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Inference in hidden Markov models (HMMs)

Maciej Augustyniak
University of Montreal

This presentation is intended to be a short course on inference and filtering in hidden Markov models (HMMs) and state space models. These models comprise a hidden (unobserved) Markov chain (either with discrete or continuous state space) that governs the distribution of an observed stochastic process. An example of a HMM is a regime-switching model for stock returns in which the stock return distribution depends on the unobservable state of the economy.

Statistical inference in HMMs is generally related to the estimation of model parameters as well as to the estimation of the (unobservable) sequence of states generated by the hidden Markov chain. This course will introduce the main techniques that are used to conduct statistical inference in HMMs. In particular, the following topics will be discussed: Hamilton filter, Kalman filter, particle filtering and the expectation-maximization (EM) algorithm.

Insurance risk models with marked Poisson arrivals

Andrei Badescu
University of Toronto

In this paper we consider an insurance risk model where the accident occurrence times, the reporting times and the settlement times are distinct and are described via a particular homogeneous marked Poisson process. The analysis of the classical ruin related measures such as the time of ruin, the surplus prior to ruin and the deficit at ruin is given using connections with fluid models. Moreover, the paper investigates the correlation between different types of aggregate claims faced by the insurer. Numerical examples are presented in the end.

On the (mis-)use of models in actuarial research

Daniel Bauer
Georgia State University

Building and using stochastic risk management models is one of the key issues in actuarial practice and research. When used properly, models—even relatively simple ones—can provide an invaluable aid to making decisions in complex risky situations.

This presentation contemplates situations in which models are misused in actuarial research in the sense that they are pushed beyond their domain of applicability. In particular, I consider two examples close to my own research to illustrate this problem: (1) The valuation of option features in annuity products based on frictionless, complete-market models; and (2) analyses of “natural hedging” of longevity risk based on (single) factor mortality models.

I argue that there are various similar situations beyond these illustrative examples, and that they occur not infrequently in actuarial research. I conclude that this calls for increased scrutiny on the part of senior actuarial researchers, particularly those with editorial responsibility.

Variable annuities with fees tied to VIX

Carole Bernard
University of Waterloo
Joint work with A. Kolkiewicz and J. Tang

A typical variable annuity (VA) consists of two phases. First, the policyholder makes regular payments into a fund managed by the insurer (accumulation phase). Then, she receives income from the insurance company with some minimum guarantees for some given period (payment phase).

As Solvency II regulation requests a market consistent value of liabilities, VAs issuers face new challenges. Reserve requirements for VA products are highly "scenario dependent" and are not known at time of issue (technical provisions and solvency capital requirements change over time depending on market conditions, e.g. interest rates, volatility, equity market...). The issuer's income on most VAs is often computed as a fixed percentage fee of the fund under management which means that it is high (resp. low) when the market goes up (resp. down). Unfortunately, the market value of embedded guarantees moves in opposite direction. When equity goes down, guarantees become expensive. Moreover, the volatility typically increases so that delta hedging programs need to be rebalanced more often (more costly), and hedging programs that require to purchase options become very expensive as options prices increase when volatility increases. Thus the VA issuers' income becomes smaller when it is most needed.

We propose a new product design that allows to better align the guarantees' values and hedging costs when the market environment is changing. We link the issuer's income to the volatility index VIX in a similar way as recent VAs issued in the U.S. The proposed design has a state-dependent fee linked to the traded VIX index. It is in the same spirit of the recent work of Bernard et al. (ASTIN, 2013) and MacKay et al. (JRI, 2015) who study fees linked to the fund value in another context.

Insurance risk retention

Edward (Jed) Frees
University of Wisconsin – Madison

In this talk, I introduce a tool for managing an insurer's portfolio of risks. This tool is based on changes in the risk profile when changes in a risk parameter, such as a deductible, coinsurance, or upper policy limit, are made. I refer to the new statistic as a risk measure relative marginal, or "RM-squared", for short, change. By examining data from the Wisconsin Local Government Property Fund, I show how RM-squared changes can be used by a policyholder to select an effective risk mitigation strategy. I also show how it can be used by an insurer to identify the "best" and "worst" risks in terms of opportunities for risk management.

The theory underpinning the development of this tool is analogous to that of statistical quantile estimation. RM-squared changes also reflect the underlying dependence structure of risks. I use an elliptical copula framework to provide an initial investigation into this aspect.

Risk processes with refracted claim

Esther Frostig
University of Haifa

We consider a Cramer-Lundberg insurance risk process with the added feature of reinsurance. If an arriving claim finds the reserve below a certain threshold γ, or if it would bring the reserve below that level, then a reinsurer pays part of the claim.

Using fluctuation theory and the theory of scale functions of spectrally negative Levy processes, We derive expressions for the Laplace transform of the time to ruin and of the joint distribution of the deficit at ruin and the surplus before ruin.

We specify these results in much more detail for the threshold set-up with proportional reinsurance.

Efficient Greek calculation of variable annuity portfolios for dynamic hedging: A two-level metamodeling approach

Guojun Gan
University of Connecticut

The financial risk associated with the guarantees embedded in variable annuities cannot be addressed adequately by traditional actuarial techniques. Dynamical hedging is a popular approach to mitigate the financial risk arising from variable annuities. However, a major challenge of dynamical hedging is to calculate the dollar Deltas of a portfolio of variable annuities within a short time interval so that rebalancing can be done timely. In this talk, I will present a two-level metamodeling approach to efficiently estimating the partial dollar Deltas of a portfolio of variable annuities under a multi-asset framework. The first level metamodel is used to estimate the dollar Deltas at some well-chosen market levels and the second level metamodel is used to estimate the dollar Deltas at the current market level based on the pre-calculated dollar Deltas. This work was done jointly with Sheldon Lin of the University of Toronto.

Bridging risk measures and classical ruin theory

Jose Garrido
Concordia University

Some recent works have proposed bridges between the extensive literature on the Cramer-Lundberg risk model in ruin theory and risk measurement of insurance risk. The uncertainty in insurance risk processes is typically decomposed into the claim frequency and the claim severity, but more generally it also includes other elements such as the premium rate.

With the bridging methods proposed so far reflect only some elements of the risk process, typically the claim severity. Here we try to analyze the risk with all its components. We propose risk measures based on a solvency criteria which includes all the above insurance risk process elements.

An application to the optimal capital allocation problem serves as an illustrative example of possible uses of the new risk measure.

(This is joint work with Wenjun Jiang, from Western U.)

Structural changes on SIEFORES' price yields based on investment portfolios

Denise Gomez-Hernandez
UAQ, Mexico

The aim of this work is to perform a statistical analysis of the Siefores' (investment companies specialized in retirement savings funds in Mexico) historical prices with emphasis on determining whether there have been structural changes on yields through the time. The methodology followed in order to find the results is to perform a quantitative analysis using statistical tools, based on an analysis of historical data of the Siefores' prices from 1997 to 2015. Hence, the analysis consists of 1) to identify extreme values on a total of 4 Siefores' yields and per Afore (retirement savings fund managers), 2) to identify the dates where these extreme values occurred and to analyse coincidences on dates for all the Siefores and Afores, 3) to determine whether changes on the Siefores' investment portfolios occurred on these dates, 4) to define segments based on the dates defined previously, 5) to perform the so called "Chow hypothesis testing" in order to conclude whether there is a structural change on the Siefores' yields. The result that we expect to find is that there is a structural change on the Siefores' yields and that these have contributed to the decrease on the portfolios returns.

General approach to the optimal portfolio selection

Zinoviy Landsman
University of Haifa
Joint work with Udi Makov and Tomer Shushi

In this paper we present an explicit solution to a problem of maximization of a ratio of function of a linear functional and function of a quadratic functional, subject to a system of linear constraints. This is of interest for solving important problems in financial economics and risk management related, for example, to optimal portfolio selection. This work essentially generalizes the results of the authors, where the problem of minimizing the combination of linear functional and a function of quadratic functional was considered. The new results essentially generalize classical results. In particularly, the mean-variance principle, the Sharpe ratio principle, the recently introduced tail mean-variance principle and the optimization with respect to translation invariant and positive homogeneous risk measures. The results are demonstrated using real data.

On minimizing drawdown risks of lifetime investments

David Landriault
University of Waterloo

Drawdown measures the decline of portfolio value from its historic high-water mark. In this talk, we study a lifetime investment problem aiming at minimizing the risk of drawdown occurrences. Under the Black-Scholes framework, we examine two financial market models: a market with two risky assets, and

a market with a risk-free asset and a risky asset. Closed-form optimal trading strategies are derived under both models by utilizing a decomposition technique on the associated Hamilton-Jacobi-Bellman (HJB) equation. We show that it is optimal to minimize the portfolio variance when the fund value is at its historic high-water mark. Also, when the fund value drops, the proportion invested in the asset with a higher instantaneous rate of return increases. We find that the instantaneous return rate of the minimum lifetime drawdown probability (MLDP) portfolio is never less than the return rate of the minimum variance (MV) portfolio. This supports the practical use of drawdown-based performance measures in which the role of volatility is replaced by drawdown.

Rating endorsements using generalized linear models

Gee Lee
University of Wisconsin - Madison

Insurance policies often contain optional insurance coverages known as endorsements. Because these additional coverages are typically inexpensive relative to primary coverages and data can be sparse (coverages are optional), rating of endorsements is often done in ad hoc manner after a primary analysis has been conducted. This paper describes a study of the Wisconsin Local Government Property Insurance Fund where it is desirable to have a formal mechanism for rating endorsements. Our goal is to provide prediction algorithms that are transparent and that promote equity among policyholders by determining rates that reflect the appropriate level and amount of uncertainty of each risk. To accommodate potentially conflicting goals of data complexity and algorithmic transparency, we utilize shrinkage techniques to moderate the effects of endorsements with penalized likelihoods. We find that the rating algorithms using shrinkage techniques have a predictive accuracy that are comparable to unbiased generalized linear model techniques and provide relativities for endorsements that are consistent with sound economic, risk management, and actuarial practice.

Option prices and model-free measurement of implied herd behavior in stock markets

Daniel Linders
Katholieke Universiteit Leuven
Joint work with Jan Dhaene, Wim Schoutens

In this presentation we will consider the problem of measuring dependence between equity prices using prices of traded derivatives. Dependence between stock prices changes randomly over time and therefore, it is a hard task to determine dependence using historical data. Indeed, such approach is only a good proxy if the future is sufficiently similar to the past. By using prices of traded options, up-to-date market information is included in the estimates and we avoid working with past data which may not be relevant for the future.

In a first part, we search for the best upper bound for an index option price, based on available market information. In particular, we determine the lowest upper bound for the price of the index option which is consistent with the observed prices of traded options on the individual stocks contained in the index. We also prove that the lowest upper bound corresponds to the price of the cheapest strategy in a broad class of static super-replicating investment strategies for the index option.

In a second part, we develop a new approach to extract the implied dependence between equity prices using the prices of traded vanilla and index options. The theory of comonotonicity is employed to

construct the hypothetical comonotonic market situation out of the available stock option data. In this artificial comono- tonic market situation stock prices move perfectly together. This market situation is then used as a point of reference and the degree of herd behavior is defined as the distance between the real (observed) market situation and the comonotonic (non-observed) extreme case.

Maximum likelihood estimation for Markov aging mortality model

Xiaoming Liu
Western University

Markov aging mortality model proposed in Lin and Liu (2007) used a finite state Markov process with one absorbing state to model human mortality. The observed mortality changes with age can be nicely interpreted as individuals going through aging process. This type of mortality model is attractive since it connects mortality rate with underlying biological mechanism of human aging. Many interesting extensions and applications have been developed based on this proposed Markov aging model structure; for example, see Ko and Bae (2015), Govorun et al (2014), Su and Sherris (2012), Foo et al. (2011), Lee and Lin (2009), etc. The resulting model falls in the class of phase-type distribution. Using a weighted least squares method, Lin and Liu (2007) have fitted the model to three Swedish cohort population data. However, the non-uniqueness of phase-type distribution makes model identification very challenging.

In this talk, we would like to discuss approaches that can improve model estimation. We will first show the results of our attempt in using maximum likelihood estimation approach to fit the model. We make some additional assumption to take into account the variability in the observed population data. More specifically, we assume the number of deaths follows a Poisson distribution. Based on this assumption, we implement maximum likelihood estimation approach to obtain model parameters; this allows us to utilize the well-defined statistical tools (such as BIC and likelihood ratio test) to compare and select different model structures. We investigate the robustness of our estimation algorithm to various situations. We have applied our method to Canadian population data at different years and for both genders. While we can achieve fairly satisfying fitting results in general, we also want to show and discuss the pitfalls with using this type of model.

Spatial modeling and analysis of insurance losses

Yi Lu
Simon Fraser University

In modeling climatological, geological or catastrophic related insurance risks such as loss cost ratios in crop insurance and damage caused by earthquakes and hurricanes, it is common to develop spatio-temporal models that can be used to analyze the related risks quantitatively as a function of time, location, and perhaps also background risk factors. In this presentation, I will present two of our recent studies that analyze the insurance loss related quantities using the spatial statistics tools. First study is on a multidimensional Bühlmann-Straub credibility model with spatial dependence structure among risk parameters and within conditional cross-sectional losses. Non-parametric estimators of structural parameters are proposed in the spatial statistics context, and credibility predictions made for the proposed model are compared to other models in an application with crop insurance data. Second study is on the modeling of regional hurricane and tropical storm damage for which we propose a fully Bayesian prediction model that uses conditional autoregressive models to account for both storm paths and spatial

patterns for storm damage. Regional damage predictions from the proposed model are then used for pricing regional insurance premiums with some distributional risk measures as premium principles. This is a joint work with Jimmy Poon, Simon Mak and Derek Bingham.

Bayesian nonparametric inference in asset allocation

Juan Carlos Martinez-Ovando
ITAM, Mexico

In this work, we examine the problem of optimal investment under uncertainty about the returns distribution. We discuss the relevance of this assumption for the construction of optimal investment frontiers. For practical purposes, we characterize the returns distribution as a Bayesian nonparametric location-scale mixture of Gaussian kernels. In this way, our approach allows for the possibility of explicitly including the first three moments of the returns distribution into the investor's objective function in a meaningful way. Thus, the traditional mean-variance approach is being extended into considering as well the effect of skewness and heavy tail behaviour of the returns in the optimal solution. We derive optimal investment frontiers for two modelling frameworks of the returns distribution: exchangeable and time-dependent. We also discuss the relevance of the prior choice of the model on the derivation of optimal solutions. We present some illustrations based on six foreign exchange rates.

Equitable retirement income tontines: mixing cohorts without discriminating

Moshe Milevsky
York University
Joint work with T.S. Salisbury

There is growing interest in the design of annuities that insure against idiosyncratic longevity risk while pooling systematic risk; for example Piggot, Valdez and Detzel (2005) or Donnelly, Guillen and Nielsen (2014). In this paper we generalize the natural retirement income tontine introduced by Milevsky and Salisbury (2015), by combining heterogeneous cohorts into one pool. We engineer this scheme by allocating tontine shares at either a premium or a discount to par based on (i.) the age of the investor and (ii.) the amount they invest. For example, a 55 year-old allocating $10, 000 to the tontine would be told to pay $200 per share and receive 50 shares, while a 75 year-old allocating $8, 000 would pay $40 per share and receive 200 shares. They would all be mixed together into the same tontine pool and each tontine share would have equal rights. This echoes a proposal by Charles Compton (1833) almost two centuries years ago; which hasn't received much attention in the literature. We address existence and uniqueness issues and prove that Compton's scheme can be constructed equitably – which is distinct from fairly – although it isn't optimal for any cohort. As such, this also gives us the opportunity to differentiate between arrangements that are socially equitable, vs. actuarially fair vs. economically optimal.

Manuel Morales
University of Montreal

Levy processes in collective risk theory: A review and new developments

Expressions for the expected discounted penalty function now exist for a wide range of models, in particular for a general class of Levy insurance risk processes [Biffis and Morales (2010) and Biffis and

Kyprianou (2010)]. Indeed, the EDPF encapsulates relevant information about ruin related quantities that are of potential interest in risk management applications. In this talk we start with a review of existing models and results while emphasizing the role of the theory of fluctuations in understanding the ruin problem. We then discuss new directions that can be studied with the ultimate aim of designing new path-dependent risk measures from the body of knowledge gathered over the years in Ruin Theory. More specifically, we will look at non-ruin quantities that contain relevant information about a Levy risk process. The field of risk theory has traditionally focused on ruin-related quantities. Although it is true that there are still many challenging questions, ruin related quantities do not seem to capture path-dependent properties of the reserve. In this talk we aim at presenting the probabilistic properties of drawdowns and the speed at which an insurance reserve depletes as a consequence of the risk exposure of the company. These new quantities are not ruin related yet they capture important features of an insurance position and we believe it can lead to the design of a meaningful risk measures. Studying drawdowns and speed of depletion for Levy insurance risk processes represent a novel and challenging concept in insurance mathematics. Indeed, drawdowns and speed of depletion are quantities that do not depend on the level but rather on path properties of the model which explain how fast the process can drop. This type of quantities has never been proposed before as measures of riskiness in insurance. Drawdowns have been only studied for diffusion processes in a finance setting, yet in insurance we need expressions for processes exhibiting jumps. Definitions of all these concepts are given as well as some examples of Levy insurance risk processes for which they can be calculated. Future work, applications and open questions are also discussed.

Dependence structures with applications to actuarial science

Luis E. Nieto-Barajas
ITAM Mexico

In this talk we will review the constuction of stochastic processes in dicrete time which are first order dependent (Markov) and order-q dependent. These processes are marginally stationary and can have very flexible dependence structures. We illustrate their use in survival analysis, solvency, claims reserving (IBNR), disease mapping and time series analysis.

Discussions on statistics in actuarial ccience

Liang Peng
Georgia State University

Nowadays it is a common practice of employing techniques in mathematical finance and statistical modeling to price insurance products. Unfortunately researchers and practitioners seldom care about using/developing efficient inference procedures and accurately evaluating variability caused by parameters uncertainty. Without doubt, using right inference and developing efficient inference will enable insurance companies to provide more personalized services to customers and manage their risk soundly. To start with brainstorming, I list some possible topics as follows: i) Stochastic differential equations and factor time series models have been used to model mortality in order to understand and hedge longevity risk, however using and developing efficient statistical inference procedures is quite under-studied; ii) Risk measure has been discussed much in the context of reinsurance, but uncertainty quantification of risk measure has not received serious attention especially when analysis involves several steps of data transformation and model fitting such as systemic risk analysis; iii) dependence modeling is agreed to be important in the practice of actuarial science, but high dimensional techniques have not

explored much in managing an insurance portfolio; iv) public information at individual levels becomes richer and richer, it may be time to employ/develop machine learning techniques so as to improve our prediction in stochastic reserving models and to price Directors and Officers' liability risk accurately?

Product design in life insurance: two examples

Ermanno Pitacco
University of Trieste

The benefits provided by many life insurance products imply a wide range of "guarantees" and hence risks borne by the insurance company (or the pension fund). Guarantees and inherent risks clearly emerge in recent scenarios, in particular because of volatility in the financial markets and trends in mortality / longevity. Appropriate modeling tools are then needed for pricing and reserving.
However, the implementation of complex mathematical methods often constitutes, on the one hand, an obstacle on the way towards sound pricing and reserving principles. On the other hand, facing the risks by charging very high premiums trivially reduces the insurer's market share.

Alternative solutions can be suggested by an appropriate product design which aims at sharing risks between the insurer and the policyholders. Interesting examples are provided by the design of long-term care covers, and by profit participation mechanisms in endowment insurance products.

A multivariate aggregate loss model

Jiaodong Ren
Western University

In this paper, we introduce a multivariate compound discrete distribution to model losses from difference sources of risks of an insur- ance company. The distribution is constructed based on a discrete time Markov chain, it generalizes the multivariate negative binomial distributions much studied in the literature. We provide explicit formulas for the joint moments of different types of losses and recursive formulas for the joint distribution. Then, an EM-algorithm is developed for estimating the parameters for the distribution. Finally, we discuss computational methods for calculating risk measures of the aggregate losses as well as for allocating the aggregate risk to individual types of risk sources.

Market-consistent actuarial valuation: application in pension valuation

Ahmad Salahnejhad
University of Maastricht

Life insurance companies and pension funds have liabilities on their books with very long dated maturities. Life business facing contractual obligations that can easily last 60 years, and sometimes even 80 or 90 years into the future. While most of these very long-dated contracts are not tradable, the supervisor's requirement for "Market-Consistent" valuation makes the pricing and risk-management of such liabilities very important. To obtain the market-consistent price, we combine the hedgeable financial risk with an unhedgeable insurance risk in the market and we price the general payoff that depends on both risks, using a pricing procedure called "Two-step market evaluation". In a general setting, the valuation process of the portfolio will be implicitly consist of the no-arbitrage price of the pure financial risk, value of the partially hedged insurance risk due to its correlation with financial risk (if available),

and finally the value of pure insurance risk via well-known actuarial premium principles. We implement two-step valuation together with backward iteration method to simultaneously achieve Time-Consistency property of the price over the valuation period.

Actuarial research on longevity and retirement financing at CEPAR

Michael Sherris
University of New South Wales

This talk will give an overview of the actuarial research program in longevity and retirement financing at CEPAR with the aim of generating discussion around potential research areas. It will outline the research from a range of projects in the areas of mortality and health models, annuity pricing and solvency, long term care, reverse mortgages and longevity risk management and hedging. Some of the longevity risk models covered include - Consistent dynamic mortality model (Blackburn and Sherris, 2013), Heterogeneity- Health status and Markov Ageing model (Su and Sherris, 2012; Sherris and Zhou, 2014), Frailty models (Su and Sherris, 2012; Fong, Sherris, and Yap, 2015), Systematic mortality and heterogeneity (Xu, Meyricke, Sherris, 2015), Cohort models (Yajing Xu, PhD student; Yang Chang and Sherris, 2015). Annuity pricing covered in - Heterogeneity, pricing and capital (Meyricke and Sherris, 2013), Annuity demand and capital requirements (Nirmalendran, Hanewald and Sherris, 2014), Hedging and costs of capital (Meyricke and Sherris, 2014), Solvency and shareholder value (Blackburn, C., Hanewald, K., Olivieri, A., and Sherris, M., 2013). Long term care and reverse mortgages covered in - Disability, LTC and Multiple State Actuarial Models (Fong, Shao and Sherris, 2015), LTC insurance pricing and solvency (Shao, Fong, Sherris, 2015), RM pricing and risk analysis (Shao, Hanewald and Sherris, 2015; Alai, Chen, Cho, Sherris and Hanewald, 2014; Cho, Hanewald and Sherris, 2014), Housing and retirement decisions (Mengyi Xu, PhD student), Optimal housing, RM, LTC (Shao) and longevity risk management – natural hedging of annuity and life business (Wong, Sherris, Stevens, 2014), Immunization and Hedging of Longevity Risk (Liu and Sherris, 2015), Multiple population models and natural hedging (Blackburn and Sherris, 2015), GLWBs (Fund, Ignatieva, Sherris, 2014).

Losses given default in the presence of extreme risks

Qihe Tang
University of Iowa

Consider a portfolio of multiple obligors subject to possible default. We propose a static structural model that takes into account the severity of default. Denote by $L(p)$ the loss given default of the portfolio, where $0<p<1$ is a given default probability. Note that p is small for a portfolio consisting of assets of good credit quality. Assuming that the loss variables of the obligors jointly possess a multivariate regularly-varying tail, we obtain an approximation for the distribution of $L(p)$ as $p\downarrow 0$.

This talk is based on a recent joint work with Zhongyi Yuan of Pennsylvania State University.

Model risk assessment

Steven Vanduffel
Vrije Universiteit Brussel
Joint work with C. Bernard, M. Denuit, G. Puccetti, L. Ruschendorf, D. Small and J. Yao

The risk assessment of high dimensional portfolios $\left(X_{1},X_{2},\ldots ,X_{d}\right)$ is a core issue in the regulation of financial institutions and in quantitative risk management. In this regard, one usually attempts to measure the risk of the aggregate portfolio (defined as the sum of individual risks X_{i}) using a risk measure (such as the variance or the Value-at-Risk (VaR)). Solving this problem is a numerical issue once the joint distribution of $\left(X_{1},X_{2},\ldots ,X_{d}\right) $ is completely specified. Unfortunately, its estimation is a difficult task, prone to model misspecification. At present, there is no generally accepted framework for quantifying model risk. A natural way to do so consists in finding the extreme possible values of a chosen risk measure in a family of candidate models.

Embrechts, Puccetti and Ruschendorf (2013) propose the Rearrangement Algorithm (RA) to find bounds on the VaR of high dimensional portfolios, assuming that marginal distributions of the individual risks are known (or prone to negligible model risk) and that the dependence structure (copula) among the risks is not specified. This assumption is natural, as fitting the marginal distribution of a single risk X_{i} $(i=1,2,...,d)$ can often be performed in a relatively accurate manner, whereas fitting a multivariate model for $(X_{1},X_{2},\ldots ,X_{d})$ is challenging, even when the number of observations is large. The bounds derived by Embrechts, Puccetti and Ruschendorf (2013) are wide, as they neglect all information on the interaction among the individual risks.

We discuss several possibilities to integrate dependence information and we discuss the impact on risk bounds. In particular we propose extended versions of the RA that deal with the availability of dependence information. We illustrate the theoretical results by various applications of interest.

Robust methods for claims reserving

Tim Verdonck
Katholieke Universiteit Leuven

The chain-ladder method is a widely used technique to forecast the reserves that have to be kept regarding claims that are known to exist, but for with the actual size is unknown at the time the reserves have to be set. The chain-ladder method is not robust and even one outlier (i.e. an observation that deviates from the pattern) can lead to a huge over- or underestimation of the overall reserve when using the chain-ladder method. Therefore we propose a robust chain-ladder method and a diagnostic tool to detect which claims have an abnormally positive or negative influence on the reserve estimates. To obtain a prediction interval, we need an estimate for the variance of the resulting reserve estimate. Computing analytic expressions for the variance is difficult and the bootstrapping technique typically offers a simple and popular alternative. Even when paired with robust estimators, classical bootstrap may break down. Therefore we present and discuss some state-of-the-art robust bootstrapping procedures in the claims reserving framework.

Recently, the claims reserving problem is also studied in a multivariate context, where multiple reserving data sets are forecasted simultaneously taking into account the correlations among the different run-off

triangles. Zhang (2010) showed that most multivariate reserving models can be summarised using the Seemingly Unrelated Regression (SUR) model. Therefore we propose a fast algorithm for robust SUR that provides useful outlier diagnostics and apply this in the framework of stochastic claims reserving. The good performance of the robust alternatives is illustrated on simulated and real data.

Solvency II: Expectations and realities of its implementation in the Mexican insurance market

Oscar Villanueva
Agroasemex Mexico

The main idea of the presentation is to make a comparison, from an insurance company point of view, between the initial expectations of Solvency II in actuarial modelling terms, and the regulator's final requirement, considering some of the main difficulties and tries to launch the programme.

Maximizing diversification benefits

Fan Yang
University of Waterloo

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

Quantitative analysis of the basis risk of index-linked CAT risk securities

Huan Zhang
University of Iowa

Insurance-linked securities (ILS) have been widely used as an alternative risk transfer of catastrophic (CAT) insurance risks to the capital market. The market of ILS is experiencing a rapid growth as the first quarter of 2015 has become the biggest first quarter ever in the history of ILS issuance.

While using an ILS with an index trigger rather than an indemnity trigger to transfer/hedge risk, a well-known problem is the existence of basis risk, which could be substantial when the dependence between the index and the sponsor's loss (that is to be hedged) is not sufficiently high.

In this paper we first develop a model to capture the basis risk, and then devote ourselves to its quantitative analysis. Using extreme value analysis and Monte Carlo simulation, we demonstrate the sensitivity of the basis risk to the dependence between the index and the sponsor's loss.

This talk is based on a joint work with Qihe Tang and Zhongyi Yuan.

On the analysis of time dependent aggregate claims

Cindy (Di) Xu
University of Waterloo
Joint work with David Landriault and Gord Willmot

This talk is focused on the analysis of the time dependent aggregate claim distribution, which is an important insurance risk model for quantifying the total claim amounts to the insurers. The knowledge of the claims experience is essential for insurers in pricing, reserving, solvency requirement, and more generally, risk management. An integral representation is derived for the sum of all claims over a finite interval when the claim value depends upon its incurral time. These time dependent claims, which generalize the usual compound model for aggregate claims, have insurance applications involving models for inflation and payment delays. The number of claims process is assumed to be a (possibly delayed) nonhomogeneous birth process, which includes the Poisson process, contagion models, and the mixed Poisson process, as special cases. Known simplified compound representations in these special cases are easily generalized to the conditional case, given the number of claims at the beginning of the interval. Applications to more general claim count models allowing multiple states are also considered.