NWO/STAR/CentER

10th Winter School on Mathematical Finance

Special Topics:

Energy Markets

Malliavin Calculus in Finance

January 24 – 26, 2011
CongresHotel De Werelt, Lunteren

Sponsored by NWO, STAR, and CentER

NWO/STAR/CentER Winter School on Mathematical Finance

In recent years, the mathematical theory associated with financial risk management and the pricing of contingent claims has been a highly active field of research. The area has established itself as one of the most vigorously growing branches of applied mathematics. Model-based analysis of contracts and portfolios has become a standard in the finance industry, and the number of academic institutions offering curricula in financial mathematics is increasing rapidly. In this context, the winter school on Mathematical Finance that will take place January 24–26, 2011 in Lunteren aims at providing a meeting place for participants both from industry and from academia. The program provides ample opportunity for discussion.

The special topics of the 10th winter school are *Energy Markets* and *Malliavin Calculus in Finance*. These are the subjects of minicourses that will be taught by two distinguished speakers: Professor Rüdiger Kiesel (Universität Duisburg-Essen) and Professor Bernt Øksendal (University of Oslo). Additionally there will be three one-hour lectures by Professors Hansjoerg Albrecher (Université de Lausanne), Gilles Pagès (Université de Paris VI) and Johan Tysk (Uppsala Universitet). Thirty-minute lectures on recent research work in the Netherlands will be presented by Ove Göttsche (Twente University), Michiel Janssen (Universiteit van Amsterdam and Eureko), Roel Mehlkopf (Tilburg University) and Enno Veerman (Universiteit van Amsterdam).

Auspices and sponsoring

The winter school takes place under the auspices of the following research schools:

- Center for Economic Research (CentER)
- STAR.

CentER is the research school of the Faculty of Economics and Business Administration of Tilburg University. The stochastics groups of the mathematics departments of the universities in The Netherlands cooperate in STAR. The winter school is supported financially by CenTER, STAR, and by the Netherlands Organization for Scientific Research (NWO). Administrative assistance is provided by the Korteweg–De Vries Institute for Mathematics of the Universiteit van Amsterdam.

Organizers

The winter school is organized by:

Hans Schumacher (Department of Econometrics and Operations Research, Tilburg University; tel. 013-4662050, e-mail jms@uvt.nl)

Peter Spreij (Korteweg–De Vries Institute for Mathematics, Universiteit van Amsterdam; tel. 020-5256070, e-mail spreij@uva.nl).

Program outline

The program starts with registration and coffee on Monday, January 24, from 10:30 to 11:30, and ends on Wednesday, January 26, at 16:00. The following events are planned:

Minicourses

Rüdiger Kiesel
Modelling energy markets

Bernt Øksendal
Malliavin calculus for Lévy processes and applications to Finance

Special invited lectures

Hansjoerg Albrecher
Solvency modelling with dependent risks

Gilles Pagès
Dual quantization methods and application to Finance

Johan Tysk
Boundary behaviour of densities for non-negative diffusions

Short contributions

Ove Göttsche
Option pricing and the cost of risk

Michiel Janssen
Portfolio optimisation with a value at risk constraint in the presence of unhedgeable risks

Roel Mehlkopf
Intergenerational risk sharing and long-run labor income risk

Enno Veerman
The affine transform formula for affine jump-diffusions with a general closed convex state space

Schedule of lectures

	Monday January 24	Tuesday January 25	Wednesday January 26
09:00 - 10:00		Øksendal	Pagès
10:30 - 11:30		Øksendal	Tysk
11:30 - 12:30	Øksendal	Kiesel	Kiesel
14:00 - 15:00			Kiesel
15:00 - 16:00	Øksendal	Kiesel	Albrecher
16:00 - 17:00	Kiesel	Øksendal	
17:30 - 18:00	Veerman	Janssen	
18:00 - 18:30	Göttsche	Mehlkopf	

Web page

Please see `www.mathfin.nl` for the latest information about the winter school.

Venue

The winter school will take place at Congreshotel De Werelt, Westhofflaan 2, Lunteren, tel. 0318-484641, fax 0318-482924. Located in the heart of the Veluwe forest, De Werelt is one of the top accommodations in the Netherlands in terms of attractiveness of surroundings. Access by car or by public transportation is easy. By train, the village of Lunteren can be reached in twenty minutes from Amersfoort, and in ten minutes from Ede-Wageningen. It takes about fifteen minutes to walk from the railway station in Lunteren to the conference center (see directions below). If you come by car, ANWB signs in Lunteren will guide you to the venue. It is also possible to take a taxi from the taxi stand at railway station Ede-Wageningen. To get a taxi in Lunteren, call 0318-484555. For further details please see `www.congrescentrum.com/route/EN/de_werelt`.

Directions from the railway station: leaving the station, turn right across the pebble-covered parking lot. Turn left into the forest (Boslaan). At the crossroads, turn right into Molenweg. The first turn left is Westhofflaan.

Abstracts

Minicourse on Energy Markets

Rüdiger Kiesel (Universität Duisburg-Essen)

Modelling energy markets

Within the last few years the market for commodities, in particular energy-related commodities, has changed substantially. New regulations and products have resulted in a spectacular growth in spot and derivative trading. In particular, electricity markets have changed fundamentally over the last couple of years. Due to deregulation energy companies are now allowed to trade not only the commodity electricity, but also various derivatives on electricity on several Energy Exchanges (such as the EEX).

During this Mini-Course we discuss basic principles of commodity markets and outline the stylized facts of electricity price processes. Then we introduce spot and forward models for commodities (with a focus on electricity). In addition, special derivatives for the electricity markets are analysed. In commodities markets the market risk premium, defined as the difference between forward prices and spot forecasts, is an important indicator of the behaviour of buyers and sellers and their views on the market spanning between short-term and long-term horizons. We show that under certain assumptions it is possible to derive explicit solutions that link levels of risk aversion and market power with market prices of risk and the market risk premium.

During the last part of the course we provide a short introduction in the theoretical properties of emission permit price dynamics regarding the effect of banking, linking of different emissions trading schemes and safety-valve mechanisms. Explicit models for the price process are constructed and calibrated to historical data on the permit prices and emissions in the European Union. We show that permit prices in emissions trading schemes without inter-phase banking resemble Digital options and are inherently prone to price jumps and high volatility. Then we discuss so-called hybrid schemes and show that they can be decomposed into ordinary cap-and-trade schemes with plain-vanilla options on permits.

Minicourse on Malliavin Calculus in Finance

Bernt Øksendal (University of Oslo)

Malliavin calculus for Lévy processes and applications to Finance

The Malliavin calculus was originally introduced by Paul Malliavin in 1978 as a tool to study smoothness of densities of solutions of stochastic differential equations. This was a rather restricted scope of applications and the theory was difficult, so for more than 10 years this was a topic of interest to only a limited group of experts. However, when Ocone in 1994 showed that Malliavin calculus could be used to obtain an explicit version of the Itô representation theorem (now known as the Clark-Ocone formula), and when subsequently Karatzas and Ocone applied this to finance, the interest in this area exploded. At the same time simpler presentations of the theory were developed. Soon even bank employees started studying Malliavin calculus!

The Malliavin calculus was first introduced for Brownian motion, but it has later been extended to Lévy processes. At the same time new applications of the theory have been discovered. In this course we give a simple introduction to Malliavin calculus for Lévy processes and we give examples of applications to finance. Here is an outline of the course:

Lecture 1: Introduction to Malliavin calculus for Brownian motion (i): The Malliavin derivative, or Hida-Malliavin derivative, as a stochastic gradient.

Lecture 2: Malliavin calculus for Brownian motion (ii): The Malliavin derivative by means of chaos expansion. Properties of the Malliavin derivative, including the chain rule, the duality theorem and the fundamental theorem of stochastic calculus.

Lecture 3: Malliavin calculus for Brownian motion (iii): Applications:
(a) The Clark-Ocone formula and applications to hedging
(b) Sensitivity results and application to efficient numerical computation of the "greeks" in finance.

Lecture 4: Malliavin calculus for Lévy processes (i): Introduction to stochastic calculus for Lévy processes. The Malliavin derivative by means of chaos expansion. Properties of the Malliavin derivative. The Clark-Ocone formula revisited. Hedging in incomplete markets.

Lecture 5: Malliavin calculus for Lévy processes (ii): Applications, for example the following:
(a) Minimal variance portfolio in incomplete markets
(b) Optimal portfolio with partial information

The presentation is based on the 3 first chapters of Part 1 and Part 2, respectively, of my book joint with Giulia Di Nunno and Frank Proske, entitled *Malliavin Calculus for Lévy Processes and Applications to Finance*, Universitext, Springer 2009.

Special invited lectures

Hansjoerg Albrecher (Université de Lausanne)

Solvency modelling with dependent risks

This talk is a survey on the effects of dependence of risks on the solvency of a portfolio of insurance policies. Exact and asymptotic results for ruin probabilities will be discussed and general techniques will be presented that make models with dependence tractable for the analysis. Related quantities like the time to ruin and the deficit of ruin under dependence will also be treated. Some of the results have applications for the pricing of path-dependent options in financial markets, including lookback and barrier options.

Gilles Pagès (Université de Paris VI)

Dual quantization methods and application to Finance

Regular quantization tree methods are based on the mapping of a discrete time Feller Markov chain at each time step on a grid following a nearest neighbour projection. When these grids are optimized with respect to the marginal distributions of the chain, the resulting backward dynamic programming computation method (the so-called quantization tree) has shown its efficiency in the solving of many non-linear problems arising in Finance like multi-asset American option pricing and hedging, stochastic control like swing options, or nonlinear filtering (see *e.g.* [2]).

We recently developed (see [3,4,5]) a new approach to quantization, called *dual quantization*, see [4,5], based on the mapping of the Markovian dynamics at each time step onto the vertices of a Delaunay triangulation spanned by a grid (the Delaunay triangulation is the dual geometrical object of the Voronoi tessellation involved in regular vector quantization). The aim of this talk is to present this new approach as well as its first applications to finance.

For a static $\mathbb{R}^d$-valued L^p-integrable random vector, say X, we prove the existence of an optimal dual quantizer of size at most N (see [4]) and, under a slightly stronger moment assumption, we establish the sharp asymptotics for the resulting optimal dual quantization error as N goes to infinity in the expected $N^{-\frac{1}{d}}$-scale (see [5]). The constant in this asymptotics depends on the distribution of X (through its density) and on a universal constant $C^{dual}_{p,d}$ (made explicit in one dimension). This result is the exact counterpart for dual quantization of Zador's Theorem (see [1]). New simulation based stochastic optimization procedures have been derived to produce optimal dual quantization grids for any simulatable distribution.

However, by contrast with optimal regular quantization, dual quantization grids all share a stationarity property, regardless of their optimality. As a first consequence, this induces a significant improvement of the performances of *dual quantization trees*, especially for smaller grid sizes. But the most striking consequence is the resulting robustness and flexibility of such trees with respect to the possible parameter variations when dealing with a parametrized underlying dynamics. So, it should become an efficient tool for perform calibrations or to solve multi-dimensional stochastic control problems when the underlying dynamics depends on the control.

First applications to credit derivatives (see [3]) and to multi-asset option pricing will be presented as well as first connections with the finite element methods.

This presentation is based on a several joint works with Benedikt Wilbertz (UPMC).

REFERENCES

[1] S. Graf, H. Luschgy, *Foundations of Quantization for Probability Distributions*, Lecture Notes in Mathematics, **1730**, Berlin, 2000.

[2] G. Pagès, J. Printems, Optimal quantization for finance: from random vectors to stochastic processes, in *Mathematical Modeling and Numerical Methods in Finance* (special volume) (A. Bensoussan, Q. Zhang guest eds.), coll. Handbook of Numerical Analysis (P.G. Ciarlet Editor), North Holland, 595-649, 2009

[3] G. Pagès, B. Wilbertz. *Dual Quantization for random walks with application to credit derivatives*, pre-pub. LPMA 1322, arXiv: 0910.5655, 2009, in revision for *J. of Comput. Fin.*

[4] G. Pagès, B. Wilbertz, *Intrinsic stationarity for vector quantization: Foundation of dual quantization*, in progress, 2010.

[5] G. Pagès, B. Wilbertz, *Sharp rate for the dual quantization problem*, in progress, 2010.

Johan Tysk (Uppsala Universitet)

Boundary behaviour of densities for non-negative diffusions

It is well-known that the transition density of a diffusion process solves the corresponding Kolmogorov forward equation. If the state space has finite boundary points, then naturally one also needs to specify appropriate boundary conditions when solving this equation. However, many processes occurring in finance have degenerate diffusion coefficients, and for these processes the density may explode at the boundary. We describe a simple symmetry relation for the density that transforms the forward equation into a backward equation, the boundary condition of which is much more straightforward to handle. This relation allows us to derive new results on the precise asymptotics of the density at boundary points where the diffusion degenerates. This is joint work with Erik Ekström.

Short contributions

Ove Göttsche (Twente University)

Option pricing and the cost of risk

The problem of pricing and hedging options is well understood in the context of the Black-Scholes model. In this model, a perfect hedge is always possible, meaning, there exists a dynamic strategy such that trading in the underlying asset replicates the payoff of the option. However, the possibility of a perfect hedge is restricted to certain models and restrictive assumptions. In more realistic models a perfect hedge is not possible and thus an option bears a residual risk that cannot be hedged away completely. Therefore, pricing an option consist of two parts: the cost of a hedging strategy that reduces the risk, and a premium to cover the residual risk.

We assume that a trader wishes to minimize the price of a given option. To avoid that she chooses hedging strategies which are too risky, the trader is punished when taking excessive risks. To do so, we introduce an extra capital reserve bank account, which earns a smaller rate of return then a standard deposit bank account. The reserve account should always contain a minimal amount of money, which depends on the residual risk that the trader's portfolio is exposed to. The residual risk is measure by a convex risk measure and the problem leads to a convex optimization problem. This problem can be solved via convex duality methods. We prove the existence of the optimal hedging strategy and give an example.

Michiel Janssen (Universiteit van Amsterdam and Eureko)

Portfolio optimisation with a value at risk constraint in the presence of unhedgeable risks

This paper addresses the portfolio optimisation problem that most European insurance companies will face after the introduction of Solvency II (the new regulatory framework in Europe to be introduced in 2012). Solvency II will limit the total Value at Risk of an insurance company. In this paper therefore I derive the optimal portfolio of hedgeable risks when also unhedgeable risks are present and the sum of both risks is constrained by a Value at Risk constraint.

This paper extends the current literature on portfolio optimisation by including both a Value at Risk constraint and Unhedgeable risks where in the current literature maximally only of these two is included. To obtain flexibility with respect to assumptions regarding the probability functions of both the hedgeable and unhedgeable risks, the state price density, and the utility function used, the problem is optimised numerically. An example shows the importance of a correct specification of the characteristics of the hedgeable risk. The results also show that the optimal portfolio is much less skewed than the optimal portfolio that is obtained when only hedgeable risks are present.

Roel Mehlkopf (Tilburg University)

Intergenerational risk sharing and long-run labor income risk

The inability of future generations to share risk with current ones causes financial markets to be incomplete and thus inefficient. By using its financial reserves efficiently, a pension fund is able to transfer current equity risk to future generations, thereby alleviating the 'biological' trading constraint that is faced in financial markets. This paper examines how comovements in stock and labor markets affect the gains from intergenerational risk sharing. If stock and labor markets move together in the long-run, the human wealth of unborn generations becomes highly correlated with stock returns, which reduces their risk appetite. I show that shifting risk into the future is not optimal anymore once the long-run dynamics of labor income are taken into account. The risk bearing capacity of a pension fund is dramatically decreased if it is unattractive for risk to be transferred to future generations. The results in this paper provide an economic rationale for a tight solvency regime, that requires pension funds to recover from their losses in a short time-period.

Enno Veerman (Universiteit van Amsterdam)

The affine transform formula for affine jump-diffusions with a general closed convex state space

Affine jump-diffusions are widely used in finance because of their flexibility and mathematical tractability. The latter is revealed by the so-called affine transform formula, which relates exponential moments to solutions of particular ODEs, called generalized Riccati equations. We establish existence of exponential moments and the validity of the affine transform formula for affine jump-diffusions with a general convex state space. This extends known results for affine jump-diffusions with a canonical state space. The key step is to prove the martingale property of an exponential local martingale, using the well-posedness of the associated martingale problem. By analytic extension we then obtain the affine transform formula for complex exponentials, in particular for the characteristic function. Next we apply our results to popular models in the literature, including the multivariate stochastic volatility models where the volatility is modelled as a matrix-valued affine process. (Joint work with Peter Spreij.)

Registration

To register for the winter school, please use the electronic registration form that is available at the web page of the winter school (see `www.mathfin.nl` or `www.science.uva.nl/~spreij/stieltjes/winterschool.html`). Alternatively, you may complete the registration form on the last page and return it to ms. E. Wallet, Korteweg–De Vries Institute for Mathematics, PO Box 94248, 1090GE Amsterdam.

The registration fee includes accommodation (single room) for the nights of January 24 and 25, all meals starting with lunch on Monday up to and including lunch on Wednesday, and tea and coffee during breaks. Payment can be made by transferral to account 7388994 of Winter School Amsterdam, Secretariaat Korteweg–De Vries Instituut, Amsterdam. For international money transfers please use the bank codes IBAN: NL27 INGB 0007388994 and BIC: INGBNL2A. The fee schedule is as follows:

	early registration (before December 1)	late registration (after December 1)
standard	€1600	€1900
full-time university staff	€365	€415

Inquiries concerning fees for partial attendance may be directed to ms. Wallet at the address given below. Registration will be valid after full payment has been received. Refunds can be given only for cancellations received before January 1, 2011.

Accommodation at the venue is limited. Therefore, reservations will be treated on a first-come-first-served basis with priority for full arrangements. Participants who cannot be lodged at the venue will be accommodated in a hotel nearby. Transportation from the hotel to the venue and vice versa will be taken care of by the organization.

Further information

For further information regarding the scientific program, please contact one of the members of the organizing committee. For information concerning registration please contact:

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Registration Form

Last name: ______________________________

First name: ______________________________

Affiliation: ______________________________

Address: ______________________________

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Telephone: ______________________________

Fax: ______________________________

Email address: ______________________________

Date: ______________________________

Signature: ______________________________

Please return the completed form *before January 1, 2011* to:

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Registration is valid only after full payment has been received following the fee schedule.