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5-6 February 2015
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WOG Stochastic Modelling with applications in Financial Markets

EXHIBITORS

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Representative : Wouter Dewolf

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Poster session :	Marble room
Lunches and coffee breaks :	Marble room
Conference dinner :	University foundation (Egmontstraat 11, 1000 Brussel)

Map with important locations : available on

http://www.afmathconf.ugent.be/index.php?page=practicalinfo

Wireless internet

There is wireless internet available in the main building and throne building.

- SSID = academie.
- This is an open network, no password is needed.

Books and software

In the Marble room you can find:

- a book stand from 'Springer Press',
- a demo stand from 'NAG' with numerical software.

PROGRAMME - 5 February

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14h00 - 14h45	**Invited speaker: Véronique Maume-Deschamps**, Université Claude Bernard 1 Lyon, France *On the estimation of aggregated VaR with marginal and/or dependence informations*
14h45 - 15h15	Contributed talk: Anne MacKay, ETH Zürich, Switzerland *Risk Management of Policyholder Behavior in Equity-Linked Life Insurance*
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16h30 - 17h00	Contributed talk : Adrien Lebègue, Université catholique de Louvain, Belgium *Iterated VaR or CTE Measures: a False Good Idea?*
19h30 - 22h00	Conference Dinner at University Foundation

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09h45 - 10h15	Contributed talk: Anne Balter, Maastricht University, the Netherlands *Pricing and hedging in incomplete markets with model ambiguity*
10h15 - 10h45	Coffee break
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10h45 - 11h30	**Invited speaker: Iain J. Clark**, Efficient Frontier Consulting, United Kingdom *Option Pricing Models for Pegged and Quasi-Pegged Currency Pairs*
11h30 - 12h00	Contributed talk: Grégory Rayée, Université libre de Bruxelles, Belgium *Extracting a quanto type implied correlation in a multivariate exponential Lévy framework*
12h00 – 13h30	Sandwich lunch combined with **Poster session**
	Chair: Carole Bernard
13h30 - 14h15	**Invited speaker: Rudi Zagst**, Technische Universität München, Germany *Closed-form solutions for Guaranteed Minimum Accumulation Benefits*
14h15 - 14h45	Contributed talk: MingJie Hao, University of Kent, United Kingdom *Adverse selection, Loss Coverage and Multiple Equilibria in Insurance*
14h45 - 15h15	Coffee break
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15h15 - 16h00	**Invited speaker: Uwe Wystup**, University of Antwerp, Belgium & MathFinance AG, Germany *Volatility as Investment - Crash Protection with Calendar Spreads of Variance Swaps*
16h00 - 16h30	Contributed talk: Daniël Linders, KU Leuven, Belgium *Model-free measurement of market fear*
16h30 - 16h45	Closing

- **Katrien Antonio**, KU Leuven, Belgium
  On the transferability of reserves in lifelong health insurance contracts

- **Enrique Calderín**, University of Melbourne, Australia
  Modeling Large Claims with the Pareto ArcTan Distribution

- **Sudip Ratan Chandra**, University of Kent, United Kingdom
  Pricing Arithmetic type Asian Option with Lévy Processes : Fourier Transform Approach

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- **Qian Feng**, Centrum voor Wiskunde en Informatica, the Netherlands
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- **Evangelia Mitrodima**, University of Kent, United Kingdom
  Component value at risk models with countercyclical adjustments for improved economic performance

- **Tobias Niedrig**, Goethe University Frankfurt, Germany
  Participating Life Insurance Contracts in different Interest Rate Environments: How Product Design affects Welfare

- **Olena Ragulina**, Taras Shevchenko National University of Kyiv, Ukraine
  Continuity and differentiability properties of the survival probabilities in risk models with investments and their applications

- **Ahmad Salahnejhad Ghalehjooghi**, Maastricht University, the Netherlands
  Time Consistent Actuarial Valuation

- **Xianming Sun**, Ghent University, Belgium
  Uncertainty Quantification of Derivative Instruments

- **Christopher Van Weverberg**, Université Libre de Bruxelles, Belgium
  Moment explosion in multifactor models

- **Stefan Waldenbergen**, Graz University of Technology, Austria
  Affine LIBOR models driven by real-valued affine processes

Securitization and Hedging of Longevity Risk

Andrew Cairns

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We will discuss two themes. First, we will outline the types of index-linked security that exists for hedging longevity risk. Second we will look at how some of these can be used to reduce a typical exposure to longevity risk. We will use a new Danish dataset divided into 10 subgroups by wealth as a case study.

Numerical Solution of Backward SDEs: Regression Later

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Joint work with: Prof. Mitja A. Stadje, Prof. Antoon Pelsser

Abstract

The aim of the work is to seek efficient numerical methods to implement the pricing methods for realistic insurance products. Precisely we are concerning by the numerical approximation of a backward stochastic differential equations (BSDE). These equations are a new class of stochastic differential equations with a prescribed terminal value. In our work we will study the particular case of a forward backward stochastic differential equations (FBSDE) on a certain time interval $[0, T]$ with $T > 0$.

Inspired by the works of E. Pardoux and S. Peng and others, under some assumptions, we can represent the solution of our FBSDE by the solution of a regular semi-linear parabolic partial differential equation (PDE).
By exploiting the markov property of the solution of the forward backward stochastic differential equations (FBSDE), we have developed a probabilistic numerical regression called "Regression later" based on the least-squares Monte Carlo and the previous connection between a semi-linear parabolic partial differential equation (PDE) and the FBSDE.

We have derived a convergence result of our probabilistic numerical scheme and provided numerical experiments in the context of option pricing problems to test the performance of the "Regression later" algorithm.

(Based on joint works with Prof. Mitja A. Stadje and Prof. Antoon Pelsser).

Keywords: BSDE , FBSDE , SDE's, Regression, Hilbert space, Projection, Numerical scheme, Monte Carlo, Pricing, Options

Uplift predictive modeling in pricing, retention and cross selling of insurance policies

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Some classical contributions concerning customer loyalty and lifetime value focus on customer retention. Instead, we address customer reaction to incentives and present some empirical results obtained in our research on customer lapse in insurance with Spanish and Canadian data. Methods to increase customer loyalty are discussed. We show the application of uplift modelling, which is a method to measure the impact of marketing actions on the retention probability, cross-selling, and ultimately on profitability. Our conclusion is that more interaction between retention strategies and pricing should be encouraged and that integrated predictive modelling is a promising area. Our proposed techniques provide insurers with a good orientation regarding business risk management.

Loss modelling using mixtures of Erlang distributions

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Joint work with: Katrien Antonio, Lan Gong, Andrei Badescu and Sheldon Lin

Modeling data on claim sizes is crucial when pricing insurance products. Such loss models require on the one hand the flexibility of nonparametric density estimation techniques to describe the insurance losses and on the other hand the feasibility to analytically quantify the risk. Mixtures of Erlang distributions with a common scale are very versatile as they are dense in the space of positive continuous distribution. At the same time, it is possible to work analytically with this kind of distributions. Closed-form expressions of quantities of interest, such as the Value-at-Risk (VaR) and the Tail-Value-at-Risk (TVaR), can be derived as well as appealing closure properties. In particular, using these distributions in aggregate loss models leads to an analytical form of the corresponding aggregate loss distribution which avoids the need for simulations to evaluate the model.

In actuarial science, claim severity data is often censored and/or truncated due to policy modifications such as deductibles and policy limits. A calibration technique exists, which is based on the EM algorithm, for fitting mixtures of Erlangs with a common scale parameter to complete data. Here, we construct an adjusted EM algorithm which is able to deal with censored and truncated data. Using the developed R program, we demonstrate the approximation strength of mixtures of Erlangs and model left truncated automobile claims from the former Belgian reinsurer Secura Re, and use the mixtures of Erlangs approach to price an excess-of-loss reinsurance contract.

We next discuss how to model dependent losses, using the multivariate extension of this class, in case of censoring and/or truncation. We demonstrate the effectiveness of the improved fitting procedure on a real data set.

On the estimation of aggregated VaR with marginal and/or dependence informations.

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Joint work with: A. Cuberos, E. Masiello

The approximation of a high level quantile or of the expectation over a high quantile (Value at Risk VaR or Tail Value at Risk TVaR in risk management) is crucial for the insurance industry. We propose a two methods to estimate high level quantiles of aggregated risks. One is based on the estimation of the ratio between the VaR of the sum and the VaR of the maximum of the risks. It uses results on consistently varying functions. The other method assumes that the distributions $F_1, \dots, F_d$ of the marginal variables $X_1, \dots, X_d$ are known and that some information on the dependence between them is given. We compare the efficiency of our methods with classical ones, on several models.

Risk Management of Policyholder Behavior in Equity-Linked Life Insurance

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Joint work with: M. Augustyniak, C. Bernard, M. Hardy

The financial guarantees embedded in variable annuity (VA) contracts expose insurers to a wide range of risks, lapse risk being one of them. When policyholders' lapse behaviour differs from the assumptions used to hedge VA contracts, the effectiveness of dynamic hedging strategies can be significantly impaired. By studying how the fee structure and surrender charges affect surrender incentives, we obtain new theoretical results on the optimal surrender region and use them to design a marketable contract that is never optimal to lapse. In particular, we investigate a fee paid only when the VA account value is below a certain threshold. Using numerical examples, we show that this contract is simpler to hedge, and that the hedge is robust to different surrender behaviours.

Elicitable risk measures and expectiles

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The talk is divided into two parts. In the first part we will recall the notion of elicitable risk measure, discuss its financial relevance and present several characterization results; in particular, we will prove that an elicitable convex risk measure is necessarily a shortfall risk measure of generalized type, thus refining a well-known result of Weber (2006).
In the second part of the talk, we will focus on the expectiles, that are the only example of an elicitable and coherent risk measure. After discussing their properties, we will show by means of numerical examples that expectiles are a perfectly reasonable alternative to more established risk measures such as Value at Risk or Expected Shortfall.

The talk is based on the following references:

Delbaen, F., Bellini, F., Bignozzi, V., Ziegel, J. (2014) Risk Measures with the CxLS property, arxiv.org/abs/1411.0426v1

Bellini, F., Di Bernardino, E. (2014) Risk Management with Expectiles, papers.ssrn.com/sol3/papers.cfm?abstract$_i d = 2475106$

Iterated VaR or CTE Measures: a False Good Idea?

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Joint work with: Pierre Devolder

The purpose of this paper is twofold. Firstly we consider different risk measures in order to determine the solvency capital requirement of a life insurance undertaking. Secondly we illustrate the impact of the time horizon of long-term guarantee products on these capital. We consider a financial market modelled by a common Black-Scholes-Merton model. We neglect here the mortality risk to keep understandable and tractable formulæ (this risk will be a part of future researches). A portfolio is built in this market according to different strategies and the insurer offers a fixed guaranteed rate on a certain time horizon. We begin with well-known static risk measures (value at risk and conditional tail expectation measures) and then we consider their natural dynamic generalization. In order to be time consistent, we consider their iterated versions by a backward iterations scheme. Within the dynamic setting we show that solvency capital can be expensive and that attention must be paid to the safety level considered. We finally introduce a kind of mixed iterated risk measure in order to overcome the previous observation.

Optimal control of stochastic Volterra equations and applications to financial markets with memory

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Joint work with: Nacira Agram

Stochastic Volterra equations appear in many applications and models, ranging from population dynamics, economic investment theory, transport of a substance dispersing in a fluid and Newtonian motion of objects in a random environment. They can also be derived from stochastic differential equations with delay. More generally, they represent interesting models for stochastic systems with memory.

Solutions of stochastic Volterra equations are not Markov processes, and therefore classical methods, like dynamic programming, cannot be used to study such control problems. However, we shall see that by using Malliavin calculus it is possible to formulate a modified, functional type of maximum principle suitable for such systems. This principle also applies to situations where the controller has only partial information available to base her decisions upon. We present both a sufficient and a necessary maximum principle of this type, and then we use the results to study some specific examples. In particular, we solve an optimal portfolio problem in a financial market model with memory.

The talk is based on recent joint work with Nacira Agram, University Med Khider, Biskra, Algeria.

Pricing and hedging in incomplete markets with model ambiguity

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Joint work with: Antoon Pelsser

We search for pricing methods of liabilities in incomplete markets, for instance insurance contracts or pensions. Our set-up is that we postulate an agent who wants to maximize the expected surplus, the expectation of the difference between the assets and liabilities, by choosing an optimal hedging strategy. The liabilities may depend on both financial as insurance risk. Furthermore, we assume that the agent is concerned about model misspecification, where we choose ellipsoid uncertainty. This robust optimisation problem translates in the worst case scenario that might happen, hence the process that minimises the surplus. The inner optimisation of the model is played by a so called "mother nature" who acts as a malevolent factor, whereas the agent searches for the best hedge strategy. By considering different drifts for the process we actually optimise the objective over different probability measures as there is a one-to-one correspondence between probability measures and drifts by Girsanov Theorem. We derive the HJB-equation for the value-function of this robust optimisation problem and we define the pricing operator as the indifference price for the agent. Hence with a minimum of assumptions, an agent who want to maximise his expected surplus and is uncertain about the economy and is allowed to hedge, our most important results are the following: we find a semi-linear PDE for the pricing operator that coincides with a FBSDE with a Lipschitz driver hence the PDE is uniquely solvable for the indifference price; the combination of model uncertainty in a complete market and hedging results in perfect hedging, the agent's response of risk-neutral pricing will eliminate the model uncertainty; model uncertainty in combination with pure unhedgeable risk results in the action of "actuarial pricing"; in a model with both hedgeable as unhedgeable risk the agent will price market-consistently plus actuarial prudence; for some special cases we can solve the semi-linear pricing PDE explicitly.

We applied a robust method to price derivative contracts in incomplete markets by the assumption of model uncertainty. We showed that in a complete market, an agent worried about model uncertainty will choose the replicating portfolio as this will eliminate the model uncertainty completely. Hence, a perfect risk-neutral agent that is facing model uncertainty will price risks by the use of no-arbitrage. In an incomplete market the agent will hedge as much of the risk as possible and will choose a market-consistent pricing operator. Dependent on the process either the analytical or the numerical solution of the PDE can be derived. Via the BSDE representation we proved the PDE to be uniquely solvable. The general result is the PDE where the drifts linked to the financial risk are identical to risk-free pricing and the hedge position in the insurance risk is partly offset by a certain position that is linked to the allowed ellipsoid of uncertainty.

Option Pricing Models for Pegged and Quasi-Pegged Currencies

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Due to skewness and kurtosis in asset price returns, the assumption of constant volatility in option pricing models such as the well known Garman-Kohlhagen model leads to mispricing in real world financial markets. While there are well established techniques for pricing with smile such as local volatility, stochastic volatility and local-stochastic volatility models, these do not work particularly well for pegged and quasi-pegged currency pairs where central bank policy is either to maintain the local currency at a peg or to defend a particular level beyond which the local currency is not allowed to appreciate. In this talk I discuss some real world examples, such as USDHKD (US dollar against Hong Kong dollar, where the Hong Kong Monetary Authority maintains the local currency in a tight band between 7.75 and 7.80 HKD per USD using their considerable FX reserves) and EURCHF (Swiss Franc against the Euro, where the Swiss National Bank announced a defence level of 1.20 CHF per EUR on 6 September 2011 and has sold CHF against Euros aggressively in the region of this barrier to maintain this floor on the realised exchange rate ever since). Option pricing models for these tradeable assets need to account for at least two regimes; one in which the structural constraints on the asset price process are maintained and one in which the constraint is completely removed (i.e. a deval/reval event) – and possibly scenarios other than these two in which the peg or defence level breaks but is subsequently reintroduced at a different level and/or with wider bands or a crawling peg. In this talk I shall introduce the various characteristics that option pricing models for pegged and quasi-pegged currency pairs require and present some results in which I attempt to fit the market better than standard smile-based models can manage.

Extracting a quanto type implied correlation in a multivariate exponential Lévy framework

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Joint work with: Laura Ballotta and Griselda Deelstra

In this paper we study the multivariate exponential Lévy model introduced by [1] in a multidimensional FX market. We show that the proposed multivariate FX model is consistent in terms of symmetries with respect to inversion and triangulation. We provide an insight into the quanto adjustment showing that higher order cumulants of the pure jump part of the systematic risk factor affect it. Using the Esscher transform for multidimensional semimartingales, we relate Quanto Options to European Call and Put options. We derive an analytical formula for the Quanto Futures and an FFT based pricing formula for Quanto Options. This allows for a fast calibration method to the Vanilla market and to the Quanto Futures and Options market. A joint calibration to the famous CME USD denominated Quanto Futures on the Nikkei 225 index and both the Nikkei 225 and USDJPY market implied volatilities allows to extract an implied correlation between the log-returns of the index and the FX rate. We illustrate this method in a subordinated Brownian motion framework.

References

[1] L. Ballotta and E. Bonfiglioli. Multivariate asset models using Lévy processes and applications. *The European Journal of Finance*, Forthcoming, (2014).

Closed-form solutions for Guaranteed Minimum Accumulation Benefits

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Joint work with: M. Krayzler, B. Brunner

Guaranteed Minimum Accumulation Benefit (GMAB) is one of the recent variable annuity products, i.e. a type of insurance and retirement product offering participation in the Performance of the financial market and a capital guarantee at the same time. In particular, GMAB offers at maturity the maximum of some account value and some guaranteed benefit. We consider the three most popular options for this guaranteed benefit: capital protection, minimum interest return, and ratchet. As these products are exposed to different risk factors, a multi-factor model is proposed. However, there is a tradeoff between a realistic model and analytical tractability. Either the contract setup or the modeling framework is simplified to derive closed-form solutions, or numerical methods are applied to price the guarantees. To fill the gap between these two approaches, we provide analytical formulas for GMAB in a hybrid model for actuarial and financial risks.

Adverse Selection, Loss Coverage and Multiple Equilibria in Insurance

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Joint work with: Dr. Pradip Tapadar and Mr. R. Guy Thomas

Insurers hope to make profit through pooling policies from a large number of individuals. Unless the risk in question is similar for all customers, an insurer is exposed to the possibility of adverse selection by attracting only high-risk individuals. To counter this, insurers have traditionally employed underwriting principles, to identify suitable risk factors to subdivide their potential customers into homogeneous risk groups, based on which risk-related premiums can be charged.

In reality, however, insurers may not have all the information reflecting individuals' risks due to information asymmetry or restrictions on using certain risk factors in their underwriting process. In either case, conventional wisdom suggests that the absence of risk classification in an insurance market is likely to lead eventually to a collapse of the whole insurance system, i.e. an adverse selection spiral. However, this concept is difficult to reconcile with the successful operation of many insurance markets, even in the presence of some restrictions on risk classification by regulators.

Moreover, arguably from society's viewpoint, the high risks are those who most need insurance. That is, if the social purpose of insurance is to compensate the population's losses, then insuring high risks contributes more to this purpose than insuring low risks. Thus, the traditional insurersâ risk classification scheme can be considered as contrary to this social purpose. To highlight this issue, Thomas (2008, 2009) introduced the concept "loss coverage", i.e. the proportion of the whole population's expected losses which is compensated by insurance. The main idea is that a modest degree of adverse selection in insurance can be desirable, as long as loss coverage is increased.

In this talk we model the outcome in an insurance market where a pooled equilibrium premium is charged for two risk-groups when there is an absence of risk-classification. Using iso-elastic and negative-exponential demand functions. Through exploring the conditions leading to multiple equilibrium premia, we find that multiple equilibria presents if and only if demand elasticity from the high risk-group is sufficiently smaller than that from the low risk-group, and the population ratio between these two risk-groups falls within certain limits, i.e. at certain extreme values. Based on these results, we further analyse the impact of demand elasticity and population ratio on loss coverage and adverse selection. The consolidated results are consistent with ideas proposed by Thomas (2008, 2009) that loss coverage can be a better measurement than adverse selection on insurance market from an absence of risk-classification. And adverse selection is not always a bad thing: a tolerable degree of adverse selection can increase the level of loss coverage.

Volatility as Investment - Crash Protection with Calendar Spreads of Variance Swaps

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Joint work with: Qixiang Zhou

Nowadays, volatility is not only a risk measure but can be also considered an individual asset class. Variance swaps, one of the main investment vehicles, can obtain pure exposure on realized volatility. In normal market phases, implied volatility is often higher than the realized volatility will turn out to be.

We present a volatility investment strategy that can benefit from both negative risk premium and correlation of variance swaps to the underlying stock index. The empirical evidence demonstrates a significant diversification effect during the financial crisis by adding this strategy to an existing portfolio consisting of 70% stocks and 30% bonds. The back-testing analysis includes the last ten years of history of the S&P500 and the EUROSTOXX50.

Model-free measurement of market fear

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Joint work with: Jan Dhaene, Wim Schoutens

Market fear refers to the level of nervousness among market participants. A high degree of market fear points to a high level of uncertainty about the future direction of the financial market. Having an idea of today's level of market fear may be used as an early warning indicator to step out of the market before, or at least in an early stage of, a major market downturn. Alternatively, an appropriate fear index can be used to determine the right time to buy a portfolio of derivatives to protect an investment portfolio in times of increased market fear.

In this paper we propose to measure market fear by combining an estimate for the implied level of volatility with an estimate for the implied degree of herd behavior. Volatility is measured by the Implied Volatility Index and the degree of herd behavior is measured by the Herd Behavior Index. These market indices can be determined in a model-free way from available option data. Using Dow Jones option data ranging from 2000 to 2009, we show that the DJ volatility and the DJ herd behavior both have the tendency to increase when the market is in distress. The market stress around 2002 was mainly driven by volatility. However, during the credit crunch in 2007 - 2008 and the subsequent European debt crisis, herding behavior between the stocks is becoming more important. Our results thus indicate that co-movement has become an important driver of market fear. Moreover, it is not likely that we go back to a situation similar to the period 2000-2004, where volatility explains the major part of market fear. Therefore, there is need for a 'fear gauge' that correctly takes into account co-movement.

On the transferability of reserves in lifelong health insurance contracts

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Joint work with: Els Godecharle, Jan Dhaene, Michel M. Denuit

We investigate the effect of medical inflation on private health insurance contracts covering medical expenses with lifelong cover and level premiums. The level premium is calculated such that the contract is actuarially fair at policy issue. Medical inflation, which is the inflation of the health benefits that cannot be predicted in advance, is only taken into account ex-post as it emerges over time. This medical inflation, not incorporated in the level premiums determined at policy issue, requires an appropriate increase of these premiums and/or of the corresponding reserves during the term of the contract in order to maintain the actuarial equivalence between future benefits and future premiums

In Vercruysse et al. (2013), appropriate premium and reserve indexing mechanisms were proposed in a discrete-time framework when the reserves are not transferable in case of policy cancellation. In this paper, we extend this work by investigating the more general situation where reserves are (partially) transferable in case of surrender. To maintain the actuarial equivalence between future benefits and future premiums, we can adjust premiums and/or reserves, but also surrender values during the time of the contract. We investigate the effect of different definitions of the surrender values.

References

Vercruysse, W., Dhaene, J., Denuit, M., Pitacco, E., Antonio, K. (2013).
Premium indexing in lifelong health insurance.
Far East Journal of Mathematical Sciences 2013, 365-384.

Modeling Large Claims with the Pareto ArcTan Distribution

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Joint work with: Emilio Gómez-Déniz

In this poster a new methodology to derive probabilistic models based on the circular $\tan^{-1}$ function is presented. This procedure generates new survival function after incorporating an extra scale parameter α to a given parent survival function. The latter survival function is determined as limiting case when α tends to zero. By choosing as parent the classical Pareto survival function, the Pareto ArcTan (PAT) distribution is obtained. After providing a comprehensive analysis of its statistical properties, theoretical results with reference to insurance are illustrated. Its performance is compared by means of the well–known Norwegian fire insurance data with other existing heavy–tailed distributions in the literature such as Pareto, Stoppa and shifted lognormal distributions.

Pricing Arithmetic type Asian Option with Lévy Processes : Fourier Transform Approach

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Joint work with: Prof. Diganta Mukherjee and Indranil SenGupta

We propose a stochastic model to compute the price of Asian option based on Itô-Lévy calculus where stock price is driven by a class of infinite activity Lévy processes leading to the market inherently incomplete and dynamic hedging is no longer risk free. Föllmer-Schweizer minimal measure is used to determine the risk neutral martingale measure for pricing. We develop a partial integro-differential equation for Asian option, and apply Fourier transform to derive a pricing expression. Subsequently, we perform the fast Fourier transform (FFT) algorithm to construct an approximation of the prices for Asian options driven by a class of Lévy models employed in quantitative finance such as the NIG, CGMY and Meixner models.

Pricing Bermudan Options under Merton Jump-Diffusion Asset Dynamics

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A recently developed regression-based option pricing method, the Stochastic Grid Bundling Method (SGBM), is implemented for pricing multidimensional Bermudan options. We compare SGBM to a traditional regression-based pricing approach and present detailed insight in the application of SGBM, including how to configure it and how to reduce the uncertainty of its estimates by control variates. We consider the Merton jump-diffusion model, which performs better than the geometric Brownian motion in modeling the heavy-tail feature of the asset price distributions. Our numerical tests show that SGBM with appropriate setup works satisfactorily on pricing multidimensional options under jump-diffusion asset dynamics.

Monte Carlo Calculation of Exposure Profiles and Greeks for Bermudan and Barrier Options under the Heston Hull-White Model

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Valuation of Credit Valuation Adjustment (CVA) has become an important field as its calculation is required in Basel III, issued in 2010, in the wake of the credit crisis. *Exposure*, which is defined as the potential future loss of a default event without any recovery, is one of the key elements for pricing CVA. This paper provides a backward dynamics framework for assessing exposure profiles of European, Bermudan and barrier options under the Heston and Heston Hull-White asset dynamics. We discuss the potential of an efficient and adaptive Monte Carlo approach, the *Stochastic Grid Bundling Method* (SGBM), which employs the techniques of *simulation*, *regression* and *bundling*. Greeks of the exposure profiles can be calculated in the same backward iteration with little extra effort. Assuming independence between default event and exposure profiles, we give examples of calculating exposure, CVA and Greeks for Bermudan and barrier options.

Component value at risk models with countercyclical adjustments for improved economic performance

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A family of dynamic quantile models of the CAViaR type is proposed that account for both low and high frequency changes in Value at Risk (VaR). Using daily returns on an index and a stock, we produce rolling one-day-ahead VaR forecasts out-of-sample for several benchmark models. We find that the proposed models are superior to or comparable with existing models in terms of exception ratios (actual number / expected number of exceedances). As both the new and several existing models are not rejected by standard statistical tests such as the Dynamic Quantile test, we conduct comparisons based on reasonable economic criteria. We find that the proposed models exhibit a superior trade-off between the mean level and the variance of the time series of VaR forecasts. The motivation for this comparison is to reduce the daily transaction cost from changes in required equity while keeping the overall capital cost low. Despite this, the average loss in excess of VaR on exceedance days is lower in our models than existing ones. This implies that firms need to sell less of their portfolios to meet risk management requirements following negative returns, hence improving their overall performance.

Participating Life Insurance Contracts in different Interest Rate Environments: How Product Design affects Welfare

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Many recent studies show that participating life insurance contracts with year-to-year (so-called cliquet-style) minimum guarantees constitute a significant financial risk to life insurance companies, in particular in low interest rate environments and volatile capital markets. In order to resolve this issue, several European life insurers seek innovations in savings products.

In this paper, we develop a flexible risk management tool to analyze the interaction of product design (profit participation and minimum guarantee) and the life insurer's asset allocation based on an integrated shareholder value optimization framework under Solvency II.

Addressing the inflexibility of traditional products, we propose a participating life insurance contract with a variable guaranteed rate of return that changes based on the recent development of an interest rate benchmark. To study the distributions of the shareholders' payout and policyholders' utility, we develop an asset-liability model with two asset classes.

We develop our market model in three steps and compare the results: First, we use the most common standard approach, which is simulating the stock dynamics using a Geometric Brownian Motion while interest rates are fixed. In a second step, we introduce a comprehensive market model which covers interest rate risk using a simple Vasicek-model and stock dynamics that are influenced by the short rate evolution. Finally, we use the Hull-White (Extended-Vasicek)-Model to incorporate four distinctive interest rate environments, which are rising, declining, u-shaped and hump shaped interest rates. Similar to empirical observations, stock returns are correlated with the short rate.

Our results show that an optimal combination of fixed guarantee and profit participation is quite sensitive to changes in the interest rate environment. This sensitivity, which is accompanied by high default risk, can be reduced by variable minimum guarantees without reducing the overall welfare. However, to uncover the dependence of risk resulting from product design and interest rates, it is vital to use a comprehensive market model that allows for interest rate environments.

Continuity and differentiability properties of the survival probabilities in risk models with investments and their applications

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We deal with the classical risk model and the risk model with stochastic premiums when all surplus of an insurance company is invested in risk-free and risky assets proportionally, and the price of the risky asset follows a jump process. We investigate continuity and differentiability properties of the infinite-horizon survival probabilities in these risk models. We also obtain sufficient conditions for continuity of the finite-horizon survival probabilities and existence of their partial derivatives. Moreover, we get bounds for the derivatives of the survival probabilities w.r.t. the initial surplus.

We consider applications of these results in three directions. Firstly, we derive formulas connecting the accuracy and reliability of the uniform approximations of the infinite-horizon and finite-horizon survival probabilities by their statistical estimates. Secondly, we find analytic expressions for the infinite-horizon survival probabilities in the classical risk model in a few cases when the c.d.f. of claim sizes is a sum of absolutely continuous and discrete components. Thirdly, we solve problems of optimal control by franchise and deductible amounts in the classical risk model from viewpoint of the in the infinite-horizon survival probability maximization (see [1]).

References

[1] Ragulina, O. (2014), Maximization of the survival probability by franchise and deductible amounts in the classical risk model. *Springer Optimization and Its Applications 90, Modern Stochastics and Applications*, pp. 287-300.

Time Consistent Actuarial Valuation

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Time-consistent valuations (i.e. pricing operators) can be created by backward iteration of one-period valuations. In this paper we investigate the continuous-time limits of well-known actuarial premium principles when such backward iteration procedures are applied. This method is applied to an insurance risk process in the form of a diffusion process and a jump process in order to capture the heavy tailed nature of insurance liabilities. We show that in the case of the diffusion process, the one-period time-consistent Variance premium principle converges to the non-linear exponential indifference price. Furthermore, we show that the Standard-Deviation and the Cost-of-Capital principle converge to the same price limit. Adding the jump risk gives a more realistic picture of the price. Furthermore, we no longer observe that the different premium principles converge to the same limit since each principle reflects the effect of the jump differently. In the Cost-of-Capital principle, in particular the operator fails to capture the jump risk for small jump probabilities, and the time-consistent price depends on the distribution of the premium jump.

Uncertainty Quantification of Derivative Instruments

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Risk analysis under model uncertainty and parameter uncertainty is attracting more and more public attention, especially after the 2008 crisis. It is of great importance to quantify the uncertainty of derivative instruments, especially the complex derivatives.

Based on the Smolyak interpolation algorithm, this paper proposes a Monte Carlo-like method to calculate the entropy and the value bounds of a derivative instrument under the uncertainty at the model and parameter levels. The entropy and the spread of the value bounds can be used to quantify the uncertainty of the target derivative value. Except that the value function is smooth with respect to the model parameters, there are no additional requirements on the payoff function or the candidate models. Numerical tests are carried out to quantify the uncertainty of Bermudan put options under the Heston model with each model parameter specified in a small interval.

Except for quantifying uncertainty of derivatives, the Monte Carlo-like method proposed in this paper can also be used to improve the efficiency of robust calibration in the Bayesian framework. In addition, the proposed method could work as a reusable simulation infrastructure in the model validation procedure.

Moment explosion in multifactor models

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The moment explosion time linked with a fixed number θ and an asset price process is defined as the supremum over all time instants t such that the moments of order θ of the asset price remain finite.

In the Heston model, Andersen and Piterbarg (2007) demonstrate that this model has the undesirable property that moments of order higher than one can become infinite in finite time. As arbitrage-free price computation for a number of important fixed income products involves calculating expectations of functions with super-linear growth, such lack of moment stability is of significant practical importance. Other references are Lee (2004), Friz and Keller-Ressel (2009), Glasserman and Kim (2010), Jena, Kim and Xing (2012), Keller-Ressel and Mayerhofer (2014).

In our paper, we focus on the joint Laplace transform, the integrated Laplace transform and the Laplace transform of the Wishart process and we study the explosion time for these Wishart transforms. Expressions for these transforms (under some hypotheses) are given for instance in Gnoatto and Grasselli (2014), Ahdida and Alfonsi (2013), Kang and Kang (2013) and Gauthier and Possamaï (2009).

Wishart processes have been introduced by Bru (1991) and are defined as a stochastic process on the cone of positive semidefinite symmetric matrices. Cuchiero and al. (2012) have provided a profound mathematical foundation for these stochastically continuous affine processes on this cone. They can be seen as matrix extensions of the CIR process or the Heston volatility process. Financial applications can be found in e.g. Gouriéroux and Sufana (2003), (2004), Da Fonseca, Grasselli, and Tebaldi (2008). In this paper, we consider non mean-reverting Wishart processes $(X_t)_{t\geq 0}$ and we give expressions for the joint Laplace transform $\Psi_{u,\mu}$

$$\Psi_{u,\mu}(t) = \mathbb{E}\left[e^{-Tr(uX_t)-Tr\left(\int_0^t \mu X_s ds\right)}\right]$$

when μ is a negative semidefinite matrix and we also study the case when μ is not definite. The question to find the smallest time t such that the Laplace transform becomes infinite is closely related with the problem of determining the moment explosion time. Under a fairly weak commutation hypothesis, we derive the time of explosion of the joint Laplace transform. This hypothesis drops when studying the times of explosion of respectively the integrated Laplace transform and the Laplace transform.

Affine LIBOR models driven by real-valued affine processes

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The class of affine LIBOR models is appealing since it satisfies three central requirements of interest rate modeling. It is arbitrage-free, interest rates are nonnegative and caplet and swaption prices can be calculated analytically. In order to guarantee nonnegative interest rates affine LIBOR models are driven by nonnegative affine processes, a restriction, which makes it hard to produce volatility smiles. We modify the affine LIBOR models in such a way that real-valued affine processes can be used without destroying the nonnegativity of interest rates. Numerical examples show that in this class of models pronounced volatility smiles are possible.

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