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PRACTICAL INFO

Registration desk

Location :	Marble room
Opening hours :	Thursday : 8h30 – 17h30
	Friday : 8h30 – 14h00
Representative :	Wouter Dewolf

Conference locations

Presentations :	Auditorium Albert II
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.

08h30 - 08h50	Registration and welcome coffee
08h50 - 09h00	Welcome
	Chair: Michel Vellekoop
09h00 - 09h45	**Invited speaker: Martijn Pistorius**, Imperial College London, UK *Distance to default, inverse first-passage time problems & counterparty credit risk*
09h45 - 10h15	Contributed talk: Peter Hieber, TU München, Germany *First-Passage times of regime switching models*
10h15 - 10h45	Coffee break
	Chair: Monique Jeanblanc
10h45 - 11h30	**Invited speaker: Tahir Choulli**, University of Alberta, Canada *Viability Structures Under Additional Information/Uncertainty*
11h30 - 12h00	Contributed talk: Ricardo Romo Romero, University of Evry, France *Variable Annuities indifference pricing with BSDE*
	Chair: Ann De Schepper
12h00 - 12h30	Poster storm session
12h30 - 14h00	Sandwich lunch combined with **Poster session**
	Chair: Steven Vanduffel
14h00 - 14h45	**Invited speaker: Christian Gouriéroux**, University of Toronto, Canada & CREST, France *Pricing default events: surprise, exogeneity and contagion*
14h45 - 15h15	Contributed talk: Tuyet Mai Nguyen, University of Evry, France *Malliavin calculus for Markov chains and applications in credit risk*
15h15 - 15h45	Coffee break
	Chair: Hansjörg Albrecher
15h45 - 16h30	**Invited speaker: Matthias Scherer**, TU München, Germany *Consistent iterated simulation of multi-variate default times: a Markovian indicators characterization*
16h30 - 17h00	Contributed talk : Ernst August von Hammerstein, University of Freiburg, Germany *Optimality of payoffs in Lévy models*
17h00 - 17h30	Contributed talk : Takuji Arai, Keio University, Japan *Local risk-minimization for Lévy markets*
19h30 - 22h00	Conference Dinner at University Foundation

08h30 - 09h00	Registration and welcome coffee
	Chair: Jan Dhaene
09h00 - 09h45	**Invited speaker: Pierre Devolder**, Université catholique de Louvain, Belgium *Some actuarial questions around a possible reform of the Belgian pension system*
09h45 - 10h15	Contributed talk: Karl-Theodor Eisele, Université de Strasbourg, France *The economic equilibrium of the insurance triangle regulator–shareholders–policyholders: the stationary case*
10h15 - 10h45	Coffee break
	Chair: Carole Bernard
10h45 - 11h30	**Invited speaker: Enrico Biffis**, Imperial College London, UK *Optimal collateralization with bilateral default risk*
11h30 - 12h00	Contributed talk: Sally Shen, Maastricht University, The Netherlands *Robust Long-Term Interest Rate Risk Hedging in Incomplete Bond Markets*
12h00 – 13h30	Sandwich lunch combined with **Poster session**
	Chair: Ludger Rüschendorf
13h30 - 14h15	**Invited speaker: Marcus Christiansen**, Universität Ulm, Germany *Deterministic optimal consumption and investment in a stochastic model with applications in insurance*
14h15 - 14h45	Contributed talk: Petar Jevtić, McMaster University, Canada *Assessing the solvency risk of insurance portfolios via a continuous time cohort model*
14h45 - 15h15	Coffee break
	Chair: Ragnar Norberg
15h15 - 16h00	**Invited speaker Ralf Korn**, TU Kaiserslautern, Germany *Save for the bad times or consume as long as you have? Worst-case optimal lifetime consumption!*
16h00 - 16h30	Contributed talk: Tina Engler, Martin Luther University Halle-Wittenberg, Germany *Worst-Case Optimization for an Investment-Consumption Problem*
16h30 - 16h45	Closing

- **Farzad Alavi Fard**, Macquarie University, Australia
  Pricing Participating Products under Regime-Switching Generalized Gamma Process

- **Luis Bermudez**, Universitat de Barcelona, Spain
  Risk classification for claim counts using finite mixture models

- **Sudip Ratan Chandra**, Indian Statistical Institute, India
  Pricing of Asian Option of Arithmetic Type Under Lévy Process : A Mellin Transform Approach

- **Kees de Graaf**, University of Amsterdam, The Netherlands
  A New Hybrid Finite Difference-Monte Carlo Method To Compute Risk Measures Under Stochastic Volatility

- **Qian Feng**, Centrum voor Wiskunde en Informatica, The Netherlands
  Two efficient valuation methods of the exposure of Bermudan options under Heston's Model

- **Naoyuki Ishimura**, Hitotsubashi University, Japan
  Evolution of Copulas and its applications

- **Tilman Sayer**, Fraunhofer Institute for Industrial Mathematics, Germany
  Pricing American derivatives in the Heston model with an application to ESOs

- **Ben Stassen**, KU Leuven, Belgium
  The Minimal Entropy Martingale Measure in markets of traded financial and actuarial risks

- **Xianming Sun**, Ghent University, Belgium
  Weighted Monte Carlo method: a way to reduce calibration risk?

- **Misha van Beek**, University of Amsterdam, The Netherlands
  The Markov modulated multivariate Ornstein-Uhlenbeck process and applications to credit derivatives

Distance to default, inverse first-passage time problems & counterparty credit risk

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Joint work with: Mark Davis

Financial models incorporating the idea that a firm defaults on its debt when the value of the debt exceeds the value of the firm were originally introduced by Merton (1974). Because 'firm value' cannot be directly measured, later contributors such as Longstaff & Schwartz (1995) and Hull & White (2001) have moved to stylized models in which default occurs when some process $Y(t)$ – interpreted as 'distance to default' – crosses a given, generally time-varying, barrier $b(t)$. The risk-neutral distribution of the default time can be inferred from the firm's credit default swap spreads, and Hull & White (2001) provide a numerical algorithm to determine $b(t)$ such that the first hitting time distribution H is equal to this market-implied default time distribution.

As we will show, these calculations are greatly simplified if, instead of starting at a fixed point $Y(0) = x > 0$ and calibrating the barrier $b(t)$ we fix the barrier at $b(t) \equiv 0$ and start Y at a random point $Y(0) = Y_0$, where Y_0 has a distribution function F on $\mathbb{R}^+$, to be chosen. If we combine this with a deterministic time change then it turns out that essentially any continuous distribution H can be realized in this way, often with closed-form expressions for F. We apply these results to the valuation of financial contracts that are subject to counterparty credit risk.

First-passage times of regime switching models

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This talk studies the first-passage times of regime switching Brownian motion on an upper and/or a lower level. In the 2- and 3-state model, the Laplace transform of the (one- and two-sided) first-passage times is — up to the roots of a polynomial of degree 4 (respectively 6) — derived in closed-form by solving the matrix Wiener-Hopf factorization. This extends the one-sided results in the 2-state model by Guo (Methodol Comput Appl Probab 3(2):135–143, 2001). If the quotient of drift and variance is constant over all states, we show that the Laplace transform can even be inverted analytically.

References

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[2] P. Hieber and M. Scherer. A note on first-passage times of continuously time-changed Brownian motion. *Statistics & Probability Letters*, Vol. 82, No. 1:pp. 165–172, 2012.

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Viability Structures Under Additional Information/Uncertainty

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Joint work with: Jun Deng

It has been known since the mid nineties of the last century that the "local" existence of the Markowitz' optimal portfolio or the solution to the local-risk minimization problem is guaranteed by specific mathematical structures on the underlying assets price processes (called Structure Conditions by Schweizer). In my talk, I will consider a semi-martingale market model (called hereafter initial market model) fulfilling these viability structures, and an arbitrary random time that is not adapted to the flow of the "public" information. In financial economics, this random time can represent the death time of the agent, the bankruptcy time of a firm, the default time, a sudden change point/regime time, or any time where an influential event will occur. This random time adds additional uncertainty/risk to the initial market model and may perturb tremendously its viability structures. The aim of my talk is to answer the question of how this random time will affect these structures from different perspectives? Our analysis led to three types of results. The first type of results consists of describing the largest class of market models for which the structures will be preserved after stopping with any random time and/or when a specific honest time is totally incorporated. The second type of results deals with specifying models of random times that do not affect the structures in any way before and/or after the random time. The last type gives more finer results by quantifying the necessary and sufficient conditions on the initial market model and the random time for which the structures remain valid.

Variable Annuities indifference pricing with BSDE

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Joint work with: E. Chevalier, T. Lim

The present work provides an analysis of the variable annuities products. In particular, we focus on the valuation of two guarantees, GMDB and GMLB. We solve the exponential utility optimization problem using backward stochastic differential equations for our wealth process and we derive the indifference prime.

The feature of this model is that we consider the indifference prime as a continuos and constant payment that will be directly discounted from the invested capital, this prime is fixed at the beginning of the contract.

We provide a verification theorem which gives the optimal strategy in each case. Finally, we show the numeric results for the indifference pricing approximations, we apply a Monte Carlo method and a dichotomy algorithm to approximate the indifference prime.

Pricing Default Events : Surprise, Exogeneity and Contagion

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Joint work with: A. Monfort, J.P. Renne

In order to derive closed-form expressions of the prices of credit derivatives, the standard models for credit risk usually price the default intensities but not the default events themselves. The default indicator is replaced by an appropriate prediction and the prediction error, that is the default-event surprise, is neglected. Our paper develops an approach to get closed-form expressions for the prices of credit derivatives written on multiple names without neglecting default-event surprises. The approach differs from the standard one, since the default counts cause the factor process under the risk-neutral probability Q, even if this is not the case under the historical probability. This implies that the default intensities under Q do not exist. A numerical illustration shows the potential magnitude of the mispricing when the surprise on credit events is neglected. We also illustrate the effect of the propagation of defaults on the prices of credit derivatives.

Keywords: Credit Derivative, Default Event, Default Intensity, Frailty, Contagion, Mispricing.

Malliavin Calculus for Markov Chains and Applications in Credit Risk

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Joint work with: S.Crépey, L.Denis

Though CDO issuances have become quite rare since the crisis, there is still a huge amount of outstanding CDO contracts which need to be marked to market and hedged up to their maturity dates. Therefore, the task of greeking CDOs and the credit portfolios in general is still relevant.

In this paper, the credit portfolios is modeled by a continuous time Markov chain on a finite state space. After a suitable change of measure, we can construct an unbiased estimator of greeks thanks to the Clark - Ocone formula and Malliavin calculus ([4]) using the lent particle method ([1]) for the new measure to compute the corresponding Malliavin derivative. This results in a direct Monte - Carlo simulation for the Greeks without resimulation. We specify and implement our results in two typical credit model, the homogeneous group model (Section 11.2 of [2]), and the common shock model ([3]). The simulation scheme is tested in these models by comparing the results with the other methods such as matrix exponentiation, regression and Marshall - Olkin copulas, but it is still tractable even in cases of high dimension or more complex Markovian models. The results are used for hedging credit derivatives both by replication and min - variance hedging.

Keywords: Portfolio credit risk, Markov chain, Malliavin calculus, Clark - Ocone formula, Greeks, Hedging, Common shocks, Homogeneous groups model.

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Consistent iterated simulation of multi-variate default times: a Markovian indicators characterization

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Joint work with: D. Brigo, J.-F. Mai

We question the industry practice of economic scenario generation involving statistically dependent default times. In particular, we investigate under which conditions a single simulation of joint default times at a final time horizon can be decomposed in a set of simulations of joint defaults on subsequent adjacent sub-periods leading to that final horizon. As a reasonable trade-off between realistic stylized facts, practical demands, and mathematical tractability, we propose models leading to a Markovian multi-variate default-indicator process. The well-known "looping default" case is shown to be equipped with this property, to be linked to the classical "Freund distribution", and to allow for a new construction with immediate multivariate extensions. If, additionally, all sub-vectors of the default indicator process are also Markovian, this constitutes a new characterization of the Marshall-Olkin distribution, and hence of multi-variate lack-of-memory. A paramount property of the resulting model is stability of the type of multi-variate distribution with respect to elimination or insertion of a new marginal component with marginal distribution from the same family. The practical implications of this "nested margining" property are enormous. To implement this distribution we present an efficient and unbiased simulation algorithm based on the Lévy-frailty construction. We highlight different pitfalls in the simulation of dependent default times and examine, within a numerical case study, the effect of inadequate simulation practices.

Optimality of payoffs in Lévy models

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Joint work with: E. Lütkebohmert, L. Rüschendorf, V. Wolf

In this talk we study optimal investment choices in incomplete markets where the prices of risky assets are driven by Lévy processes, and the pricing of derivatives is based on the Esscher martingale measure. In particular, we solve for the investment strategy with minimal costs that achieves a given payoff distribution. This strategy is called cost-efficient with respect to the given distribution and can be obtained using the well-known upper and lower Fréchet bounds. Our work builds on the paper of Bernard, Boyle, and Vanduffel (2012) and extends their approach to a more general and incomplete Lévy market setting. We consider Lévy models where the price process is driven by an NIG- and a VG-process.

For a variety of vanilla options, spreads, and forwards we explicitly derive the cost-efficient strategies, that is, we improve the payoffs in the sense of the stochastic order $\leq_{\mathrm{st}}$ for agents with increasing preferences.

Calculations of efficient put prices based on estimated parameters from German stock prices show that the potential savings the optimal payoffs provide can be quite substantial. Moreover, we consider the problem of hedging such claims, derive explicit formulas for the deltas of efficient calls and puts and apply the results to German stock market data. As a main result we find that cost-efficient options also show an improved behaviour concerning delta hedging compared to their classical counterparts.

References

Bernard, C., Boyle, P., Vanduffel, S. (2012) *Explicit representation of cost-efficient strategies*, working paper, University of Waterloo

Local risk-minimization for Lévy markets

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Joint work with: Ryoichi Suzuki

Locally risk-minimizing, a well-known hedging method for contingent claims in a quadratic way, is discussed by using Malliavin calculus, and some examples are introduced.

We consider a financial market composed of one riskless asset and one risky asset. The risky asset price process is given by a solution to the following SDE:

$$dS_t = S_{t-}\left[\alpha_t dt + \beta_t dW_t + \int_{\mathbb{R}\setminus\{0\}} \gamma_{t,z}\widetilde{N}(dt,dz)\right], \quad S_0 > 0,$$

where W is a one-dimensional standard Brownian motion, $\widetilde{N}$ is a compensated Poisson random measure; and α, β and γ are predictable processes. By using the Clark-Ocone type formula shown by Suzuki(2011), we obtain an representation of locally risk-minimizing with Malliavin derivatives of the contingent claim. We illustrate, in this talk, how to calculate Malliavin derivatives of call options, Asian options and lookback options for the case where α, β and γ are deterministic. Moreover, the Ornstein-Uhlenbeck type stochastic volatility model(Barndorff-Nielsen Shephard model) is also discussed as a typical example of models with random coefficients.

Some actuarial aspects around a possible reform of the Belgian pension system

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Until now, no major reform have been undertaken in order to reshape the Belgian pension social security system. However macroeconomic figures show that measures are unavoidable and quite urgent if we want to guarantee on the medium and the long term the sustainability of our pension social security at an affordable cost. In this perspective, the Belgian government has appointed an academic commission who must submit recommendations for Easter 2014.

The purpose of the presentation is to develop possible scenarios of reform and to enlighten the actuarial problems emerging from these changes in a risk management perspective. In particular, we will detail the concept of NDC (Notional Defined Contributions) and present some recent results on the financial solvency of such a technique and the pertinence of automatic balance mechanisms in a stochastic environment. Optimal diversification between pay as you go and funding will also be addressed using portfolio theory arguments.

Keywords: Pension reform, Notional Defined Contribution, Automatic Balance Mechanism, Portfolio Theory

The economic equilibrium of the insurance triangle regulator–shareholders–policyholders: the stationary case

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Joint work with: HJ. Albrecher, M. Wüthrich

We analyze the economic situation of the insurance business where the three agents regulator, the shareholders, and the policyholders have to find a commonly acceptable equilibrium. Instead of a finite risk horizon, as in Solvency II, we regard the stationary situation of an infinite horizon, where the insurance risks are given by i.i.d. random variables.

In a first step, the regulator fixes for each period a minimal capital requirement, the so-called supervisory provision, via a first risk assessment (like VaR or Tail-VaR) applied to the risk bearing capital.

Next, we search for an economic equilibrium between the investment of the shareholders, the so-call solvency capital requirement (SCR), and the premiums, paid by the policyholders. A simple annual book-keeping equation shows the possible dividend payments. Thereby, the shareholders do not always expect positive dividends, but are ready in critical situations to reinvest into the company with new capital. This however only up to a certain level.

In order to find this maximal reinvestment level (as a function of the premiums), we start from the idea of Madan and Chery (2010) in the one-period case, to represent market bid prices of non-tradeable values as an infimum of the expected outcome w.r.t. a set of test probabilities. We generalize this concept to infinite time value processes using a market- and time-consistent risk assessment.
here, the value process generated by the cash flows of positive or negative dividends has independent increments, conditioned by the non-ruin assumption, we assume that our bid price risk assessment is stationary on the independent increments. This property leads to fix-point equilibrium equation for the maximal reinvestment level, resembling the renewal equation in standard risk theory.

In the final step, the policyholders are willing to accept the these premiums which are minimal under the condition that the complementary shareholders part is till less than the maximal reinvestment level.

Optimal Collateralization with Bilateral Default Risk

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Joint work with: D. Bauer and L.R. Sotomayor

We consider over-the-counter (OTC) transactions with bilateral default risk, and study the optimal design of the Credit Support Annex (CSA). In a setting where agents have access to a trading technology, default penalties and collateral costs arise endogenously as a result of foregone investment opportunities. We show how the optimal CSA trades off the costs of the collateralization procedure against the reduction in exposure to counterparty risk and expected default losses. The results are used to provide insights on the drivers of different collateral rules, including hedging motives, re-hypothecation of collateral, and close-out conventions. We show that standardized collateral rules can have a detrimental impact on risk sharing, which should be taken into account when assessing the merits of standardized vs. bespoke CSAs in non-centrally cleared OTC instruments.

Robust Long-Term Interest Rate Risk Hedging in Incomplete Bond Markets

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Joint work with: P. Schotman, A. Pelsser

Pricing and hedging long dated liability faces two challenges. On one hand, the market for long maturity financial instrument is missing. The longest government bonds even in developed financial markets (such as US and Germany) has maturities no longer than 30 year. However, pension liabilities are well defined future cash flow obligations with at least more than 50 years of maturities. It is regulated by Solvency II that pension and insurance companies should follow a "market-consistent" principle to value their liabilities. Here comes the puzzle: how could we implement "market - based " valuation on those commitments with maturities long than 30 years; or how to discount the far future cash flows with the absence of a complete bond market?

On the other hand, there is model uncertainty. Any valuation of a long dated liability with partially missing bond market must be model based. Extrapolating term structure curve can be dated by to 1960's. Up till now, mountains of work has been done on improving the specification of the term structure model. Conditional on a model we could derive a term structure for all maturities. However, there are a large number of different models that perfectly fit bond prices up to maturity of 30 years but yet imply different prices for the non-traded-period bonds. Therefore, given the incompleteness of the bond market, it is impossible to avoid model misspecification no matter how complicated the underlying model is.

Despite much work on the term structure models, there are very few studies considering parameter uncertainty of the bond yield model and further, how does model misspecification mislead agents' hedging or investment decisions. In this paper, we propose a robust optimal replication portfolio that minimize the hedging error of long dated liabilities in the presence of parameter uncertainty and missing bond market. Our replicating portfolio is robust to model misspecification in the sense that the investment policy is less sensitive to the choice of model. Even if the model is misleading, the resulting replication portfolio does not move too far away from the true optimal one.

We solve a dynamic robust optimization problem that maximin agent's utility. On one hand, agent allocates her instantaneous wealth between a short-term and a median-term bond market so as to minimize the expected shortfall of a long maturity commitment. On the other hand, Mother nature perturbs the estimate parameters in order to maximize the expected shortfall given the decision of the agent. The equilibrium portfolio is therefore, robust against model ambiguity. We use GMM approach to estimate the one-factor affine term structure model. Then we employ Least Square Monte Carlo method to solve the backward stochastic differential equation numerically.

Keywords: Model misspecification, robust optimization, uncertainty set, incomplete market, LSMC

Deterministic optimal consumption and investment in a stochastic model with applications in insurance

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Joint work with: M. Steffensen

We motivate and solve the classical financial optimization problem of optimizing terminal wealth and intermediary consumption in a Black-Scholes market with the special feature that the consumption rate and the investment proportion are constrained to be deterministic processes. Regardless of the fact that deterministic processes are less optimal than the more general stochastic processes, in insurance practice deterministic strategies are used in various life insurance products. One possible reason might be that stochastic control leads to immediately and diffusively investment decisions and consumption and, therefore, does not reflect a policyholder's probable preferences for smooth cash flows. In control theory, it is non-standard to control a stochastic system by an optimal deterministic control. We show how to adapt the standard theory to this situation. Unfortunately, apart from a few specific examples, analytical solutions are out of reach. We present numerical solution methods and show some examples of optimal consumption-investment profiles.

Assessing the solvency risk of insurance portfolios via a continuous time cohort model

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Joint work with: Luca Regis

The assets and liabilities owned by an insurance company or pension fund are subject to various sources of uncertainty, making the assessment of their solvency risk a challenging task. In this paper, we propose an ALM modelling framework, which allows for proper evaluation of the evolution of an insurer's portfolio, having taken into account the combined effects of investment risk, interest-rate risk, and idiosyncratic as well as systematic longevity risk.

The assets owned are affected by the investment risk. In our setting, we assume that part of the premiums collected can be invested into a stock, whose dynamics follow a Geometric Brownian Motion. The remaining part can be invested in a risky bond, subject to an interest-rate risk, and/or kept in a safe money market account. The short rate evolves according to a Vasicek process. In addition, we allow the fund to disinvest from any of these categories to meet its obligations.

Since liabilities are evaluated at fair-value, interest-rate risk affects them as well. Our setting allows for the portfolio to contain annuities (immediate or deferred), pure endowments, and life insurance policies, possibly written on different cohorts. The valuation of liabilities at each point in time accounts for the presence of systematic longevity risk, since mortality intensity is described by means of a cohort-based continuous time model, as in Luciano and Vigna (2008). Deaths in the portfolio of insureds occur according to a Poisson process having such an intensity, giving rise to idiosyncratic mortality risk. In our work, we disentangle the effects of interest-rate and longevity risk on liabilities by providing both a market and a technical valuation of future obligations.

Our focus is on the funding ratio $(F(t))$ as the key quantity at each point in time. We define solvency risk as the likelihood of underfunding $(F(T) < 1)$ at different horizons. Further, we assume that the company runs until the event of bankruptcy, which happens when it has no resources left to pay its contractual obligations.

The solvency risk is evaluated by means of Monte Carlo simulation of the entire life of the portfolio in run-off. Assessments of the underfunding probability and the moments of the funding ratio, at different horizons, are provided in conjunction with the probability of bankruptcy. By analyzing the performance of different investment and hedging strategies, we give an insight on the ability of our model to accompany the decision process regarding ALM policies.

Our bond market and longevity models are calibrated to UK data. The sensitivity to other relevant parameters has been comprehensively analyzed. The results show that unhedged portfolios of annuities have incentives to more risky investment behaviors when liabilities are discounted at a technical rate. Consequently, this behavior has the effect of increasing the variability of the funding ratio and the probability of bankruptcy. Moreover, we show that natural hedging strategies, as proposed in Luciano et al.(2013), seem to be particularly effective in reducing solvency risk, but may increase the variability of the funding ratio in the long run.

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Save for Bad Times or Consume as Long as You Have? Worst-Case Optimal Life-Time Consumption

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Worst-case portfolio optimization has been introduced in Korn and Wilmott (2002) and is based on distinguishing between random stock price fluctuations and market crashes which are subject to Knightian uncertainty.

In normal times, the stock price dynamics follow a classical model such as the Black-Scholes type one or any other desired model. At the crash time, the stock prices fall by an individual unknown percentage of which we only know upper bounds, but make no distributional assumption.

Due to the absence of full probabilistic information, a worst-case portfolio problem is considered that will be solved completely. The corresponding optimal strategy is of a multi-part type and makes an investor indifferent between the occurrence of the worst possible crash and no crash at all.

We will consider various generalizations of this setting and - as a very recent result - will in particular answer the question "Is it good to save for bad times or should one consume more as long as one is still rich?"

Surprisingly, this question has two answers that are both very reasonable from an economic point of view. The mathematical methods used are classical stochastic control methods combined with abstract controller-stopper games and indifference arguments.

Worst-Case Optimization for an Investment-Consumption Problem

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In this talk, we investigate an investment-consumption problem of Merton type with a stochastic interest rate under the threat of a market crash. The evolution of the interest rate is described by a Vasicek model and can be correlated with the price fluctuations of the risky asset. The investor has the possibility to invest both in a risky asset, e.g. a stock, and in a riskless asset and chooses a consumption rate. The market crash is modeled as an uncertain event while the price fluctuations before and after the crash are risky. At the crash time τ the stock price loses an uncertain fraction l of its value and for $t < \tau$ and $t > \tau$ the stock price follows a geometric Brownian motion. The investor wants to maximize the expected discounted utility of consumption over an infinite time horizon in the worst-case scenario. After determining the Post-Crash Strategy by solving a classical stochastic optimal control problem, we can reformulate the worst-case optimization problem into a 'controller-vs-stopper game'. Then, the investor chooses a Pre-Crash Strategy such that the worst-case performance does not depend on the crash time. By application of the Optional Sampling Theorem we can find a sufficient condition for the Pre-Crash Strategy to be such an indifference strategy. This Martingale approach is based on the work of Seifried [1] and Desmettre et al. [2] and is extended for the case of a stochastic interest rate. By the notion of an indifference frontier, which shows that it is sufficient to consider strategies that are dominated by an indifference strategy, and by an Indifference-Optimality Principle, we can characterize the optimal investment-consumption strategy.

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Pricing Participating Products under Regime-Switching Generalized Gamma Process

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We propose a model for valuing participating life insurance products under a regime-switching generalized gamma process. The Esscher transform is employed to determine an equivalent martingale measure in the incomplete market. The results are further manipulated through the utilization of the change of numeraire technique to reduce the dimensions of the pricing formulation. Due to the path dependency of the payoff of the insurance product and the non-existence of a closed-form solution for the PIDE, the finite difference method is utilized to numerically calculate the value of the product. To highlight some practical features of the product, we present a numerical example.

Risk classification for claim counts using finite mixture models

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When modelling insurance claim counts data, the actuary often observes overdispersion and excess of zeros that may be caused by the unobserved heterogeneity. A common approach for accounting for overdispersion is to consider models with some overdispersed distribution as opposed to Poisson models. Zero-inflated, hurdle, and compound frequency models are usually applied to insurance data to account for such a features of the data. A natural way to allow for overdispersion is to consider mixtures of a simpler model. In this paper, we consider an m-finite mixture of Poisson regressions. This approach has interesting features: first, the zero-inflated model represents a special case; and second, it allows for an elegant interpretation based on the typical clustering application of finite mixture models. These models are applied to an automobile insurance claims data set in order to analyse the consequences for risk classification.

Pricing of Asian Option of Arithmetic Type Under Lévy Process : A Mellin Transform Approach

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We propose a method to compute the prices and greeks of single continuous Arithmetic Asian options driven by a class of Lévy processes with infinite activity under incomplete market and developed a partial integro- differential equation(PIDE) for Asian Option of Arithmetic type option, and applied Mellin Transform on it.Subsequently we perform the Inversion of these Mellin transform to construct the prices and sensitivities of Asian option in a class of Lévy models. The class includes many of the Lévy models employed in quantitative finance such as the NIG,CGMY and Meixner models.

A New Hybrid Finite Difference-Monte Carlo Method To Compute Risk Measures Under Stochastic Volatility

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Joint work with: Q. Feng, B.D. Kandhai, C.W. Oosterlee

In this talk a new method for computing Expected Exposures (EE) for derivatives is presented. EE is an important building block for quantification of risk measures such as Counterparty Credit Risk (CCR). The method is based on the well-known Monte Carlo method for the generation of paths, while the future option prices are computed using a backward finite difference method. The finite difference method computes prices for an entire grid of underlying values and the Monte Carlo paths "shoot" through this grid and thereby sample the relevant part of a distribution of the option price at any given timepoint.

The finite difference method evolves from maturity back in time, while the Monte Carlo method propagates paths from $t = t_0$ towards maturity. At a intermediate time point $t = t^*$ one has a grid of option values stemming from the finite difference procedure, next to that the Monte Carlo method gives N undelying values for every generated path. The resulting option values for these underlying values can be obtained using a straightforward interpolation scheme resulting in the desired distribution for the option value at any time $t^* \in [t_0, T]$.

For European call options an analytic pricing formula for the Black Scholes model is available, so in this case the method is tested against analytic prices. After that, the method is extended to the more exotic American options. Recent studies by Klein and Yang (Counterparty Credit Risk and American Options, 2013) show that CCR is still relevant in early exersize contracts. For American options the finite difference routine is implemented with the Brennan-Schwarz algorithm. In this case the method is compared with a Monte Carlo-COS method which is applied in the Black Scholes case in Shen, van der Weide and Anderluh (A benchmark approach of counterparty credit exposure of Bermudan option under Lévy Process: the Monte Carlo-COS Method, 2013) and a Monte Carlo-SGBM method which all agree.

The obtained distribution can be used to compute the EE, which is the mean of the distribution at the intermediate timepoints. This EE plays an important role when the possible loss from a counterparty default is considered. Next to EE, quantiles can be extracted from the distribution. The finite difference grid can be non-uniformly adjusted to acquire more accuracy in the desired region.

In the final step the model is extended to the Heston stochastic volatility model. In this case, a highly efficient non-uniform grid is used in the volatility and the stock dimension. For the time integration, a state of the art ADI-scheme is implemented. Again the results are compared to the Monte Carlo-Cos method and the Monte Carlo-SGBM. The simplicity, straigth forward implementation aswell as the flexibility of our proposed method are promising for a wide range of products.

Two efficient valuation methods of the exposure of Bermudan options under Heston's Model

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Expected Exposure (EE) is one of the key elements in Credit Value Adjustment (CVA). In credit risk management, Potential Future Exposure (PFE) is another important indicator- it indicates the maximum expected exposure at some level of confidence. Valuation of EE or PFE of path-dependent derivatives has the additional difficulty that some event may happen at any time over the entire path, either earlier or later than the valuation time.

A Bermudan option is an option where the buyer has the right to exercise at a set of times, which we may call watch times. If the option is exercised, the exposure disappears as the holder has realized the value of the option; otherwise, the holder will lose the current value of the option if the counterparty defaults.

When simulating scenarios, the option value at each watch time can be calculated as the stock price and the variance value in the stochastic volatility model are known; when a large number of scenarios is available, we can get an empirical distribution of the option value at each time point. It is easy to get EE and PFE when the distribution of the exposure is known.

The option value is always the maximum of the continuation value and the exercise value at each watch time. The continuation value is the expected value of the option conditioned on current market information; while the exercise value is the value if the option is exercised immediately. The difficulty lies in how to get the expectation in the continuation value efficiently.

In this paper we will show that two numerical methods – COS method and SGBM method – can give us the EE and PFE for a Bermudan option till the maturity time under Heston's model. In fact, the EE and PFE are natural by-products when pricing a Bermudan option itself in those two methods.

COS method offers an efficient way to recover the conditional density from the characteristic function based on Fourier-cosine expansion; while SGBM employs bundling to approximate the conditional distribution using simulation.

Monte Carlo simulation is needed for generating the scenarios. We apply the QE scheme with Martingale correction for generating the paths under Heston's Model.

Evolution of Copulas and its applications

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Copula is a well employed tool for investigating the dependence structure among risk factors. Copulas make a link between multivariate joint distributions and univariate marginal distributions. Because of their flexibility, copulas have been extensively studied and applied in a wide range of areas concerning the problem of dependence relations.

Copulas, however, are concerned mainly with the static problems and not with the time-dependent ones. There exist of course a few attempts which deal with the time variable in the copula theory. We recall the study on the copulas with the Markov processes by W.F. Darsow, B. Nguyen, and E.T. Olsen (1992), and also on the dynamic copulas by A.J. Patton (2006).

On the other hand, we have introduced the concept of the evolution of copulas both in continuous and discrete times (2011)(2012), which proclaims that a copula itself evolves according to the time variable. To be precise in continuous time, let $\{C(u,v,t)\}_{t\geq 0}$ be a time parameterized family of bivariate copulas, which satisfy the heat equation:

$$\frac{\partial C}{\partial t}(u,v,t) = \Big(\frac{\partial^2}{\partial u^2} + \frac{\partial^2}{\partial v^2}\Big) C(u,v,t).$$

Here, by the definition of copula, $C(\cdot,\cdot,t)$ fulfills:

(i) $C(u,0,t) = C(0,v,t) = 0$, $C(u,1,t) = u$, and $C(1,v,t) = v$;

(ii) For every $(u_i, v_i, t) \in [0,1]^2 \times (0,\infty)$ $(i = 1,2)$ with $u_1 \leq u_2$ and $v_1 \leq v_2$, it follows that $C(u_1,v_1,t) - C(u_1,v_2,t) - C(u_2,v_1,t) + C(u_2,v_2,t) \geq 0$.

In this poster session proposal, we make a review on the evolution of copulas and consider its applications.

Pricing American derivatives in the Heston model with an application to ESOs

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We introduce a refined tree method to compute option prices using the popular stochastic volatility model of Heston, where we in particular address correlation issues.

In a first step, we model the stock price and variance process as two separate trees. Here, although transformations as well as multiple jumps have to be incorporated into the generation of the trees, we in particularly focus on creating computational efficient trees. The respective transition probabilities are obtained by matching marginal tree moments up to order two against the Heston model ones. To this end, we develop a simple recursive formula to determine the joint moments in the Heston model.

Incorporating the correlation between the two driving Brownian motions is the main part of the presentation and is done via a node-wise adjustment of the probabilities. This adjustment, leaving the already matched marginal moments fixed, optimizes the match between tree and model correlation. It is efficient, since it is done only once for all occurring tree nodes and independently of the time discretization. In those nodes where an exact moment match up to order two is possible, we use the remaining degree of freedom to match a mixed cumulant of higher order of the Heston distribution with the rationale to achieve a lower distributional approximation error. Numerically this gives convergence orders faster than $1/N$, where N is the number of discretization steps.

We check the accuracy of our method for European option prices against the semi closed-form solution available in the Heston model. Afterwards we compare both European and American option prices of our algorithm to alternative approaches. Finally, we empirically show that matching against a third order moment at least partly is computationally inexpensive and very effective.

Having empirically shown that the valuation algorithm is efficient and applicable for a wide range of model parameters, we utilize it to value Employee Stock Options (ESOs) that have become a popular part of employee remuneration. ESOs typically are non-tradable call options on a publicly-traded company's stock that are granted by the firm to its employees. These options usually are of American type and often possess product specific exercise hurdles.

We extend our financial market setting for personal beliefs and employ the concept of utility functions to model risk averse employees. We determine market, subjective and objective option values, examine the effect of the vesting period and state optimal exercise frontiers for the ESOs for different parameter settings.

The minimal entropy martingale measure in a market of traded financial and actuarial risks

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In arbitrage-free but incomplete markets, the equivalent martingale measure chosen by the market for pricing traded assets is not uniquely determined. A possible approach when it comes to chosing a particular pricing measure is to consider the one that is 'closest' to the physical probability measure, where closeness is measured in terms of minimal entropy.

In this paper, we determine the minimal entropy martingale measure in a market where securities with payoffs depending on financial as well as actuarial risks are traded. In case only purely financial and purely actuarial securities are traded, we prove that financial and actuarial risks are independent under $\mathbb{P}$ if and only if these risks are independent under the entropy measure. Moreover, in such a market the entropy measure of the combined financial-actuarial world is the product measure of the entropy measures of the financial and actuarial subworlds, respectively.

Keywords: Minimal entropy martingale measure, real-world probability measure $\mathbb{P}$, risk-neutral probability measure $\mathbb{Q}$, financial risks, actuarial risks, dependence relations, no-arbitrage conditions.

Weighted Monte Carlo method: a way to reduce calibration risk?

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The weighted Monte Carlo method has been proved to be an efficient way to calibrate a Monte Carlo model to the market data and to reduce variance in the Monte Carlo simulation. It can recover the implied volatility of benchmark options by assigning special weights to the simulated paths in the Monte Carlo model. Its sensitivity with respect to the market data has been investigated in the existing literature. This paper will empirically investigate its sensitivity with respect to the prior estimation used to generate the Monte Carlo model. The numerical studies suggest that it is not sensitive to the prior estimation and can reduce the calibration risk when pricing exotic options.

The Markov modulated multivariate Ornstein-Uhlenbeck process and applications to credit derivatives

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We consider a Markov modulated multivariate Ornstein-Uhlenbeck (MMM-OU) process, described by

$$\mathrm{d}\boldsymbol{X}_t = \Theta_{J_t}(\boldsymbol{\mu}_{J_t} - \boldsymbol{X}_t)\mathrm{d}t + S_{J_t}\boldsymbol{W}_t, \qquad \boldsymbol{X}_0 = x, \qquad \mathbb{P}[J_0 = j] = p_{j0},$$

where Θ_j are $d\ n \times n$ rate matrices, $\boldsymbol{\mu}_j$ are the $n \times 1$ equilibrium means, S_j are the $n \times m$ covariances and $\boldsymbol{W}_t$ is an $m \times 1$ Brownian motion. J_t is a switching process with $d \times d$ generator Q and its jumps do not depend on $\boldsymbol{X}_t$. The goal of the present research is the exact mathematical analysis of the MMM-OU process and the application of results to the valuation of credit derivatives.

We show that given initial state probabilities $\boldsymbol{p}_0$, starting point $\boldsymbol{x}$ and any vector of non-negative powers $\boldsymbol{a} \in \mathbb{N}_0^n$, the higher (mixed) moments $\mathbb{E}[X_{1t}^{a_1} \cdots X_{nt}^{a_n}]$ admit a closed form solution. We derive an iterative formula from Itô's lemma in which every higher moment is a functions of lower moments. Furthermore, we give the infinitesimal generator of the process and its adjoint. These generators can be used to write down Feynman-Kac and Fokker-Planck type systems of partial differential equations (PDEs) for the expectation of functions of $\boldsymbol{X}_t$ and for its distribution.

We show that the process is suitable to represent realistic joint term structures of interest rates and hazard rates of default. Plots of the term structure for different parameterizations illustrate this. Credit derivatives such as defaultable bonds, letters of credit, credit default swaps (CDSs), colleterized debt obligations (CDOs) and first-and n-to-default swaps typically depend on both a short rate process and one or more hazard rates of default that are not independent. The multiplicity of hazard rates stems from adjustments due to counterparty risk. For example if a firm buys a CDO to protect itself against the default of a client, then it must also price the risk that the seller of the protection defaults. This price is a credit valuation adjustment (CVA). Similarly an adjustment has to be made for the probability that the buyer of protection default; a debit valuation adjustment (DVA). These adjustments are often substantial and interacting [4]. The MMM-OU process is flexible enough to represent the complex interactions of hazard rates of default. For many derivatives it is easy to find the price as the solution of a system of PDEs using our mathematical results.

The OU process itself is well suited for both the short rate process and the hazard rates. The model nests a multi-factor Vasicek short rate process, and it has been shown that log-hazard rates that follow an OU process outperform other popular processes [1, 5]. The additional feature of Markov modulation adds great flexibility to the term structure, by allowing the parameters of the process randomly to change over time [2, 3]. In the finance literature a specific set of parameters is understood as a regime, and Markov modulation is referred to as regime switching. Classical examples of regimes are the bull and bear markets. We show that by specifying different regimes in the MMM-OU process, the resulting term structure of interest rates and default probability can capture the features of the term structures that are observed in the market.

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