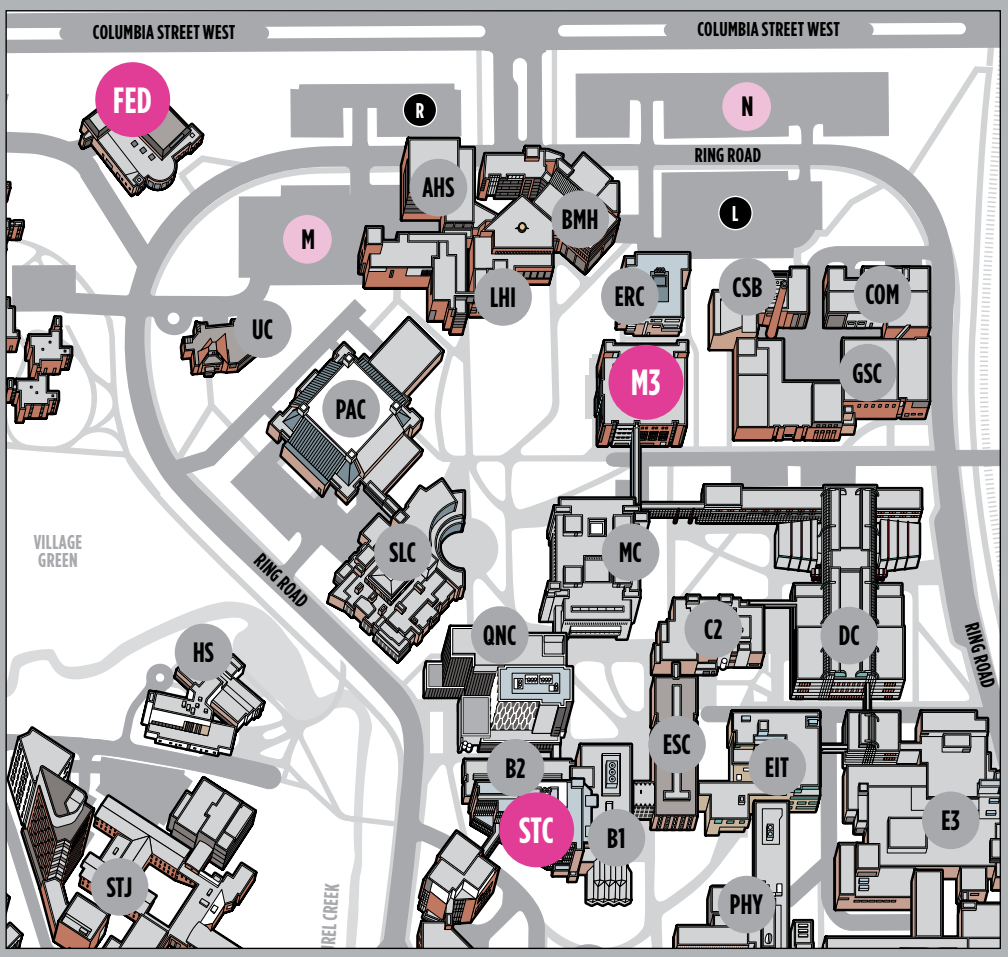

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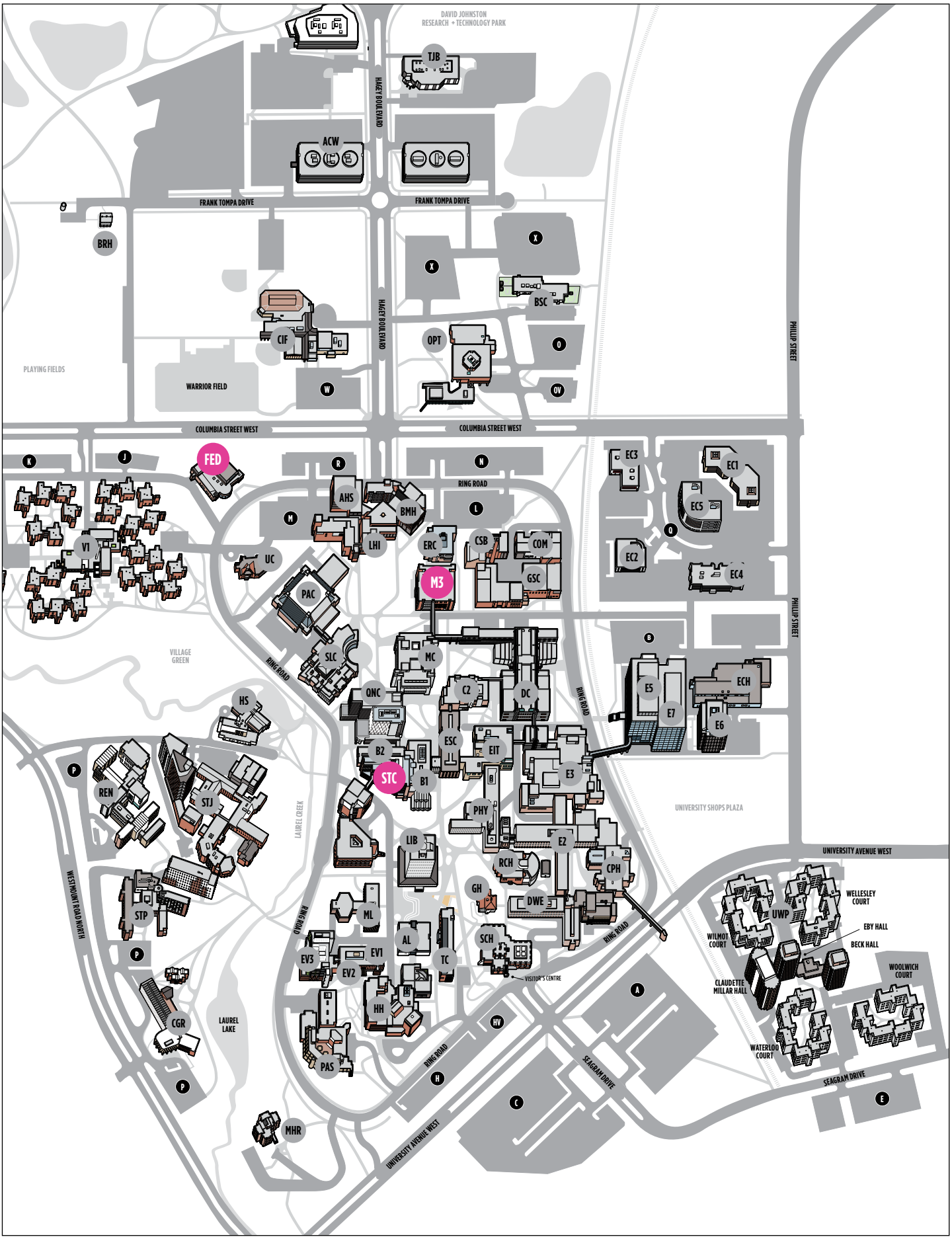
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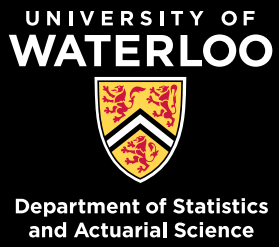

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