NWO/STAR/WONDER/CentER

12th Winter School on Mathematical Finance

Special Topics:

Adjoint methods in computational finance

Mathematical behavioural finance

January 21 – 23, 2013
Congrescentrum De Werelt, Lunteren

Sponsored by NWO, STAR, WONDER, and FWO

NWO/STAR/WONDER/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 21–23, 2013 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 12th winter school are *Adjoint methods in computational finance* and *Mathematical behavioural finance*. These are the subjects of minicourses that will be taught by two distinguished speakers: Professor Mike Giles (Oxford University) and Professor Xunyu Zhou (Oxford University). Additionally there will be three one-hour lectures by Professors Pierre Collin-Dufresne (Columbia Business School and Swiss Finance Institute), Ronnie Sircar (Princeton University) and Agnès Sulem (Inria-Rocquencourt). Thirty-minute lectures on recent research work in The Netherlands and Belgium will be presented by Lech Grzelak (Rabobank), Alexander de Roode (Tilburg University), Marjon Ruijter (CWI, Amsterdam) and Kim Volders (Universiteit Antwerpen).

Auspices and sponsoring

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

- Center for Economic Research (CentER)
- STAR
- WONDER.

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. 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 euro 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, 2012.

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 21, from 10:30 to 11:30, and ends on Wednesday, January 23, at 16:00. The following events are planned:

Minicourses

Mike Giles
Adjoint methods for option pricing, Greeks and calibration using PDEs and SDEs

Xunyu Zhou
Mathematical behavioural finance

Special invited lectures

Pierre Collin-Dufresne
Insider trading, stochastic liquidity and equilibrium prices

Ronnie Sircar
Portfolio optimization and stochastic volatility asymptotics

Agnès Sulem
A stochastic control approach to duality methods in finance

Short contributions

Lech Grzelak
An equity-interest rate hybrid model with stochastic volatility and the interest rate smile

Alexander de Roode
Determinants of expected inflation in affine term structure models

Marjon Ruijter
2D-COS method for pricing financial options

Kim Volders
Stability and convergence analysis of discretizations of the Black-Scholes PDE with the linear boundary condition

Schedule of lectures

	Monday January 21	Tuesday January 22	Wednesday January 23
09:00 - 10:00		Giles	Giles
10:30 - 11:30		Giles	Giles
11:30 - 12:30	Giles	Zhou	Zhou
14:00 - 15:00			Zhou
15:00 - 16:00	Zhou	Zhou	Collin-Dufresne
16:00 - 17:00	Sircar	Sulem	
17:30 - 18:00	Grzelak	Ruijter	
18:00 - 18:30	de Roode	Volders	

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 Adjoint methods in computational finance

Mike Giles (Oxford University)

Adjoint methods for option pricing, Greeks and calibration using PDEs and SDEs

In computational finance it is very important to be able to compute the sensitivity of option prices to various input parameters. As well as being used to compute the so-called Greeks for risk hedging, they are also used for calibrating models to market prices.

Adjoint methods are a well-established mathematical approach for efficiently computing sensitivities when there are multiple input parameters, but only one output quantity. In this case, the computational cost is similar to the original pricing calculation, whereas the standard linear sensitivity approach would have a cost proportional to the number of inputs.

In this series of lectures, I will discuss the mathematical foundations for adjoints methods, concentrating on the discrete level, not the differential level (i.e. finite difference and recurrence equations, rather than PDEs) and the use of automatic differentiation software to generate the adjoint code. I will then discuss its application to both finite difference methods for PDEs, and Monte Carlo methods for SDEs.

1. Foundations
    - generic black-box approach
    - algorithmic differentiation
    - adjoints for higher-level linear algebra
    - automatic differentiation software
2. PDEs and finite difference methods: I
    - formulation of adjoint PDEs and finite difference methods
    - financial application
    - possible advantages for pricing calculation
    - FDE sensitivities for linear explicit discretisations
3. PDEs and finite difference methods: II
    - nonlinear implicit equations
    - what can go wrong?
    - calibration using Fokker-Planck discretisation
    - Greeks using Black-Scholes discretisation
    - local volatility example
4. SDEs and Monte Carlo methods: I
    - Monte Carlo simulation and augmented state
    - LRM and pathwise sensitivity approaches

- adjoint pathwise approach
- use of automatic differentiation software
- storage / re-computation tradeoff
- local volatility example, revisited

5. SDEs and Monte Carlo methods: II

   - multiple payoffs
   - binning and correlation Greeks
   - non-smooth payoffs

Mini-course on Mathematical behavioural finance

Xunyu Zhou (Oxford University)

Mathematical behavioural finance

This mini-course will cover the recent development of a rigorous mathematical treatment of behavioural finance, including the economic background, formulation of continuous-time behavioural portfolio choice models, Arrow-Debreu equilibrium and asset pricing, the quantile/distribution approach, and behavioural optimal stopping models.

Special invited lectures

Pierre Collin-Dufresne (Columbia Business School)

Insider trading, stochastic liquidity and equilibrium prices

We extend Kyle's (1985) model of insider trading to the case where liquidity provided by noise traders follows a general stochastic process. Even though the level of noise trading volatility is observable, in equilibrium, measured price impact is stochastic. If noise trading volatility is mean-reverting, then the equilibrium price follows a multivariate 'stochastic bridge' process, which displays stochastic volatility. This is because insiders choose to optimally wait to trade more aggressively when noise trading activity is higher. In equilibrium, market makers anticipate this, and adjust prices accordingly. More private information is revealed when volatility is higher. In time series, insiders trade more aggressively, when measured price impact is lower. Therefore, execution costs to uninformed traders can be higher when price impact is lower.

Ronnie Sircar (Princeton University)

Portfolio optimization and stochastic volatility asymptotics

We discuss the Merton portfolio optimization problem in the presence of stochastic volatility using asymptotic approximations when the volatility process is characterized by its time-scale of fluctuation. When volatility is fast mean-reverting, this is a singular perturbation problem for a nonlinear Hamilton-Jacobi-Bellman PDE, and when it slowly varying, it is a regular perturbation. These analyses can be combined for multiscale stochastic volatility models. The asymptotics shares remarkable similarities with the linear option pricing problem, using the properties of the Merton risk-tolerance function. We also discuss extensions that include transaction costs.

Agnès Sulem (Inria-Rocquencourt)

A stochastic control approach to duality methods in finance

A celebrated financial application of convex duality theory gives an explicit relation between the following two quantities:

(i) The optimal terminal wealth $X^*(T) := X_{\phi^*}(T)$ of the classical problem to maximise the expected U-utility of the terminal wealth $X_\phi(T)$ generated by admissible portfolios $\phi(t); 0 \leq t \leq T$ in a market with the risky asset price process modelled as a semimartingale;

(ii) The optimal scenario dQ^*/dP of the dual problem to minimise the expected V-value of dQ/dP over a family of equivalent local martingale measures Q. Here V is the convex dual function of the concave function U.

In this talk we consider markets modelled by Itô-Lévy processes, and we present a new approach to the above result in this setting, based on the maximum principle in stochastic control theory. An advantage with our approach is that it also gives an explicit relation between the optimal portfolio ϕ^* and the optimal scenario Q^*, in terms of backward stochastic differential equations. This is used to obtain a general formula for the optimal portfolio ϕ^* in terms of the Malliavin derivative. We illustrate the results with explicit examples. (Joint work with Bernt Øksendal)

Short contributions

Lech Grzelak (Rabobank)

An equity-interest rate hybrid model with stochastic volatility and the interest rate smile

In this presentation define an equity-interest rate hybrid model in which the equity part is driven by the Heston stochastic volatility Heston [1993], and the interest rate (IR) is generated by the displaced-diffusion stochastic volatility Libor Market Model Andersen and Andreasen [2002]. We assume a non-zero correlation between the main processes. A number of approximations leads to an approximating model which falls within the class of affine processes Duffie et al. [2000], for which we then provide the corresponding forward characteristic function. By using the appropriate change of measure and freezing of the Libor rates the dimension of the corresponding pricing PDE can be greatly reduced. We discuss in detail the accuracy of the approximations and the efficient calibration. Finally, by experiments, we show the effect of the correlations and interest rate smile/skew on typical equity-interest rate hybrid product prices. For a whole strip of strikes this approximate hybrid model can be evaluated for equity plain vanilla options in just milliseconds.

Alexander de Roode (Tilburg University)

Determinants of expected inflation in affine term structure models

Breakeven inflation is observable in financial markets with traded inflation-linked securities. However, the inflation risk premium and expected inflation cannot be directly obtained from the breakeven inflation without a structural model. Affine term structures models have been widely used in the literature on real interest rates to identify expected inflation. Most studies conjecture that expected inflation is largely determined by the Consumer price inflation due to the contractual agreements of inflation-linked securities. Other inflation measures may determine expected inflation as well. This paper answers the question whether these factors have an empirical relation to inflation in affine term structure models.

Our affine term structure model is estimated using a minimum Chi-squared methodology instead of a maximum likelihood estimation. Although this approach is asymptotically equivalent to MLE, it can reduce computational issues.

Marjon Ruijter (CWI, Amsterdam)

2D-COS method for pricing financial options

The COS method for pricing European and Bermudan options with one underlying asset was developed by Fang and Oosterlee (2008, 2009). We extend the method to higher dimensions, with a multi-dimensional asset price process. The algorithm can be applied to, for example, pricing two-color rainbow options, but also to pricing under the Heston stochastic volatility model. For smooth density functions, the method converges exponentially in the number of terms in the Fourier cosine series summations.

Kim Volders (Universiteit Antwerpen)

Stability and convergence analysis of discretizations of the Black-Scholes PDE with the linear boundary condition

We consider the stability and convergence of numerical discretizations of the Black-Scholes partial differential equation (PDE) when complemented with the popular linear boundary condition. This condition states that the second derivative of the option value vanishes when the underlying asset price gets large and is often applied in the actual numerical solution of PDEs in finance. To our knowledge, the only theoretical stability result in the literature up to now pertinent to the linear boundary condition has been obtained by Windcliff, Forsyth and Vetzal (2004), who showed that for a common discretization a necessary eigenvalue condition for stability holds. In this presentation, we shall present sufficient conditions for stability and convergence when the linear boundary condition is employed. We deal with finite difference discretizations in the spatial (asset) variable and a subsequent implicit discretization in time. As a main result we prove that even though the maximum norm of $\exp(tM)$ $(t \geq 0)$ can grow with the dimension of the semidiscrete matrix M, this generally does not impair the convergence behavior of the numerical discretizations. Our theoretical results are illustrated by numerical experiments.

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 21 and 22, 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)
industry professional	€1650	€1900
full-time academic	€375	€425

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, 2013.

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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12th Winter School on Mathematical Finance

Lunteren, January 21–23, 2013

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, 2013* to:

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