NWO/STAR/PWN

18th Winter School on Mathematical Finance

Special topics:

Rough volatility

Long term investments

January 21–23, 2019
Congrescentrum De Werelt, Lunteren

Sponsored by NWO, STAR, PWN, and FWO

NWO/STAR/PWN
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 has increased rapidly. In this context, the winter school on Mathematical Finance that will take place on January 21–23, 2019 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 18th winter school are *Rough volatility*, and *Long term investments*. These are the subjects of minicourses that will be taught by two distinguished speakers: Professors Jim Gatheral (The City University of New York) and Paolo Guasoni (Dublin City University). Additionally there will be three one-hour special invited lectures by Professors Jean-Philippe Bouchaud (Capital Fund Management and Académie des Sciences, Paris), Stéphane Crépey (Université d'Évry), and Roger Lord (Cardano). Thirty-minute lectures on recent research work in the Netherlands will be presented by Misha van Beek (BlackRock NY and University of Amsterdam), Anastasia Borovykh (CWI, Amsterdam), Rogier Quaedvlieg (Erasmus University Rotterdam) and Shuaiqiang Liu (Delft University of Technology).

Auspices, sponsoring and grants

The Winter School takes place under the auspices of the mathematics cluster STAR and of PWN. The stochastics groups of the mathematics departments of the universities in The Netherlands cooperate in STAR. PWN (Platform Wiskunde Nederland) is a national organization that aims to strengthen the position of mathematics in The Netherlands in all its aspects. The winter school is supported financially by STAR, PWN, 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 University of Amsterdam.

The FWO WOG research network Stochastic Modelling with applications in financial markets has made available a limited number of grants for young researchers (PhD students and postdocs) associated to the network to be used as a waiver of the registration fee for the winter school. For those researchers the grants completely cover the registration fee. For other young researchers a limited number of grants of € 250 each is available 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 (information about network members can be obtained from the institutional membership list), but others are invited to apply as well. Applications for the grant can be sent by email to both Michel Vellekoop 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. Applications should be submitted before the deadline, November 20, 2018.

Organizers

The winter school is organized by:

Michel Vellekoop (Faculty Economics and Business, University of Amsterdam; tel. +31 20 5254210, e-mail m.h.vellekoop@uva.nl)

Peter Spreij (Korteweg–De Vries Institute for Mathematics, University of Amsterdam and IMAPP, Radboud University; tel. +31 20 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

Jim Gatheral
Rough volatility

Paolo Guasoni
Long term investments

Special invited lectures

Jean-Philippe Bouchaud
Market impact: a review

Stéphane Crépey
When capital is a funding source: the XVA anticipated BSDEs

Roger Lord
Optimal contours and controls in semi-analytical option pricing revisited

Short contributions

Misha van Beek
Conditional scenario generation

Anastasia Borovykh
Pricing Bermudan options under local Lévy models with default

Shuaiqiang Liu
Pricing options and computing implied volatilities using artificial neural networks

Rogier Quaedvlieg
Realized semicovariances: Looking for signs of direction inside the covariance matrix

Website

https://staff.fnwi.uva.nl/p.j.c.spreij/winterschool/winterschool.html

Schedule of lectures

	Monday January 21	Tuesday January 22	Wednesday January 23
09:00 - 10:00		Gatheral	Gatheral
10:30 - 11:30		Gatheral	Gatheral
11:30 - 12:30	Gatheral	Lord	Guasoni
14:00 - 15:00			Guasoni
15:00 - 16:00	Guasoni	Guasoni	Crépey
16:00 - 17:00	Bouchaud	Guasoni	
17:30 - 18:00	Van Beek	Quaedvlieg	
18:00 - 18:30	Borovykh	Liu	

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 `https://dewerelt.nl/en/` (under ABOUT US).

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 Rough volatility

Jim Gatheral (The City University of New York)

Rough volatility

The scaling properties of historical volatility time series, which now appear to be universal, together with the scaling properties of implied volatility smiles, motivate a new class of stochastic volatility models where paths of volatility are rougher than those of Brownian motion. Rough volatility connects the microstructure of financial markets with the large-scale behavior of volatility as encoded in the implied volatility surface. Rough volatility models are typically very parsimonious yet are in remarkable agreement with both econometric data and option prices. Practical applications include efficient forecasting of future integrated variance and option pricing.

This mini-course will include the following topics:

- Scaling properties of the time series of historical volatility
- Estimation of H
- Volatility forecasting
- The volatility surface: Stylized facts
- The rough Bergomi model
- Relating historical and implied model parameters
- The rough Heston model
- The hybrid BSS scheme
- Diamonds and the Exponentiation Theorem
- Calibration of model parameters

References:

1. Elisa Alòs, Jim Gatheral, and Radoš Radoičić, Exponentiation of conditional expectations under stochastic volatility, `https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2983180`, (2017).
2. Christian Bayer, Peter Friz and Jim Gatheral, Pricing under rough volatility, Quantitative Finance 16(6), 887-904, (2016).
3. Mikkel Bennedsen, Asger Lunde, and Mikko S. Pakkanen, Hybrid scheme for Brownian semistationary processes, Finance and Stochastics 21(4), 931-965, (2017).
4. Mikkel Bennedsen, Asger Lunde, and Mikko S. Pakkanen, Decoupling the short-and long-term behavior of stochastic volatility, `https://arxiv.org/abs/1610.00332`, (2016).
5. Omar El Euch and Mathieu Rosenbaum, The characteristic function of rough Heston models, Mathematical Finance, `https://onlinelibrary.wiley.com/doi/10.1111/mafi.12173`, (2018).

6. Jim Gatheral, Thibault Jaisson, and Mathieu Rosenbaum, Volatility is rough, Quantitative Finance 18(6), 933–949, (2018).

7. Jim Gatheral and Martin Keller-Ressel, Affine forward variance models, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3105387, (2017).

8. Jim Gatheral and Radoš Radoičić, Rational approximation of the rough Heston solution, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3191578, (2018).

9. Antoine Jacquier, Claude Martini, and Aitor Muguruza, On VIX Futures in the rough Bergomi model, Quantitative Finance 18(1), 45–61, (2018).

Minicourse on Long term investments

Paolo Guasoni (Dublin City University)

Long term investments

Individuals planning for retirement and institutions investing for present and future generations face significantly different risks than short or medium term investors with only a few years' horizons. This minicourse will explore the challenges of investing and spending over a long horizon in the presence of (i) fluctuating investment opportunities; (ii) reliance on the steady spending levels, i.e., loss aversion; (iii) aging and health spending; and (iv) permanent vs. temporary wealth shocks.

Fluctuations in investment opportunities involve both variations in interest rates and in risk premia of asset classes. Such variations imply that a long run investor does not make investment decisions merely on the prospect of the immediate return and risk of an asset, but also in relation to the assets' own covariations with shocks in investment opportunities. We discuss the mathematical techniques that make such models tractable and their resulting intuition and implications for asset pricing.

Reliance on steady spending is typical of university endowments, sovereign funds, and other foundations that fund long-term commitments that cannot be easily reduced before their original schedule. Family offices and trust funds may also face similar challenges. For such investors, it is critical to design and finance a spending schedule that is significantly less volatile than wealth, even if this means that spending must be significantly lower in earlier times. We see how to embed such a preferences in a dynamic optimization problem, and how to derive rational and self-financed spending policies and their investment counterparts.

Health expenses rise significantly in retirement and are different from other forms of consumption - they do not generate utility per se, but rather help reducing mortality, thereby increasing lifetimes. We solve a model of investment, consumption, and healthcare spending in the presence of aging, with mortality increasing according to the Gompertz' law, and healthcare partially reducing mortality growth. While portfolio composition is insensitive to aging, the composition of expenditures markedly shifts toward health expenses in time of retirement.

Some asset classes entail exposure to shocks that gradually recede over time, in contrast to the permanent risks that are assumed in most standard models. We discuss how portfolio choice intuition changes for such asset classes, and the preference restrictions that lead to a the different treatment of non-permanent shocks. We conclude with a summary of results and an overview of open questions and applications.

Special invited lectures

Jean-Philippe Bouchaud (Capital Fund Management and Académie des Sciences, Paris)

Market impact: a review

Price impact refers to the correlation between an incoming order (to buy or to sell) and the subsequent price change. That a buy (sell) trade should push the price up (down) is intuitively obvious and is easily demonstrated empirically. Such a mechanism must, in fact, be present for private information to be incorporated into market prices. But it is also a sore reality for trading firms for which price impact induces large (but often overlooked) extra costs. Monitoring and controlling impact has therefore become one of the most active domains of research in quantitative finance since the mid-nineties. A large amount of empirical results has accumulated over the years concerning the dependence of impact on traded quantities, the time evolution of impact, the impact of metaorders, cross-impact, etc. In this lecture, I will present some of the most salient empirical findings, and a variety of theoretical ideas that have been proposed to rationalise them. Some remaining puzzles and open problems will be discussed as well.

Stéphane Crépey (Université d'Évry)

When capital is a funding source: the XVA anticipated BSDEs

XVAs refer to various financial derivative pricing adjustments accounting for counterparty risk (CVA) and its funding (FVA) and capital (KVA) implications for a bank. We show that the XVA equations are well posed, including in the realistic case where capital (including capital at risk) is deemed fungible as a source of funding for variation margin. This intertwining of capital at risk and FVA, added to the fact that the KVA is part of capital at risk, lead to a system of anticipated McKean BSDEs (ABSDEs) for the FVA and the KVA, with coefficients entailing a conditional risk measure of the one-year-ahead increment of the martingale part of the FVA. We first consider the resulting XVA ABSDEs in the case of a hypothetical bank without debt. In the practical case of a defaultable bank, the XVA ABSDEs, which are stopped before the default of the bank, are solved by reduction to a reference stochastic basis, corresponding to the pricing model used by the base (as opposed to XVA) traders of the bank. This reduction methodology, which is of independent interest, generalizes several previous default intensity pricing formulas in the credit risk literature. The FVA reduction provided by the use of capital as a funding source is found very significant numerically, as high as one half or more on a real banking (uncollateralized) portfolio.

Roger Lord (Cardano)

Optimal contours and controls in semi-analytical option pricing revisited

For models with analytically available characteristic functions, Fourier inversion is an important computational method for a fast and accurate calculation of plain vanilla option prices. To improve the numerical stability of the inversion, Lord and Kahl [2007] suggested a method to find an optimal contour of integration. Joshi and Yang [2011] built on Andersen and Andreasen?s [2002] suggestion, and used the Black-Scholes formula as a control variate. This presentation gives an overview of work done in this area, and shows new work on the effectiveness of combining controls and contours. Joint work with Christian Kahl.

Short contributions

Misha van Beek (BlackRock NY and University of Amsterdam)

Conditional scenario generation

Scenario generation is an integral part of financial economics, and often relies on Monte-Carlo simulation. However, many application require conditional paths rather than unconditional simulation. For example, in policy analysis a central bank is interested in future scenarios conditional on a certain policy implementation. In stress testing, banks and insurers want to know future paths conditional on an impending recession. In portfolio construction, portfolio managers look to construct portfolios conditional on analyst views of certain assets. In this talk I bring together macro-economic models and factor models of asset returns in a common framework, and show how to derive analytical distributions of future macro-economic variables and asset returns, conditional on any set of views about the future of the economy, factor returns or asset returns. I show that the framework is a multi-period, multi-factor, macro-informed generalization of the Black-Litterman model.

Anastasia Borovykh (CWI, Amsterdam)

Pricing Bermudan options under local Lévy models with default

In this presentation we will discuss an efficient method for pricing Bermudan options under a so-called local Lévy model. We consider a defaultable asset whose risk-neutral pricing dynamics are described by an exponential Lévy-type martingale. This class of models allows for a local volatility, local default intensity and a locally dependent Lévy measure, therefore being a very flexible framework for modelling asset dynamics. We present a pricing method for Bermudan options based on an analytical approximation of the characteristic function combined with the COS method. Due to a special form of the obtained characteristic function the price can be computed using a fast Fourier transform-based algorithm resulting in a fast and accurate calculation.

Shuaiqiang Liu (Delft University of Technology)

Pricing options and computing implied volatilities using artificial neural networks

We proposed a data-driven approach, by means of an Artificial Neural Network (ANN), to value financial options and calculate implied volatilities with the aim of accelerating the corresponding numerical methods. In order to solve advanced financial asset models, different numerical methods have been developed, e.g. finite differences PDE techniques, Fourier methods and Monte Carlo simulation. However, fast and efficient computation is increasingly important, especially in the case of model calibration or financial risk management. It is well-known that ANNs are powerful universal function approximators without assuming any mathematical form. Recent advances in data science have shown that by deep learning techniques even highly nonlinear multi-dimensional functions can be accurately represented. Besides, training an ANN is expensive, but running the trained ANN is cheap. Based on the above facts, we develop an ANN solver under a unified data-driven frame to further speed up the computation of the solution to an asset model. More precisely, an 'ANN solver' is typically decomposed into two separate phases, a training phase and a testing (or prediction) phase. During the training phase, the ANN 'learns' the existed solver, which is usually time consuming, however, it will be done once and off-line. During the testing phase, the trained ANN delivers the derivative prices or other quantities highly efficiently and can be employed as an agent of the original solver in practice. We test this approach on different types of solvers, including the analytic solution for the Black-Scholes equation, the COS method for the Heston stochastic volatility model and the iterative root-finding method for the calculation of implied volatilities. The numerical results show that the ANN solver can reduce the computing time significantly.

Rogier Quaedvlieg (Erasmus University Rotterdam)

Realized semicovariances: Looking for signs of direction inside the covariance matrix

We propose a new decomposition of the realized covariance matrix into four 'realized semicovariance' components based on the signs of the underlying high-frequency returns. We derive the asymptotic distribution for the different components under the assumption of a continuous multivariate semimartingale and standard infill asymptotic arguments. Based on high-frequency returns for a large cross-section of individual stocks, we document distinctly different features and dynamic dependencies in the different semicovariance components. We demonstrate that the accuracy of portfolio return variance forecasts may be significantly improved by exploiting these differences and 'looking inside' the realized covariance matrices for signs of direction. Joint work with Tim Bollerslev and Andrew Patton.

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 https://staff.fnwi.uva.nl/p.j.c.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 transfer 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, 2019.

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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for easier online registration:

https://staff.fnwi.uva.nl/p.j.c.spreij/winterschool/winterschool.html

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, 2019* to:

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