NWO/STAR/WONDER

14th Winter School on Mathematical Finance

Special topics:

Nonlinear Pricing

Dependence and Model Risk

January 26 – 28, 2015
Congrescentrum De Werelt, Lunteren

Sponsored by NWO, STAR, WONDER, and FWO

NWO/STAR/WONDER
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 26–28, 2015 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 14th winter school are *Nonlinear Pricing* and *Dependence and Model Risk*. These are the subjects of minicourses that will be taught by two distinguished speakers: Professor Damiano Brigo (Imperial College) and Professor Ludger Rüschendorf (University of Freiburg). Additionally there will be three one-hour lectures by Professors Christian Bender (Saarland University), Freddy Delbaen (ETH Zürich) and Matheus Grasselli (McMaster University). Thirty-minute lectures on recent research work in the Netherlands and Belgium will be presented by Kees de Graaf (Universiteit van Amsterdam), Shashi Jain (NRG), Andrei Lalu (Universiteit van Amsterdam) and Daniël Linders (Katholieke Universiteit Leuven).

Auspices and sponsoring

The winter school takes place under the auspices of the research schools STAR and WONDER. The stochastics groups of the mathematics departments of the universities in The Netherlands cooperate in STAR. WONDER is the Dutch research school in Mathematics. The winter school is supported financially by STAR, WONDER, by the Netherlands Organization for Scientific Research (NWO) and by the Research Foundation - Flanders (FWO). Administrative assistance is provided by the Korteweg–De Vries Institute for Mathematics of the Universiteit van Amsterdam.

The FWO WOG research network Stochastic Modelling with applications in financial markets has made available a limited number of grants of € 250 each for young researchers (PhD students and postdocs) associated to the network to be used as a reduction on the registration fee for the winter school. Eligible for the grants are with priority those whose supervisor is a member of the network, but others are invited to apply as well. Applications for the grant can be sent by email to both Hans Schumacher and Peter Spreij (make sure that both are addressed). Applications are required to contain a brief motivation why the grant should be beneficial for the research of the applicant, a brief motivation why the applicant has a specific need for the grant, a (link to) a CV of the applicant and the name of her/his principal supervisor. The deadline for applications is December 1, 2014.

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 26, from 10:30 to 11:30, and ends on Wednesday, January 28, at 16:00. The following events are planned:

Minicourses

Damiano Brigo
Nonlinear valuation under credit gap risk, collateral initial and variation margins, funding costs and multiple curves

Ludger Rüschendorf
Mathematical risk analysis

Special invited lectures

Christian Bender
Primal-dual Monte-Carlo methods for nonlinear pricing problems

Freddy Delbaen
Monetary utility functions with the CxLS (convex level sets) property

Matheus Grasselli
A stock-flow consistent macroeconomic model for asset price bubbles

Short contributions

Kees de Graaf
Efficient computation of CVA sensitivities in the finite-difference Monte-Carlo method for portfolios of FX options

Shashi Jain
The Stochastic Grid Bundling Method: application to exposure calculations

Andrei Lalu
Asset returns with self-exciting jumps: option pricing and time-varying jump risk premia

Daniël Linders
Basket option pricing and implied correlation in a Lévy copula model

Schedule of lectures

	Monday January 26	Tuesday January 27	Wednesday January 28
09:00 - 10:00		Brigo	Brigo
10:30 - 11:30		Brigo	Brigo
11:30 - 12:30	Rüschendorf	Rüschendorf	Rüschendorf
14:00 - 15:00			Grasselli
15:00 - 16:00	Rüschendorf	Brigo	Delbaen
16:00 - 17:00	Bender	Rüschendorf	
17:30 - 18:00	de Graaf	Lalu	
18:00 - 18:30	Jain	Linders	

Web page

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

Venue

The winter school will take place at Congrescentrum De Werelt, Westhofflaan 2, Lunteren, tel. +31-(0)318-484641, fax +31-(0)318-482924. 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 +31-(0)318-484555. For further details please see `www.congrescentrum.com` (under De Werelt Lunteren and Route).

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

Mini-course on Nonlinear Pricing

Damiano Brigo (Imperial College)

Nonlinear valuation under credit gap risk, collateral initial and variation margins, funding costs and multiple curves

The market for financial products and derivatives reached an outstanding notional size of 708 trillion USD in 2011, amounting to ten times the planet's gross domestic product. Even discounting double counting, derivatives appear to be an important part of the world economy and have played a key role in the onset of the financial crisis in 2007.

After briefly reviewing the Nobel-awarded option pricing paradigm by Black, Scholes, and Merton, hinting at precursors such as Bachelier and DeFinetti, we explain how the self-financing condition and Itô's formula lead to the Black-Scholes Partial Differential Equation (PDE) for basic option payoffs. We hint at the Feynman-Kac theorem and explain how the risk-neutral measure of no arbitrage theory may be related to this.

Following this quick introduction, we describe the changes triggered by post-2007 events. We re-discuss the valuation theory assumptions and introduce valuation under counterparty credit risk, collateral posting, initial and variation margins, and funding costs. We explain model dependence induced by credit effects, hybrid features, contagion, payout uncertainty, and nonlinear effects due to replacement closeout at default and possibly asymmetric borrowing and lending rates in the margin interest and in the funding strategy for the hedge of the relevant portfolio. Nonlinearity manifests itself in the valuation equations taking the form of semi-linear PDEs or Backward SDEs. We discuss existence and uniqueness of solutions for these equations.

We present an invariance theorem showing that the final valuation equations do not depend on unobservable risk-free rates, that become purely instrumental variables. Valuation is thus based only on real market rates and processes. We also present a high level analysis of the consequences of nonlinearities, both from the point of view of methodology and from an operational angle, including deal/entity/aggregation-dependent valuation probability measures and the role of banks' treasuries.

Finally, we hint at how one may connect these developments to interest rate theory under multiple discount curves, thus building a consistent valuation framework encompassing most post-2007 effects.

Mini-course on Dependence and Model Risk

Ludger Rüschendorf (University of Freiburg)

Dependence, risk bounds, optimal allocations and portfolios

The main focus in this course is on the description of the influence of dependence in multivariate stochastic models for risk vectors. In particular we are interested in the description of the impact of dependence on the formulation of risk bounds, on the range of portfolio risk measures on problems of optimal risk allocation (diversification), and the construction of optimal portfolios.

In more detail:

1) We will point out general methodological tools for dependence modeling and analysis. In particular we discuss Hoeffding-Fréchet bounds and mass transportation and their impact on the representation of risk measures for portfolio vectors, on the characterization of worst-case dependence structures, and, in particular, on possible generalizations of comonotonic dependence structures.

2) We introduce recent developments on obtaining (sharp) risk bounds for the Value at Risk and other risk functionals of joint portfolios. A field of active recent development is the inclusion of partial dependence information to obtain improved risk bounds. In particular we also consider the question of model risk as, for example, apparent in several of the popular and much used credit risk models.

3) We give an introduction to the use of positive resp. negative dependence in order to construct improved (optimal) risk allocations and optimal portfolios. Applications to real data show the considerable potential of these relatively recent construction methods.

4) Based on extreme value theory, the notion of extreme risk index (ERI) is introduced and based on it a new method of portfolio optimization is introduced taking into account the inherent dependence between the data. This ERI based approach is compared with the Markowitz approach in an empirical study of S & P 500 data.

Reference: Rüschendorf, L.: *Mathematical Risk Analysis.* Springer (2013), `http://www.springer.com/mathematics/probability/book/978-3-642-33589-1`

Special invited lectures

Christian Bender (Saarland University)

Primal-dual Monte-Carlo methods for nonlinear pricing problems

Nonlinear option pricing problems arise e.g. in the presence of early exercise features, model risk, or credit/funding value adjustments. Many of these problem lead (possibly after a time discretization is performed) to a backward dynamic program. In this lecture we first review the primal-dual method of Andersen and Broadie for the construction of confidence intervals on the price of a Bermudan option by Monte Carlo simulation. We then explain how this approach can be extended to a wide class of convex dynamic programs. The results are illustrated by various numerical examples including European option pricing under uncertain volatility and Bermudan option pricing under funding risk.

Freddy Delbaen (ETH Zürich)

Monetary utility functions with the CxLS (convex level sets) property

Monetary utility functions are — except for the expected value — not of von Neumann-Morgenstern type. In case the utility function has convex level sets in the set of probability measures on the real line, we can give some characterisation that comes close to the vN-M form. For coherent utility functions this was solved by Ziegel. The general concave case, under the extra assumptions of weak compactness, was solved by Stefan Weber. In the general case the utility functions are only semicontinuous. Using the fact that law determined utility functions are monotone with respect to convex ordering, we can overcome most of the technical problems. The characterisation is similar to Weber's theorem, except that we need vN-M utility functions that take the value $-\infty$. Having convex level sets can be seen as a weakened form of the independence axiom in the vN-M theorem.

Matheus Grasselli (McMaster University)

A stock-flow consistent macroeconomic model for asset price bubbles

In this talk I first describe a stock-flow consistent model for an economy with households, firms, and banks in the form of a three-dimensional dynamical system for wages, employment, and firm debt. This is then extended by a fourth variable representing the flow of borrowing that is used purely for speculation on an existing financial asset, rather than productive capital investment. Finally, the system is augmented by introducing a price dynamics for the financial asset in the form of a standard geometric Brownian motion plus a downward jump modelled as a non-homogeneous Poisson process whose intensity is an increasing function of the speculative ratio. The compensator for this downward jump then leads to the super-exponential growth characteristic of asset price bubbles. Moreover, when the bubble bursts the cost of borrowing in the real economy increases, leading to a feedback mechanism from the asset price dynamics to the original system. This is joint work with Bernardo Costa Lima and Adrien Nguyen Huu.

Short contributions

Kees de Graaf (Universiteit van Amsterdam)

Efficient computation of CVA sensitivities in the finite difference Monte-Carlo method for portfolios of FX options

In this talk we discuss a recently developed efficient method to measure the Expected Exposure (EE) over the lifetime of options. This is done by combining the scenario generation of the Monte Carlo (MC) method with the option valuation based on solving a Partial Differential Equation (PDE) on a grid. The results are accurate and computationally efficient. After introducing the method we will show how to extend this method by applying it on multiple options and show how to compute first (delta) and second order (gamma) sensitivities. Our results show that the method is accurate and computationally more efficient than a traditional bump-and-revalue routine. As a first application we assess the impact on CVA, delta and gamma of adding a barrier option to a portfolio of a call and a put option.

Shashi Jain (NRG)

The Stochastic Grid Bundling Method: application to exposure calculations

Since the credit crisis of 2008, managing counterparty credit risk has become an integrated part of derivative trading desks' day-to-day activities. Banks use Monte Carlo methods to simulate the future values of the portfolio of derivatives with a counterparty. For derivatives that are priced using Monte Carlo methods might require a nested simulation in order to compute their values for all the future scenarios.

In this talk we present the Stochastic Grid Bundling Method (SGBM) — as an alternative to the traditional Monte Carlo based option pricing methods — for efficient simulation of the future values of such derivatives, while avoiding expensive nested simulations. We analyze results computed using SGBM for Bermudan and European options (such as swaptions, and baskets of equity options).

Andrei Lalu (Universiteit van Amsterdam)

Asset returns with self-exciting jumps: option pricing and time-varying jump risk premia

We develop a semi-closed-form option pricing approach in the context of a parametric model for asset returns with clustered jumps. The stochastic jump intensity in the model self-excites as a result of jumps occurring, so the model can accommodate jump clustering, a phenomenon which is empirically relevant when markets are in turmoil. Assuming an arbitrage free pricing kernel, we develop a procedure to filter out the latent state variables and estimate model parameters via the generalized method of moments. The moment conditions are based on the model's conditional characteristic function. Using a long time series of S&P 500 options prices we estimate model parameters and conduct inference on the risk premiums specified in the pricing kernel for variance and jump risk. We find strong evidence in favor of self-excitation in the jump intensity process for the S&P 500 index. Lastly, we find that the in-sample and out-of-sample option pricing performance of our model exceeds that of alternative models with time-varying jump intensity specifications.

Daniël Linders (Katholieke Universiteit Leuven)

Basket option pricing and implied correlation in a Lévy copula model

We introduce the Lévy copula model and consider the problem of finding accurate approximations for the price of a basket option. The basket is a weighted sum of dependent stock prices and its distribution function is unknown or too complex to work with. Therefore, we replace the random variable describing the basket price at maturity by a random variable with a more simple structure. Moreover, the Carr-Madan formula can be used to determine approximate basket option prices.

In a second part of the paper we show how implied volatility and implied correlation can be defined in our Lévy copula model. In our model, each stock price is described by a volatility parameter and the marginal parameters can be calibrated separately from the correlation parameters using single-name option prices. However, the available market prices for basket options together with our newly designed basket option pricing formula enable us to determine implied Lévy correlation estimates. We observe that implied correlation depends on the strike, and the so-called implied Lévy correlation smile is flatter than its Gaussian counterpart. The standard technique to price non-traded basket options (or other multi-asset derivatives) is by interpolating on the implied correlation curve. In the Gaussian copula model, this can sometimes lead to non-meaningful correlation values. We show that the Lévy version of the implied correlation solves (at least to some extent) this problem. This is joint work with Wim Schoutens.

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/winterschool/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 26 and 27, 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 IBAN account number: NL27 INGB 0007388994 of Winter School Amsterdam, Secretariaat Korteweg–De Vries Instituut, Amsterdam and (for international money transfers) BIC: INGBNL2A. The fee schedule is as follows:

	early registration (before December 1)	late registration (after December 1)
industry professional	€1195	€1350
full-time academic	€395	€445

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, 2015.

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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14th Winter School on Mathematical Finance

Lunteren, January 26–28, 2015

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, 2015* to:

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