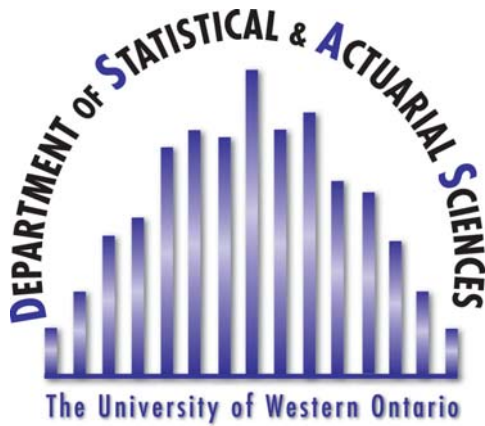

Department of Statistical & Actuarial Sciences
August 02, 2013



9th Annual MSc Day

9th Annual MSc Day

The University of Western Ontario

Schedule of Events

9:00 am	Poster Session I Setup
9:25 am	Opening Remarks Dr. W. John Braun
9:30 am	Poster Session I
11:15 am	Poster Cleanup
11:45 am	Lunch Served in the Atrium – Outside WSC 248
1:00 pm	Poster session II Setup
1:30 pm	Keynote Address– Dr. Paul Murrell The University of Auckland, New Zealand R Graphics for the Web
2:45 pm	Poster Session II
4:30 pm	Poster Session Cleanup
4:45pm	Final Reception and Pictures

ABSTRACTS

Malcolm Cameron

Modelling Reward Redemption using Independent Dynamic Non-Stationary Compound Poisson Processes

**supervisor: Dr. Wenqing He*

Reward Redemptions, such as Air Miles Redemption, are very popular marketing strategies in business. Recent changes in the reward redemption programs have provided a different approach at modeling this statistical problem. Understanding the underlying models of the reward redemption can help the funding financial institutions plan their reward funds. In this project, independent dynamic non-stationary compound Poisson processes are employed to postulate the underlying reward redemption model. Maximum likelihood estimation techniques are employed to recover process parameters, and to make inference about the assumed processes. The assumed processes allow for a lot of important fluctuation in process variables. Simulations with different distributions are used to assess the performance of the proposed method.

Yiqun Chen

A simulation study for paired censored survival data, with an application to the study of ear disease in children

**supervisors: Dr. Reg Kulperger & Dr. Neil Klar*

In biomedical studies, correlated failure time data arise often. We review methods, such as Poisson GEE, Cox regression and Kendall's Tau, to compare treatment and control. Simulation studies are carried out to examine the finite sample performance. The methodology is motivated by a data set studying the time to failure of ventilation tubes in children with otitis media. We study the size of the tests, and for those with the correct size we study the power. The results show that, overall, the experimental intervention reduces the risk of ventilation tube failure in children with otitis media.

Jingjia Chu and Bei Zhao

Interval Estimation of the Binomial Proportion in Cluster Randomized Trials

**supervisor: Dr. Duncan Murdoch*

Agresti and Coull (1998) introduced the *Plus 4* interval to get the 95% confidence interval of the binomial proportions. The *Plus 4* interval was an approximation of the Wilson interval which used the Wald formula after adding two “successes” and two “failures” to the sample. In this report, we explored variations on the *Plus 4* interval in the context of cluster randomized trials. Three confidence intervals were examined for the expected success proportion under the beta-binomial model: the Wald interval, the *Plus 4* interval and an intermediate method we call the *Plus 2* interval. Generally, the Wald interval is equal or better than the others for most simulations. The *Plus 4* interval and the *Plus 2* interval work better when the cluster size or the number of clusters is small (e.g. equal to 2) while the Wald method is the best in other cases. We do not see much difference between the *Plus 4* interval and the *Plus 2* interval unless they are both bad. When the cluster size is 100 and the number of clusters is 2, all of these methods have poor performance.

Yue Dong and Zhenbin Zhou

Wait Time Analysis of Endoscopy Suites

**supervisor: Dr. Dave Stanford*

The purpose of this study is to assist two hospitals in Canada to improve patient wait times in their current Endoscopy Suites. Two main steps are involved in the study: data analysis of endoscopy requests and procedure durations on the one hand, and patient appointment scheduling on the other. More specifically, standard statistical analyses have been applied to determine overall trends, and seasonal variation of demand patterns and service patterns. Meanwhile, some basic statistical analyses have been done for procedure time as well. Secondly, a prioritized scheduling algorithm has been proposed to reduce the backlog and to schedule appointments efficiently, subject to stated wait time targets for the different priority classes.

Xuemeng Hou, Yilu Liu and Lin Wu

Developing R Trix: R Teaching Resources for Interactive eXploration of data & chance

**supervisors: Dr. Bethany White and Dr. John Braun*

R Trix is extensive collection of resources developed to support early learning of probability and statistics in the schools. Motivated by the probability and statistics covered in the Ontario high-school mathematics curriculum, **R Trix** consists of three main parts: interactive web applications that do not require R knowledge, practice problems tied to curriculum topics with R solutions, and an R package called RTricks. An **R Trix** website was designed to make these resources attractive and accessible to everyone regardless of their interest or comfort level with R. **R Trix** should not only free teachers and students from drawing plots and doing calculations by hand, but these tools will hopefully help facilitate classroom activities to make abstract concepts a little more intuitive. For instance, the relationship between theoretical probabilities and experimental probabilities can be easily explored through simulation of many repetitions of simple experiments like flipping a coin or spinning a spinner. In our poster, we will present the **R Trix** tools, and share details on their development and the website design process. We will also have a computer on hand so you can give **R Trix** a try.

Shuaiqi Hu

A Spatial Control Chart

**supervisor: Dr. John Braun*

A control chart is used to monitor processes. Measurements are taken at regular intervals and they are plotted in time sequence. Usually, an observation is identified as 'out-of-control' when it differs from the process average by more than 3 standard deviations. The current project proposes a spatial version of a control chart which can be used to monitor processes located at different spatial locations. To construct this chart, an average is estimated at each location, using past data. The standard deviation is also estimated at each location. Spatial locations are plotted as a 2-d scatterplot, using different colors to indicate how many standard deviation units they are above the mean. The spatial control chart was applied to Fire Weather Index (FWI) data from the province of Ontario. The Fire Weather Index for a given day indicates the fire danger and suppression difficulty that would result if a fire were to burn on that day. The data set used in this project has FWI measurements at 399 weather stations over a period of 40 years. Daily means and standard deviations were estimated at each location using an additive model to handle the problem of missing observations at specific times and locations. The spatial control chart is illustrated with some specific examples.

Wenlong Jia

Market risk measure computation under two heavy-tailed distributions

**supervisor: Dr. Rogemar Mamon*

The calculation of value at risk (VaR) and conditional tail expectation (CTE) of a portfolio consisting of a default-free bond, and four stocks is considered. The stochastic dynamics of the four stocks are assumed to evolve according to two models, namely, a regime-switching model modulated by a discrete-time Markov chain with correlated innovations and a model driven with correlated Student's t-distributed noise. Parameter estimation for both models is demonstrated, and likelihood-based criteria for model selection are employed. Using market data for the four stocks, we found that the regime-switching two-state model yields the highest likelihood but the model following the Student's t-distribution is better in terms of the Akaike and Bayesian information criteria. Finally, a solution to the optimization problem of minimizing the CTE subject to a target portfolio return is provided under the two modelling frameworks.

Chunling Li

The Index-Based Securities and Other Insurance-Linked Securities:

Product Overview and Risk Elements

**supervisor: Dr. Jiandong Ren*

Insurance-linked securities (ILS) are innovative financial vehicles that have important roles to play in financing catastrophes and other types of insurance losses. They greatly expanded the risk-bearing capacities of insurers and reinsurers. This article first provides an overview of the ILS products and then discusses the main risk elements of index-based insurance derivatives, including moral hazard, basis risk, model risk, and timing risk. Our analysis will focus primarily on the basis risk of index-based insurance derivatives. In particular, we compare the hedge effectiveness of derivatives based on individual loss index, state loss index and regional loss index.

Lu Li

Portfolio Optimization Using Normal Mixture Model

**supervisor: Dr. Hao Yu*

In real financial markets, investors always establish investment portfolios to minimize the risk under their expected returns. Those portfolios consist of risky assets and non-risky assets. This project aims to find an optimal investment strategy. Bimodal normal mixture models are fitted into daily log returns of four stocks from different industries.

Those simulated components following the estimated distributions are then used to find the optimal portfolio with respect to various risk measurements (variance, VaR and CVaR). This project also discusses the optimal portfolio changes over multiple periods.

Yuchen Li

A study of some moments under the classical ruin model

**supervisor: Dr. Kristina Sendova*

In insurance companies, ruin happens due to the occurrence of a claim. There are several ruin-related quantities, which are of interest as risk measures. They are studied through a penalty function on the surplus immediately before ruin and the deficit at ruin. Recently, Cheung et al. (2010) introduce a new random variable, which is the surplus immediately after the second-to-the-last claim, which also allows the study of the last interclaim time. In this project, based on the joint densities introduced by Cheung et al. (2010), the joint moments are calculated and the results in some special cases are deduced.

Tianjiao Liu

Analysis of Clustered Censored Data using Regression Spline

**supervisor: Dr. Wenqing He*

Regression analysis on clustered data has been of considerable interest in last decades. When the response in the clustered regression models is survival time, however, traditional regression models have to be modified to incorporate censoring. In this project a regression spline method is used to model the relationship between survival time and covariates with censored response being transformed. Numerical study is conducted to assess the performance of the proposed method.

Xin Liu

Estimation of Catch Equations Parameters

**supervisor: Dr. Jiguo Cao*

During shing dynamics, the well known Baranov catch equations suggest a way to take into consideration the catch volume, the initial size of a population as well as mortality rate in terms of a single closed region over some period, which, nevertheless, is too short to take reproduction into account. In our model, we make an extension that introduces multiple regions and seasons into Baranov catch equations, thus including dispersion rate between each pair of two regions and age models for the sake of estimating the volume of recruits. In reality, unknown parameters, such as the dispersion rate between two regions, initial populations for different ages and the shing mortality rate need to be estimated. Hence the nonlinear least squares are employed, and the dynamics of the species are simulated according to the results. The system is then applied for estimating the population size of a sh species in Ontario Lake from real data sets.

Amy Morin

Analyzing Spatially Correlated Forest Fire Lifetime Data Using Proportional Hazards Frailty Models

**supervisor: Dr. Douglas Woolford*

The lifetime of a wildland fire will depend on locally-observed covariates, such as weather variables, fuel type and fuel moisture. A fire's survival time will also depend on variables related to fire management, such as the length of delay between the time a fire is reported and the start of fire suppression, as well as fire management strategy in that region. Understanding which covariates are important and how they might impact the lifetime of a fire can lead to more effective suppression efforts: this information can be incorporated into decision support systems used by fire management agencies to allocate resources and prioritize suppression efforts. This project presents a thorough survival analysis of the lifetime of forest fires recorded in the fire management database for Sioux Lookout, Ontario from 1985 through 2009. Life tables, simple parametric models, accelerated failure time models and proportional hazards models were developed. The analysis was extended to the forest fires in the province of Ontario, Canada over the same time period in order to investigate patterns across fire management zones. Further investigation of spatially correlated patterns in fire management compartments was carried out using proportional hazards Gaussian shared frailty models.

Philip Munz

A Framework for Modelling Counts of Wildfire Ignitions with Applications to Forest Fires in Alberta, Canada

**supervisor: Dr. Douglas Woolford*

This report describes the exploration and development of a hurdle-based generalized additive model (GAM) framework for counts of forest fires. Our hurdle model has two components. First, a logistic GAM is used to predict the probability of the presence/absence of fires on the landscape on a daily, 20 km x 20 km scale. Response-based sampling is employed to make the size of the data computationally feasible, which induces a deterministic offset into the model. However, given the spatial scale of the grid, it is possible for there to be more than one fire in a grid cell. The second component of the hurdle model develops a zero-truncated Poisson GAM, which is used to model the expected counts of fires, given locally observed covariates assuming fires are present. We outline the theory of hurdle models in this context and illustrate their application through an analysis of forest fire data from two study regions in Alberta, Canada. The data is explored, model-selection via cross-validation, and an assessment of goodness of fit and predictive capabilities for multiple models are conducted and discussed.

Kejia Peng, Lei Sun and Di Wang*Smoothed Averaged Shifted Histograms as Density Estimates***supervisor: Dr. Serge Provost*

This project proposes univariate and bivariate density estimation techniques that consist in smoothing averaged shifted histograms by means of polynomials. In the univariate case, the density estimate is obtained as a moment-based polynomial approximation to an average shifted histogram. Four approaches are described to determine its coefficients; one of them involves a linear combination of Legendre polynomials while another one relies on an explicit representation of the elements of the inverse of a Hilbert matrix. In the two-dimensional case, the product of polynomial approximations to the marginal density functions is adjusted by making use of a bivariate polynomial whose coefficients are such that the joint moments of the resulting distribution agree with the sample moments up to a certain order. It is explained that, in fact, this methodology gives rise to copula density functions. Alternatively, a density estimate may be obtained by smoothing a bivariate averaged shifted histogram by means of a least-squares approximating polynomial. Guidelines for selecting appropriate bin widths are suggested. Several illustrative examples are presented.

Adam Rahman*A Queuing Approach to Classic Ruin Theory***supervisor: Dr. David Stanford*

In classic ruin theory, it is assumed that the moment a claim arrives to the system it is paid immediately. This is clearly not reflective of reality - an arriving claim must be reported and processed before being paid. For this reason, we propose to apply a queuing framework to the classic ruin problem to reflect this reality. We assume claims arrive to a single server system according to a Poisson process at rate λ , and are subject to an Exponential (μ_s) service time before being paid. Claim sizes are assumed to be Exponential (μ_x), and premiums are paid continuously at rate 1. Under this model, when a claim arrives while the server is busy, the claim joins a queue and waits to be processed; otherwise, its processing time starts immediately. If a queue exists upon payment of a claim, the service time of the next claim begins immediately. However, if the queue is empty, we must wait for a claim to arrive before its processing time can begin and the next payment instant can occur. With this new framework established, we are primarily interested in the probability of ruin at a given claim instant. As such, we expand the work of Stanford & Stroinski (1994) and attempt to establish a recursive relationship to compute the desired probabilities at claim payment instants, utilizing Mathematica to obtain numerical results.

Xingchen Shen

Simulation results for finite-time ruin probabilities

**supervisors: Dr. Kristina Sendova*

This project is concerned with the problem of ruin under the classical compound Poisson model with continuous joint distribution of the claim amounts and the compound Poisson model with constant interest force. The primary purpose of this project is to evaluate the finite-time ruin probability under the two models employing simulation techniques.

First, based on the compound Poisson model assumption of joint inverted Dirichlet distributed claim amounts, we employ simulation to compare the results with the theoretical results which are given by Ignatov and Kaishev (2004). Then, due to the lack of explicit results for the compound Poisson model with constant interest force, simulations are useful for finding the finite-time ruin probability. We employ the ultimate ruin probability with exponential claim sizes to verify the simulation approach where the theoretical results are given by Cai and Dickson (2002).

Finally, we implement simulations to estimate the finite-time ruin probabilities and compare with the asymptotical results which are given by Tang (2005).

Xiaoge Song

Valuation of FX quanto options under a Markov-driven regime-switching model

**supervisor: Dr. Rogemar Mamon*

This project investigates the foreign exchange (FX) rate modelling for the purpose of FX quanto option pricing. In particular, the FX's log returns are assumed to have drifts and volatility governed by a discrete-time, finite-state Markov chain. Two techniques for parameter estimation are employed, viz.: the special Expectation-Maximisation (EM) algorithm in Hamilton (1994) and the method of Hardy (2001). Results from both estimation techniques are compared and differences analyzed. The numerical implementation involves a 16-year data set of daily JPY/USD FX rates from 02 Jan 1995 to 31 Dec 2010 compiled by the Chicago Mercantile Exchange. Using Hardy's estimation method, we found that the 3-state model gives the best goodness of fit for the data set under consideration. The total sojourn time random variable is characterised to provide prices for the two-, five-, and ten-year call and put quanto options. The prices under the 3 modelling settings are examined. This research study culminates with a sensitivity analysis illustrating the variation of the option price when perturbations in each model parameter are introduced.

Keynote Speaker

Dr. Paul Murrell

Department of Statistics, University of Auckland, New Zealand

R Graphics for the Web

A lot of publishers are publishing material on the web as well as (or instead of) in print. Even more publishing is happening without publishers, in blog posts and wikis, also on the web.

This talk will look at a number of ways to produce R plots for use on the web.

There will be a heavy bias towards producing graphics in the SVG format, and an even heavier bias towards producing SVG graphics using the 'gridSVG' package for R.



Zhiyuan Su

Simulation results of ruin quantities under the classical risk model

**supervisor: Dr. Kristina Sendova*

The evaluations of the ruin quantities under the classical risk model is one of the biggest topics in the study of ruin theory. In this project, we focus on simulations aimed at estimating the probability of ruin and some other ruin quantities, such as the proper distribution of the deficit at ruin, given that ruin occurs, and the moments of time to ruin, given that ruin occurs. Three different simulation algorithms are employed to obtain the results. The exact results obtained under the case of exponential claim sizes are used to check the accuracy of those algorithms. The project also makes comments on the efficiency and accuracy of the algorithms, as well as comparison on simulation results.

Dongyi Sun and Fan Xiao

Estimating claims reserves in R

**supervisor: Dr. Jiandong Ren*

Claims reserves in general insurance is an accounting provision in the financial statements of an insurer, which provide for the future liability for claims which have been incurred but not yet settled (IBNeR).

A commonly used method to calculate claim reserves in the industry is the so called distribution-free chain-ladder technique. In this paper, following England, P.D., Verrall (2002), we discuss several possible underlying statistical models for the chain ladder method. We then use R to implement the models to estimate claim reserves and give prediction errors. We also gave solutions to some technique problems when applying R.

Zhiying Sun

Portfolio Optimization using Mixture M-GARCH Model

**supervisor: Dr. Hao Yu*

This project is concerned with optimization problem of a portfolio consisting of various financial assets. Multivariate GARCH model provides us a way to fit the daily log returns of stocks, as it can reflect the dynamics of returns. In order to capture heavy tails in the data, we replace the assumption of multivariate normality by that of a finite mixture of multivariate normal distributions. With respect to various risk measures, we use the estimated distribution of returns after a single static period to find the optimal investment strategy, and aim to attain an expected target return at the same time.

Xiaoxu Tan

Estimating prediction errors of chain ladder method

**supervisor: Dr. Jiandong Ren*

Claims reserves are funds that set aside for the future payment of incurred claims that have not been settled and thus represent a balance sheet liability. In this project, we apply the models in Mack (1993, 1999) to estimate the prediction errors of the chain ladder method in predicting claim reserves. We also investigate a Bayes estimation for the chain ladder model suggested by Verrall (1990).

Caleb Tarzwell

Ruin Measures in an Earthquake Modeling Context

**supervisor: Dr. Kristina Sendova*

The classical compound Poisson risk model assumes independence between interclaim times and claim sizes. In many circumstances, particularly catastrophe modeling, this assumption proves to be inaccurate. The Seismic Gap Hypothesis claims that the size of earthquakes is related to the time which has passed since the last earthquake. Dargahi-Noubary and Razzaghi (1993) confirmed this hypothesis using dependence introduced through a basic Farley-Gumbel-Morgenstein (FGM) copula. Cossette et al. (2010) investigate ruin quantities through a classical compound Poisson model with dependence introduced by the same FGM copula. In this project, we further the results found by Cossette et al. (2010) by applying parametric results found by Dargahi-Noubary and Razzaghi (1993). We determine the moments and the CDF of the deficit at ruin. As a numerical example, these are computed using the parameters of Dargahi-Noubary and Razzaghi (1993) and compared to capital adequacy requirements to compare the effectiveness of capital requirements in this catastrophe context.

Alexander Tsang

Displaying R Profiling Data

**supervisor: Dr. Duncan Murdoch*

Programs in R can take a long time to execute. R has the `Rprof()` function to "profile" the execution: it measures the time taken by each function or each line of code, or it measures memory use of each of these.

The usual way to examine profiling data is with the `summaryRprof()` function, which produces a table of output.

In this project we developed a display of the original source code in HTML, usable in any browser, that highlights each line according to the length of time spent on it. This allows easy recognition of bottlenecks in program execution, so manual optimization is easier.

We plan to release our code as an R package on CRAN.

Eric Vanderwey

Health and Benefit Claims Aging Study

**supervisor: Dr. Bruce Jones*

This study develops claim cost aging factors for multiple post-retirement benefits. The types of benefits include prescription drugs, hospital, vision, dental, and paramedical. In determining the aging factors, we consider differences by province and gender. The results of the analysis will be used as the basis for assumptions in the valuation of Canadian non-pension post retirement medical and dental benefits.

Wantao Wang

Composite Likelihood Analysis of PBDE Data

**supervisors: Dr. Wenqing He*

Composite likelihood method deals with multivariate survival data, where only the modeling of the marginal distribution of pairs of related failure times is required. Polybrominated diphenyl ethers (PBDEs) are a class of brominated flame retardants commonly used in household products. Prenatal exposure to PBDEs has been found to associate with adverse neurodevelopment. A study was conducted between 2009 and 2010 in New York City to investigate predictors of exposure to PBDEs, where a cohort of pregnant women were enrolled. To estimate the association between the concentrations of the 4 PBDE congeners and the common effects of covariates on the 4 outcomes, we develop a composite likelihood estimation procedure for the PBDE data analysis, where the parameter estimation is achieved by maximizing the composite likelihood and the covariance matrix of the estimated parameters is obtained based on a sandwich type covariance matrix calculation. The performance of the proposed composite likelihood estimation procedure is assessed through a simulation study. We apply the composite likelihood estimation procedure to the PBDE data. The result shows strong association among the concentrations of the 4 PBDE congeners. The common effects of statistically significant predictors on the concentrations of the 4 PBDE congeners are explained.

Xin Wang

Functional data analysis for circular data

**supervisors: Dr. Jiguo Cao*

Circular data are one type of directional data, which are distributed on the circle. The particularity of circular data derives from the facts that 1 degrees are close to 359 degrees, and the mean of both angles is 0 degrees not 180 degrees, so that the special statistical methods are called for analyzing this type of data. In this paper, functional data analysis is used to study circular data, where the penalized SSE is derived based on von Mises distribution instead of Gaussian distribution. Meanwhile, due to the multimodal property of the penalized SSE, we propose the modified genetic algorithm to obtain the estimated parameters, and compare with the penalized least square on both simulation data and real data. We find that under the assumption of von Mises distribution, the modified genetic algorithm is consistently better than the penalized least square, which can inspire us to extend the current work from circular data to the data on Riemannian manifolds in the future.

Long Wen

The determinants of derivative usage and firm value: the case of Chinese non-financial companies

**supervisor: Dr. Ricardas Zitikis*

There are a number of determinants of derivative usage that have been noted and explored in several financial theories and applied to various geographies. This project focuses on analyzing if decisions of derivative usage by Chinese companies are significantly related to certain company characteristics that have been proven to be determinants of derivative usage in previous studies based on different samples. The results of my empirical study in this project suggest that the derivative usage in China mainly depends on the size of the company. It has also been noted in some other contexts that using derivatives can increase the firm value. Hence, in this project I also explore the relation between derivative usage and firm value. My results suggest, however, that using derivatives may not particularly increase the firm value of those Chinese companies that I have explored, and I provide some reasons why this might be the case.

Jiang Wu

The core-periphery model and the increasing returns framework

**supervisor: Dr. Ricardas Zitikis*

Since the establishment of the core-periphery model, whose main idea originated in the seminal paper by Krugman (1991), a new theory known as the new economics geography (NEG) has been developed by many authors. In this project, I explain the idea of the core-periphery model and demonstrate its profound usefulness when analyzing economic aspects such as gains and patterns of trade, agglomeration of production, location of cities, and so on. I also discuss other problems, such as ideological inheritance. In this project I also hint at further possible research directions and innovations related to the core-periphery model, particularly within the increasing returns framework.

Rouzhou Xue

Portfolio Optimization: a GARCH-copula approach

**supervisor: Dr. Reg Kulperger*

Co-movement of asset returns is one important factor for asset allocation strategies. Much of the literature that approaches this problem assumes iid and multi-normal or t distribution for asset returns. Unfortunately, this assumption is violated according to empirical studies. We instead adopt a flexible time series model, GARCH with copula innovations to more realistically capture the marginal distributions and conditional dependence structure. In our studies, a portfolio consisting of riskless (1 bond) and risky (4 stocks) assets is optimized in the sense of minimized risk under target return. Mean-variance model, VaR and CVaR model are employed to measure risk. The empirical research suggests GARCH-t-copula model from the five copulas chosen from two families has the best yearly economic performance consistently for three years (2010, May to 2013, April) with a rebalance every 6 months.

Chen Yang

Simulating Perpetual Put Option with Time Lag in C sharp

**supervisor: Dr. Matt Davison*

The theory of Real Options models the flexibility inherent in a real business. Many real options are adequately modelled by perpetual options. Perpetual options never expire and have analytic solutions assuming continuous trading and exercise possibilities. However, market changes, the time taken for information to travel through a firm, and the time required for managers to make decisions, as well as trader execution time, may cause exercise delay in practice. The delays can destroy real options value. In my master project I use simulation to investigate the amount of value lost by exercise delays. The discrete time steps used in simulation are also responsible for some value loss, which is our first topic of investigation. For simulating, I use C sharp, a young but powerful programming language, full of challenges and possibilities. In this report, using C sharp, we simulated the stock price, perpetual option value and perpetual option value with time lag. We are able to quantify the value destroyed as an (increasing) function of exercise delays.

Dong Zhang

Modified Kolmogorov-Smirnov Goodness-of-Fit Test for GARCH Models with Normal Mixture Innovations

**supervisor: Dr. Hao Yu*

In many financial fields, the GARCH model plays an important role in modeling the return rates of securities, such as stocks. In the meantime, the Kolmogorov-Smirnov (KS) test is one of the well-known statistic to test whether the innovation is from a specific distribution. In this project we use the modified KS statistic to test if the innovation of a GARCH model is from a normal mixture distribution instead of a standard normal distribution. Simulation study is conducted to study the size and power of the KS and the modified KS tests.



Dr. Paul Murrell

Dr. Paul Murrell received his PhD in 1998 from the University of Auckland, where he is now a Senior Lecturer in Statistics. He was appointed as a Fellow of the American Statistical Association in 2010.

Dr. Murrell is widely known as a leading expert on statistical graphics. He is the author of "R Graphics", originally released in 2005, with its second edition published in 2011.

