Program

SIAM Conference on Financial Mathematics & Engineering

Sponsored by the SIAM Activity Group on Financial Mathematics and Engineering.

The Activity Group on Financial Mathematics and Engineering focuses on research and practice in financial mathematics, computation, and engineering. Its goals are to foster collaborations among mathematical scientists, statisticians, computer scientists, computational scientists, and researchers and practitioners in finance and economics, and to foster collaborations in the use of mathematical and computational tools in quantitative finance in the public and private sector. The activity group promotes and facilitates the development of financial mathematics and engineering as an academic discipline.

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Sebastian Jaimungal
University of Toronto, Canada

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McMaster University, Canada

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Northwestern University, U.S.

Harvey Stein
Bloomberg LP, U.S.

Conference Themes

Algorithmic Trading
Behavioral Finance
Commodity Markets
Computational Finance
Credit Risk
Financial Technology
Insurance
Machine Learning
Market Microstructure
Mean Field Games
Model Risk and Uncertainty
Optimal Stopping
Optimal Transport
Option Pricing and Hedging
Regulations and Finance
Risk Measures
Robust Finance
Statistical Finance
Stochastic Control
Stochastic Games
Stochastic Volatility
Systemic Risk

SIAM Registration Desk

The SIAM registration desk is located in the Myhal Atrium, Myhal Centre for Engineering Innovation and Entrepreneurship, University of Toronto. It is open during the following hours:

Tuesday, June 4
7:30 a.m. - 5:30 p.m.

Wednesday, June 5
8:00 a.m. - 6:45 p.m.

Thursday, June 6
8:00 a.m. - 6:30 p.m.

Friday, June 7
8:00 a.m. - 1:30 p.m.

All sessions are being held at the University of Toronto

June 4, 6:40 p.m. – 8:40 p.m.

Networking/Welcome Reception and Poster Session are being held at:

Fields Atrium, Fields Institute for Research in Mathematical Sciences
222 College Street, Toronto, Ontario, M5T 3J1, Canada

June 4-7, Conference sessions are being held at:

Myhal Centre for Engineering Innovation and Entrepreneurship
55 St. George Street, Toronto, Ontario, M5S 0C9, Canada

Child Care

Tourism Toronto recommends Babysitting Angels and Care.com for attendees interested in child care services. Care.com provides a web-based resource to connect individuals with vetted babysitters and nannies. Attendees are responsible for making their own child care arrangements.

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SIAM corporate members provide their employees with knowledge about, access to, and contacts in the applied mathematics and computational sciences community through their membership benefits. Corporate membership is more than just a bundle of tangible products and services; it is an expression of support for SIAM and its programs. SIAM is pleased to acknowledge its corporate members and sponsors. In recognition of their support, non-member attendees who are employed by the following organizations are entitled to the SIAM member registration rate.

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Funding Agency

SIAM and the Conference Organizing Committee wish to extend their thanks and appreciation to the U.S. National Science Foundation for its support of this conference.

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If you are a SIAM member, it only costs $15 to join the SIAM Activity Group on Financial Mathematics and Engineering (SIAG/FME). As a SIAG/FME member, you are eligible for an additional $15 discount on this conference, so if you paid the SIAM member rate to attend the conference, you might be eligible for a free SIAG/FME membership. Check at the registration desk.

Students who paid the Student Non-Member Rate will be automatically enrolled as SIAM Student Members. Please go to *my.siam.org* to update your education and contact information in your profile. If you attend a SIAM Academic Member Institution or are part of a SIAM Student Chapter you will be able to renew next year for free.

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SIAM does not provide computers for any speaker. When giving an electronic presentation, speakers must provide their own computers. SIAM is not responsible for the safety and security of speakers' computers.

A data (LCD) projector and screen will be provided in all technical session meeting rooms. The data projectors support both VGA and HDMI connections. Presenters requiring an alternate connection must provide their own adaptor.

Internet Access

The University of Toronto Myhal Centre for Engineering Innovation & Entrepreneurship offers wireless internet access to attendees in the public space and classrooms at no additional charge.

Registration Fee Includes

Admission to all technical sessions

Business Meeting (open to SIAG/FME members)

Coffee breaks daily

Room set-ups and audio/visual equipment

Networking/Welcome Reception and Poster Session

Job Postings

Please check *https://jobs.siam.org/* regarding the availability of job postings.

Poster Participant Information

The poster session is scheduled for Tuesday, June 4 from 6:40 p.m. to 8:40 p.m. Poster presenters must set-up their poster material (with the Velcro provided) on the 3' x 6' poster boards in the Fields Atrium on June 4 between the hours of 5:00 p.m. and 6:30 p.m. All materials must be posted by Tuesday, June 4, 6:40 p.m., the official start time of the session. **Posters must be removed at the end of the session by 8:40 p.m.**

SIAM Books and Journals

Please stop by the SIAM books table to browse and purchase our selection of textbooks and monographs. Enjoy discounted prices and free shipping. Complimentary copies of selected SIAM journals are available, as well. The books booth will be staffed from 9:00 a.m. through 5:00 p.m. Tuesday, Wednesday and Thursday. The books table will not be open Friday, but the Titles on Display list will be available to facilitate online and phone orders using the conference discount.

Table Top Displays

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Comments?

Comments about SIAM meetings are encouraged! Please send to:

Cynthia Phillips, SIAM Vice President for Programs (vpp@siam.org).

Get-togethers

Tuesday, June 4

Networking/Welcome Reception and Poster Session

6:40 p.m. – 8:40 p.m.

Fields Atrium, Fields Institute for Research in Mathematical Sciences, University of Toronto

Thursday, June 6

Business Meeting (open to SIAG/FME members)

7:00 p.m. – 8:00 p.m.

Myhal Auditorium, Myhal Centre for Engineering Innovation and Entrepreneurship, University of Toronto

Complimentary refreshments will be served.

Statement on Inclusiveness

As a professional society, SIAM is committed to providing an inclusive climate that encourages the open expression and exchange of ideas, that is free from all forms of discrimination, harassment, and retaliation, and that is welcoming and comfortable to all members and to those who participate in its activities. In pursuit of that commitment, SIAM is dedicated to the philosophy of equality of opportunity and treatment for all participants regardless of gender, gender identity or expression, sexual orientation, race, color, national or ethnic origin, religion or religious belief, age, marital status, disabilities, veteran status, field of expertise, or any other reason not related to scientific merit. This philosophy extends from SIAM conferences, to its publications, and to its governing structures and bodies. We expect all members of SIAM and participants in SIAM activities to work towards this commitment.

Please Note

SIAM is not responsible for the safety and security of attendees' computers. Do not leave your laptop computers unattended. Please remember to turn off your cell phones, pagers, etc. during sessions.

Recording of Presentations

Audio and video recording of presentations at SIAM meetings is prohibited without the written permission of the presenter and SIAM.

Social Media

SIAM is promoting the use of social media, such as Facebook and Twitter, to enhance scientific discussion at its meetings and enable attendees to connect with each other prior to, during and after conferences. If you are tweeting about a conference, please use the designated hashtag to enable other attendees to keep up with the Twitter conversation and to allow better archiving of our conference discussions. The hashtag for this meeting is #SIAMFM19.

SIAM's Twitter handle is @TheSIAMNews.

Changes to the Printed Program

The printed program was current at the time of printing, however, please review the online program schedule (*http://meetings.siam.org/program.cfm?CONFCODE=FM19*) for up-to-date information.

Invited Plenary Speakers

*** All Invited Plenary Presentations will take place in the Myhal Auditorium, Myhal Centre for Engineering Innovation and Entrepreneurship, University of Toronto***

Tuesday, June 4

11:10 a.m. - 11:55 a.m.

IP1 Market Microstructure Invariance: A Dynamic Equilibrium Model
Albert S. Kyle, *University of Maryland, U.S.*

5:40 p.m. - 6:25 p.m.

IP2 Latency in Electronic Markets
Alvaro Cartea, *University of Oxford, United Kingdom*

Wednesday, June 5

11:15 a.m. - 12:00 p.m.

IP3 Reservoir Computing, Rough Paths and Learning of Stochastic Dynamics in Finance
Josef Teichmann, *ETH Zürich, Switzerland*

6:15 p.m. - 7:00 p.m.

IP4 Managing the Libor Transition: A Quant Perspective
Fabio Mercurio, *Bloomberg LP, U.S.*

Thursday, June 6

11:00 a.m. - 11:45 a.m.

IP5 On Fairness of Systemic Risk Measures
Jean-Pierre Fouque, *University of California, Santa Barbara, U.S.*

6:00 p.m. - 6:45 p.m.

IP6 New Trends in Optimal Execution
Charles-Albert Lehalle, *Capital Fund Management, France*

Friday, June 7

11:00 a.m. - 11:45 a.m.

IP7 Rough Covariance Modeling
Christa Cuchiero, *University of Vienna, Austria*

6:00 p.m. - 6:45 p.m.

IP8 Diamond Trees, Forests, and the Exponentiation Theorem
Jim Gatheral, *City University of New York, Baruch College, U.S.*

Minitutorials

Tuesday, June 4

8:30 a.m. - 10:30 a.m.

MT1 Machine Learning in Finance

Organizer and speaker: Peter Cotton, *JP Morgan, U.S.*

Myhal Auditorium (Room 150)

MT2 Monte Carlo Methods for Tail Risks

Organizer and Speaker: Emmanuel Gobet, *École Polytechnique, France*

Room 360

Prize Presentations

*** All Prize Presentations will take place in in the Myhal Auditorium, Myhal Centre for Engineering Innovation and Entrepreneurship, University of Toronto***

Wednesday, June 5

11:00 a.m. - 11:15 a.m.

SIAG/FME Early Career Prize Ceremony

Mykhaylo Shkolnikov, *Princeton University, U.S.*

and

Daniel Lacker, *Columbia University, U.S.*

Friday, June 7

11:45 a.m. - 1:15 p.m.

SIAG/FME Conference Paper Prize Session

Winners will be announced at the conclusion of the session.

SIAM Activity Group on Financial Mathematics and Engineering (SIAG/FM)

www.siam.org/Activity-Groups/FM

A great way to get involved!

Collaborate and interact with mathematical scientists, statisticians, computer scientists, computational scientists, and researchers and practitioners in finance and economics, to foster the use of mathematical and computational tools in quantitative finance in the public and private sector.

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ACTIVITIES INCLUDE

- Special sessions at SIAM Annual Meetings
- Biennial conference
- SIAG/FM Early Career Prize
- SIAG/FM Conference Paper Prize
- SIAM Presents features FM prize lecture, invited speakers, and select minisymposia online
- Wiki

BENEFITS OF SIAG/FM MEMBERSHIP

- Listing in the SIAG's online membership directory
- Additional discount on registration at the SIAM Conference on Financial Mathematics and Engineering (excludes student)
- Electronic communications about recent developments in your specialty
- Eligibility for candidacy for SIAG/FM office
- Participation in the selection of SIAG/FM officers

ELIGIBILITY

- Be a current SIAM member.

COST

- $15 per year
- Student members can join two activity groups for free!

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Program Director: Agostino Capponi, *Columbia University*
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SIAM Conference on Financial Mathematics & Engineering

Tuesday, June 4

Registration

7:30 a.m.-5:30 p.m.

Room: Myhal Atrium

Tuesday, June 4

MT1

Machine Learning in Finance

8:30 a.m.-10:30 a.m.

Room: Myhal Auditorium (Room 150)

Machine learning (ML) is changing virtually every aspect of our lives. Today ML algorithms accomplish tasks that until recently only expert humans could perform. As it relates to finance, this is the most exciting time to adopt a disruptive technology that will transform how everyone invests for generations. This tutorial explains scientifically sound ML tools that are used by some of the largest asset managers.

Organizer and Speaker:
Peter Cotton, J. P. Morgan, U.S.

Tuesday, June 4

MT2

Monte Carlo Methods for Tail Risks

8:30 a.m.-10:30 a.m.

Room: Room 360

In the last twenty years, frequently updated risk management methodologies are implemented in banks with the concern of better analyzing and managing financial risks of different types. These risks are usually modeled with high-dimensional variables and explicit computations of risk metrics are simply impossible. Then we have to resort with numerical methods, like Monte Carlo methods. However, naive MC methods may be inefficient since we deal with the tails of distributions, some events have very small probabilities, risky quantities may be nested, parameters are uncertain. In this short lecture, I will give an overview of different Monte Carlo methods that can be used to address these issues: importance sampling, MCMC, multilevel splitting, stochastic approximations, multilevel Monte Carlo methods, regression Monte Carlo... these techniques will be presented in general and illustrated on some relevant examples.

Organizer and Speaker:
Emmanuel Gobet, Ecole Polytechnique, France

Tuesday, June 4

CP1

Stochastic Simulation and Estimation

8:30 a.m.-10:30 a.m.

Room: Room 315

Chair: Alex Shkolnik, University of California, Santa Barbara, U.S.

8:30-8:55 Parameter Estimation of Affine Term Structure
Samyukta Venkataramanan and Dr Stephen O'Sullivan, Technological University Dublin, Ireland

9:00-9:25 Conditional Monte Carlo Methods under Stochastic Volatility Models
Ioannis Kyriakou, Cass Business School, London, United Kingdom; Gianluca Fusai, Cass Business School, United Kingdom and Università degli Studi del Piemonte Orientale, Italy; Riccardo Brignone, Universita degli Studi di Milano-Bicocca, Italy

9:30-9:55 Multi-Level Monte-Carlo Methods and Primal/Dual Estimates in Initial Margin Computations
Stefano De Marco, Florian Bourgey, and Emmanuel Gobet, Ecole Polytechnique, France; Alexandre Zhou, Université Paris-Est, France

10:00-10:25 Exact Importance Sampling of Affine Processes
Alex Shkolnik and *Brennan Hall*, University of California, Santa Barbara, U.S.

Tuesday, June 4

CP2

Financial Econometerics

8:30 a.m.-10:30 a.m.

Room: Room 330

Chair: Thomas Kokholm, Aarhus University, Denmark

8:30-8:55 A Closed Formula for Illiquid Corporate Bonds and an Application to the European Market
Roberto Baviera, Politecnico di Milano, Italy; Aldo Nassigh, Unicredit SpA, Italy; Emanuele Nastasi, Politecnico di Milano, Italy

9:00-9:25 Detecting Long-Range Dependence in Financial Time Series
Manveer K. Mangat and Erhard Reschenhofer, University of Vienna, Austria

9:30-9:55 Probability Space of Regression Models and its Applications to Financial Time Series
Vladimir S. Ladyzhets, University of Connecticut, U.S.

10:00-10:25 Shock Waves and Golden Shores: The Asymmetric Interaction Between Gold Prices and the Stock Market
Thomas Kokholm and Alice Buccioli, Aarhus University, Denmark

Tuesday, June 4

CP3

Portfolio Selection and Credit Contagion

8:30 a.m.-10:30 a.m.

Room: Room 380

Chair: Andrea Fontanari, Delft University of Technology, Netherlands

8:30-8:55 Portfolio Risk and the Quantum Majorization of Correlation Matrices
Andrea Fontanari, Delft University of Technology, Netherlands

9:00-9:25 Bayesian Uncertainty Quantification of Local Volatility
Kai Yin, Case Western Reserve University, U.S.

9:30-9:55 A Closed Form Solution to the Markowitz Portfolio Problem
Alex Bernstein, University of California, Santa Barbara, U.S.

10:00-10:25 Contagious Defaults in a Credit Portfolio: A Bayesian Network Approach
Ioannis Anagnostou, University of Amsterdam and ING Bank, The Netherlands

Coffee Break

10:30 a.m.-11:00 a.m.

Room: Myhal Atrium

Welcome Remarks

11:00 a.m.-11:10 a.m.

Room: Myhal Auditorium (Room 150)

Tuesday, June 4

IP1

Market Microstructure Invariance: A Dynamic Equilibrium Model

11:10 a.m.-11:55 a.m.

Room: Myhal Auditorium (Room 150)

Chair: Agostino Capponi, Columbia University, U.S.

Invariance relationships are derived in a dynamic, infinite-horizon, equilibrium model of adverse selection with risk-neutral informed traders, noise traders, risk-neutral market makers, and endogenous information production. Scaling laws for bet size and transaction costs require the assumption that the effort required to generate one bet does not vary across securities and time. Scaling laws for pricing accuracy and market resiliency require the additional assumption that private information has the same signal-to-noise ratio across markets. Prices follow a martingale with endogenously derived stochastic volatility. Returns volatility, pricing accuracy, market depth, and market resiliency are closely related to one another. The model solution depends on two state variables: stock price and hard-to- observe pricing accuracy. Invariance makes predictions operational by expressing them in terms of log-linear functions of easily observable variables such as price, volume, and volatility.

Albert S. Kyle
University of Maryland, U.S.

Lunch Break

11:55 a.m.-1:25 p.m.

Attendees on own

Tuesday, June 4

Industrial MS1: Derivativates Valuation and Risk Management

1:25 p.m.-2:55 p.m.

Room: Myhal Auditorium (Room 150)

Industrial MS2: Advances in Machine Learning and Systemic Risk

1:25 p.m.-2:55 p.m.

Room: Room 360

Coffee Break

2:55 p.m.-3:25 p.m.

Room: Myhal Atrium

Tuesday, June 4

PD1

Panel on Systemic Risk and Financial Stability

3:25 p.m.-4:25 p.m.

Room: Myhal Auditorium (Room 150)

Intermission

4:25 p.m.-4:40 p.m.

Tuesday, June 4

PD2

Panel on Fin Tech and AI

4:40 p.m.-5:40 p.m.

Room: Myhal Auditorium (Room 150)

Tuesday, June 4

IP2

Latency in Electronic Markets

5:40 p.m.-6:25 p.m.

Room: Myhal Auditorium (Room 150)

Chair: Matheus R. Grasselli, McMaster University, Canada

Latency is the time delay between an exchange streaming market data to a trader, the trader processing information and deciding to trade, and the exchange receiving the order from the trader. Liquidity takers face a stochastic moving target problem as a consequence of their latency. They send market orders with a limit price that aim at a price and quantity they observed in the limit order book (LOB), and by the time their order is processed, prices could have worsened, so the order may not be filled, or prices could have improved, so the order is filled at a better price. We provide two modelling approaches to include latency in optimal trading for liquidity takers, compute the costs of improving the marksmanship of liquidity taking strategies, and show the tradeoff between execution certainty and the costs of reducing the adverse effects of latency. In our first approach, a trader targets a fill ratio and minimises the cost of walking the LOB. We derive the optimal strategy in closed-form and employ a proprietary data set to compute the shadow price of latency in FX markets. In our second approach, we employ marked point processes to model the interaction of a trader with the LOB when there is latency. We employ a variational analysis approach to derive optimal strategies, characterise them as solutions of a new class of FBSDEs, prove uniqueness and existence of the FBSDEs, and for particular examples, solve them numerically.

Alvaro Cartea
University of Oxford, United Kingdom

Intermission

6:25 p.m.-6:40 p.m.

Tuesday, June 4

PP1

Networking/Welcome Reception and Poster Session

6:40 p.m.-8:40 p.m.

Room: Fields Atrium, Fields Institute

Xva Principles, Nested Monte Carlo Strategies, and GPU Optimizations
Lokman Abbas Turki and Babacar Diallo, Laboratoire de Probabilités, Statistique et Modélisation (LPSM), France; Stephane Crepey, Evry University, France

Optimal Timing of Investments and Divestment Associated with Perpetual American Options in a Levy Market
Ini Adinya, University of Ibadan, Nigeria

Operator Splitting Schemes for the Two-Asset Merton Jump-Diffusion Model
Lynn Boen and Karel In 't Hout, University of Antwerp, Belgium

A Penalty-Like Method for CVA Calculation by a PDE Model
Yuwei Chen and Christina Christara, University of Toronto, Canada

Semi-Analytical Prices for Lookback and Barrier Options under the Heston Model
Luca De Gennaro Aquino, Grenoble Ecole de Management, France; Carole Bernard, VU Brussel, Belgium and Grenoble EM, France

Price Discovery in a Mean-Field Game of Optimal Execution
Lucas Farias, FGV, Brazil; David Evangelista, King Abdullah University of Science & Technology (KAUST), Saudi Arabia; Yuri Saporito, Fundacao Getulio Vargas, Brazil

Collocating Local Volatility: A Competitive Alternative to Stochastic Local Volatility Models
Lech A. Grzelak, Delft University of Technology, Netherlands

Testing Risk Prices in Factor Models: Model Selection and Uniformly Valid Inference
Raul Guarini, Yuri Saporito, and Caio Almeida, FGV-EPGE, Brazil

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Tuesday, June 4

PP1

Networking/Welcome Reception and Poster Session

continued

Fuzzy Regime Switching Portfolio Selection with Capital Gain Tax
Sini Guo, Wai-Ki Ching, Wai-Keung Li, and Zhiwen Zhang, University of Hong Kong, China

Hierarchical Adaptive Sparse Grids for Option Pricing under the Rough Bergomi Model
Chiheb Ben Hammouda, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

Extending (s,S) Policy for Concave Piecewise Linear Ordering Cost
Md Abu Helal, University of Texas at Dallas, U.S.; Alain Bensoussan, The University of Texas at Dallas and City University of Hong Kong, Hong Kong; Suresh P. Sethi and Viswanath Ramakrishna, University of Texas at Dallas, U.S.

A Performance Analysis of the Kalman Filter used in the Estimation of Dynamic Affine Term Structure Models Based Upon Data Structure and Econometric Attributes
Januj Juneja, San Diego State University, U.S.

Hedging Effectiveness of Cross Listed Nse Nifty Index Fututes
K. K. Kumar, Indian Institute of Management, Indore, India

Pricing Real Options with a Finite Time Horizon under Regime-Switching Jump-Diffusion Models
Sunju Lee and *Younhee Lee*, Chungnam National University, South Korea

Momentum and Volatility Timing
Yulia Malitskaia, VKY Analytics, LLC, U.S.

Artificial Intelligence Guided Algorithmic Trading for Optimal Price Discovery: a Bayesian Approach
Menzi Mthwecu

Investment Strategies with Long Memory Processes: Log-Optimal and Approximative Solutions
Zsolt Nika, Pázmány Péter Catholic University, Hungary

Insurance Against Bad Times for Spectrally Negative Markov Assets
Meral Simsek, Middle East Technical University, Turkey; Florin Avram, University of Pau, France; Ceren Vardar-Acar, Middle East Technical University, Turkey; Ulyses Solon, University of Pau, France

The Pricing of Univariate European Crack Spread Option with Jumps
Lenny Suardi, Ramaprasad Bhar, and David Colwell, University of New South Wales, Sydney, Australia

A Pairs Trading Implementation based on Hidden Markov Model Approach
Özge Tekin and Ömür Ugur, Middle East Technical University, Turkey

Generalized Marchenko–Pastur for Datasets with Fixed Time Horizons
Gregory Zitelli, University of California, Irvine, U.S.

continued in next column

Wednesday, June 5

Registration

8:00 a.m.-6:45 p.m.

Room: Myhal Atrium

Wednesday, June 5

MS1

Machine Learning - Part I of III

8:30 a.m.-10:30 a.m.

Room: Myhal Auditorium (Room 150)

For Part 2 see MS7

This minisymposium will cover machine learning in quantitative finance, including models, numerical methods, and mathematical analysis. There will be a special focus on deep learning, which has recently produced breakthroughs for modeling financial data (e.g., loan and high frequency data) and solving high-dimensional partial differential equations. There are 3 sessions in total ("Machine Learning I, II, and III").

Organizer: Justin Sirignano
Imperial College London, United Kingdom and University of Illinois at Urbana-Champaign, U.S.

Organizer: Kay Giesecke
Stanford University, U.S.

Organizer: Vadim Linetsky
Northwestern University, U.S.

Organizer: Konstantinos Spiliopoulos
Boston University, U.S.

8:30-8:55 Towards Explainable AI: Significance Tests for Neural Networks
Kay Giesecke, Stanford University, U.S.

9:00-9:25 Universal Features of Price Formation: Perspectives from Deep Learning
Rama Cont, CNRS - Universite Paris VI, France

9:30-9:55 Predicting Returns with Text Data
Tracy Ke, Harvard University, U.S.; Bryan Kelly, Yale University, U.S.; *Dacheng Xiu*, University of Chicago, U.S.

10:00-10:25 Mean Field Analysis of Neural Networks
Justin Sirignano, Imperial College London, United Kingdom and University of Illinois at Urbana-Champaign, U.S.

Wednesday, June 5

MS2

Robust Finance and Optimal Transport - Part I of II

8:30 a.m.-10:30 a.m.

Room: Room 360

For Part 2 see MS8

The aim of this minisymposium is to bring together a group of researchers with interest in robust (or model-independent) finance, to present the latest directions of research in this field, the new mathematical techniques as well as the forefront numerical methodologies (in particular in connection with neural networks). One of the approaches that proved to be very successful in this study and to provide new perspectives, is the application of the Optimal Transport theory. This analysis, which is of mathematical interest on its own, goes under the name of Martingale Optimal Transport. Great effort has been devoted in this area of research in recent years, starting with the problems of pricing and super-replication in a model-independent framework. These problems will be addressed in the presentations, along with others which had been little - or not yet - explored in a robust framework in conjunction with Optimal Transport. These include control problems, utility maximization under trading constraints, risk aggregation, price impact, statistical aspects in Martingale Optimal Transport, and the role of Wasserstein distance in Mathematical Finance.

Organizer: Beatrice Acciaio
London School of Economics, United Kingdom

8:30-8:55 Utility Maximisation with Model-Independent Trading Constraints
Alex Cox, University of Bath, United Kingdom

9:00-9:25 Super-Replication with Transient Price Impact
Yan Dolinsky, Hebrew University of Jerusalem, Israel

9:30-9:55 Measure-Valued Martingales and Robust Pricing
Sigrid Kaellblad, KTH Royal Institute of Technology, Sweden

10:00-10:25 From Martingale Optimal Transport to McKean-Vlasov Control Problems
Xiaolu Tan, Ceremade, France

Wednesday, June 5

MS3

Mean Field Models in Mathematical Finance - Part I of III

8:30 a.m.-10:30 a.m.

Room: Room 315

For Part 2 see MS9

Over the past decade, mean field models have become increasingly prevalent in mathematical finance, not to mention a variety of other social-scientific and engineering disciplines. The mean field framework, including both descriptive models of interacting particle systems as well as their game-theoretic counterparts known as mean field games, naturally accommodates many otherwise intractable large-scale systems. Notable recent applications include systemic risk, algorithmic trading, bank runs, tournament games, income inequality, oligopoly markets, etc. New applications have in turned fueled theoretical research on the subject, pertaining in particular to questions of solvability, convergence, and network effects. This minisymposium will highlight both theory and applications of the mean field paradigm.

Organizer: Ruimeng Hu
Columbia University, U.S.

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Columbia University, U.S.

Organizer: Tomoyuki Ichiba
University of California, Santa Barbara, U.S.

Organizer: Daniel Lacker
Columbia University, U.S.

Organizer: Marcel Nutz
Columbia University, U.S.

8:30-8:55 Convergence to the Mean Field Game Limit: A Case Study
Marcel Nutz, Columbia University, U.S.

9:00-9:25 Mean-Field Games with Differing Beliefs for Algorithmic Trading
Philippe Casgrain, University of Toronto, Canada

9:30-9:55 Stationary Stochastic Local Volatility
Jiacheng Zhang, Princeton University, U.S.

continued on next page

Wednesday, June 5

MS3

Mean Field Models in Mathematical Finance - Part I of III

continued

10:00-10:25 Mean-Field and Tree Interactions for Stochastic Volatility
Tomoyuki Ichiba, University of California, Santa Barbara, U.S.

Wednesday, June 5

MS4

Systemic Risk: Stochastic Games, Policies, and Economic Incentives - Part I of II

8:30 a.m.-10:30 a.m.

Room: Room 330

For Part 2 see MS10

The objective of this minisymposium is to gather experts in the area of systemic risk, games, and financial stability to illuminate on the latest advances on systemic risk modeling. The emphasis will be on (I) the assessment of policies aiming for financial stability, such as design of stress-testing and determination of systemic capital requirements; (II) the concept of systemic diversification and the banks' incentives in choosing diversified portfolios while running away from fire-sale externalities of other banks in the network; (III) the provision of regulatory incentives to rescue distressed banks in the network; (IV) disruptions in supply chain networks; (V) the selection of portfolios in the face of systemic events; (VI) the use of interacting particle systems to model network formation and propagation of contagion; (VII) the use of graphons to identify systemically important nodes; and (VIII) the design of capital allocations under the Fundamental Review of Trading Books.

Organizer: Agostino Capponi
Columbia University, U.S.

9:00-9:25 Optimal Portfolio Allocations in a Heterogeneous Banking System
Marko Weber, Columbia University, U.S.

9:30-9:55 Bail-Ins and Bailouts: Incentives, Connectivity, and Systemic Stability
Benjamin Bernard, University of California, Los Angeles, U.S.; Agostino Capponi and Joseph Stiglitz, Columbia University, U.S.

10:00-10:25 Disruption and Rerouting in Supply Chain Networks
Peng Chu Chen, Hong Kong University, Hong Kong

Wednesday, June 5

MS5

Quantitative Methods in Insurance Market Modelling - Part I of II

8:30 a.m.-10:30 a.m.

Room: Room 380

For Part 2 see MS11

This minisymposium presents recent advancements in insurance markets modelling. The presentations encompass a variety of problems from the pricing problem of a pure endowment contract under limited information on the mortality intensity of the policyholder to the quantification of informational risks in credit risk and life insurance and martingale techniques in credit risk valuation. Furthermore, a machine learning approach to portfolio risk management and a class of complex problems related to integrated insurance/ financial models and GARCH(p,q) processes will be presented.

Organizer: Francesca Biagini
Ludwig-Maximilians-Universität München, Germany

8:30-8:55 Indifference Pricing of Life Insurance Contracts in a Market with Longevity Bonds via BSDEs under Partial Information
Alessandra Cretarola, University of Perugia, Italy

9:00-9:25 Martingale Representation in Credit Risk Modelling
Ania Aksamit, University of Sydney, Australia

9:30-9:55 Reduced-Form Framework under Model Uncertainty
Francesca Biagini, Ludwig-Maximilians-Universität München, Germany

10:00-10:25 Neural Networks for Solvency Capital Requirement
Thorsten Rheinländer, Technische Universität Wien, Austria

Wednesday, June 5

MS6

New Developments on Optimization under Time-Inconsistency

8:30 a.m.-10:30 a.m.

Room: Room 320

Time-inconsistency arises when Bellman's optimality principle fails, such that dynamic programming cannot be applied. New discoveries of what triggers the failure of Bellman's principle and how it can possibly be restored are explored in this minisymposium. Topics involved include the set-valued Bellman principle, the connection between time-inconsistency and model uncertainty, and the construction of optimal equilibrium strategies in multi-dimensional settings. This relates to various financial applications, such as dynamic mean-variance portfolio optimization, superhedging under transaction costs, systemic risk management via multivariate risk measures, and optimal stopping under model uncertainty.

Organizer: Yu-Jui Huang
University of Colorado Boulder, U.S.

8:30-8:55 Dynamic Multivariate Programming
Zachary Feinstein, Washington University in St. Louis, U.S.; Gabriela Kovacova and *Birgit Rudloff*, Vienna University of Economics and Business, Austria

9:00-9:25 Dynamic Mean-Variance Efficient Fractional Kelly Portfolios in a Stochastic Volatility Model
Xuedong He and Zhaoli Jiang, The Chinese University of Hong Kong, Hong Kong

9:30-9:55 Time Inconsistency Induced by Model Uncertainty -- The Stopping Case
Yu-Jui Huang, University of Colorado Boulder, U.S.; Xiang Yu, Hong Kong Polytechnic University, China

10:00-10:25 Multi-Dimensional Optimal Equilibria for Time-Inconsistent Stopping Problems
Yu-Jui Huang and *Zhenhua Wang*, University of Colorado Boulder, U.S.

Wednesday, June 5

CP4

Credit Risk

8:30 a.m.-10:30 a.m.

Room: Room 350

Chair: Diogo Duarte, Florida International University, U.S.

8:30-8:55 Structural Option Pricing: A Test of Relative Pricing Between the Option and the CDs Markets
Federico Maglione, Cass Business School, London, United Kingdom

9:00-9:25 A Credit Risk Model with Liquidity and Solvency Risk
Artur Kotlicki and Rama Cont, University of Oxford, United Kingdom

9:30-9:55 Robust Bounds of Default Probabilities in Financial Networks
Dohyun Ahn and Nan Chen, The Chinese University of Hong Kong, Hong Kong; Kyoung-Kuk Kim, Korea Advanced Institute of Science and Technology, Korea

10:00-10:25 Vanishing Contagion Spreads
Diogo Duarte, Florida International University, U.S.; Rodolfo Prieto, INSEAD, France; Marcel Rindisbacher, Boston University, U.S.; Yuri Saporito, FGV-EPGE, Brazil

Wednesday, June 5

CP5

Portfolio Selection

8:30 a.m.-10:30 a.m.

Room: Room 370

Chair: Sergei Levendorskii, Calico Science Consulting, U.S.

8:30-8:55 Eigen Portfolio Selection: A Robust Approach to Sharpe Ratio Maximization
Chengguo Weng and Danqiao Guo, University of Waterloo, Canada; Phelim Boyle, Wilfrid Laurier University, Canada; Tony Wirjanto, University of Waterloo, Canada

9:00-9:25 Risk-Based Optimal Portfolio of An Insurer with Regime Switching and Noisy Memory
Calisto J. Guambe, Eduardo Mondlane University, Mozambique; Rodwell Kufakunesu and Lesedi Mabitsela, University of Pretoria, South Africa

9:30-9:55 A Sparse Learning Approach to Relative-Volatility-Managed Portfolio Selection
Chi Seng Pun, Nanyang Technological University, Singapore

10:00-10:25 Static and Semi-Static Hedging, in the Dual Space
Svetlana Boyarchenko, University of Texas at Austin, U.S.; *Sergei Levendorskii*, Calico Science Consulting, U.S.

Coffee Break

10:30 a.m.-11:00 a.m.

Room: Myhal Atrium

Wednesday, June 5

SIAG/FME Early Career Prize Ceremony

11:00 a.m.-11:15 a.m.

Room: Myhal Auditorium (Room 150)

Wednesday, June 5

IP3

Reservoir Computing, Rough Paths and Learning of Stochastic Dynamics in Finance

11:15 a.m.-12:00 p.m.

Room: Myhal Auditorium (Room 150)

Chair: Tim Leung, University of Washington, U.S.

We connect paradigms of reservoir computing, fundamental insights of rough path theory (or the theory of regularity structures) and the theory of random projections to construct provably universal and remarkably easy to train dynamical systems for purposes of Finance, e.g. model free market scenario generation, prediction tasks, or hedging tasks.

Josef Teichmann
ETH Zürich, Switzerland

Lunch Break

12:00 p.m.-1:30 p.m.

Attendees on own

Wednesday, June 5

MS7

Machine Learning - Part II of III

1:30 p.m.-3:30 p.m.

Room: Myhal Auditorium (Room 150)

For Part 1 see MS1
For Part 3 see MS13

This minisymposium will cover machine learning in quantitative finance, including models, numerical methods, and mathematical analysis. There will be a special focus on deep learning, which has recently produced breakthroughs for modeling financial data (e.g., loan and high frequency data) and solving high-dimensional partial differential equations. There are 3 sessions in total ("Machine Learning I, II, and III").

Organizer: Justin Sirignano
Imperial College London, United Kingdom and University of Illinois at Urbana-Champaign, U.S.

Organizer: Kay Giesecke
Stanford University, U.S.

Organizer: Vadim Linetsky
Northwestern University, U.S.

Organizer: Konstantinos Spiliopoulos
Boston University, U.S.

1:30-1:55 Robo-Advising as a Human-Machine Interaction System
Agostino Capponi, Alsabah Homoud, Octavio Ruiz Lacedelli, and Matt Stern, Columbia University, U.S.

2:00-2:25 Machine Learning of Dynamics in Mathematical Finance
Josef Teichmann, ETH Zürich, Switzerland

2:30-2:55 Reinforcement Learning in Portfolio Optimization
Vivek Farias, Massachusetts Institute of Technology, U.S.; Eli Gutin, Uber, U.S.; *Ciamac C. Moallemi*, Columbia University, U.S.

3:00-3:25 DGM: A Deep Learning Algorithm for Solving Partial Differential Equations
Konstantinos Spiliopoulos, Boston University, U.S.; Justin Sirignano, Imperial College London, United Kingdom and University of Illinois at Urbana-Champaign, U.S.

Wednesday, June 5

MS8

Robust Finance and Optimal Transport - Part II of II

1:30 p.m.-3:30 p.m.

Room: Room 360

For Part 1 see MS2

The aim of this minisymposium is to bring together a group of researchers with interest in robust (or model-independent) finance, to present the latest directions of research in this field, the new mathematical techniques as well as the forefront numerical methodologies (in particular in connection with neural networks). One of the approaches that proved to be very successful in this study and to provide new perspectives, is the application of the Optimal Transport theory. This analysis, which is of mathematical interest on its own, goes under the name of Martingale Optimal Transport. Great effort has been devoted in this area of research in recent years, starting with the problems of pricing and super-replication in a model-independent framework. These problems will be addressed in the presentations, along with others which had been little - or not yet - explored in a robust framework in conjunction with Optimal Transport. These include control problems, utility maximization under trading constraints, risk aggregation, price impact, statistical aspects in Martingale Optimal Transport, and the role of Wasserstein distance in Mathematical Finance.

Organizer: Beatrice Acciaio
London School of Economics, United Kingdom

1:30-1:55 Computation of (Martingale) Optimal Transport and Related Hedging Problems with Neural Networks
Michael Kupper, Universität Konstanz, Germany

2:00-2:25 Robust Risk Aggregation with Neural Networks
Mathias Pohl, University of Vienna, Austria

2:30-2:55 Concentration of Dynamic Risk Measures in a Brownian Filtration
Ludovic Tangpi, Princeton University, U.S.

3:00-3:25 Wasserstein and Adapted Wasserstein Distances in Mathematical Finance
Daniel Bartl, University of Vienna, Austria

Wednesday, June 5

MS9

Mean Field Models in Mathematical Finance - Part II of III

1:30 p.m.-3:30 p.m.

Room: Room 315

For Part 1 see MS3
For Part 3 see MS15

Over the past decade, mean field models have become increasingly prevalent in mathematical finance, not to mention a variety of other social-scientific and engineering disciplines. The mean field framework, including both descriptive models of interacting particle systems as well as their game-theoretic counterparts known as mean field games, naturally accommodates many otherwise intractable large-scale systems. Notable recent applications include systemic risk, algorithmic trading, bank runs, tournament games, income inequality, oligopoly markets, etc. New applications have in turned fueled theoretical research on the subject, pertaining in particular to questions of solvability, convergence, and network effects. This minisymposium will highlight both theory and applications of the mean field paradigm.

Organizer: Ruimeng Hu
Columbia University, U.S.

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Organizer: Tomoyuki Ichiba
University of California, Santa Barbara, U.S.

Organizer: Daniel Lacker
Columbia University, U.S.

Organizer: Marcel Nutz
Columbia University, U.S.

1:30-1:55 Mean Field Games with Finite States in the Weak Formulation, and Application to Contract Theory
Rene Carmona, Princeton University, U.S.

2:00-2:25 Beyond Mean Field Limits: Local Dynamics for Large Sparse Networks of Interacting Diffusions
Daniel Lacker, Columbia University, U.S.

2:30-2:55 Large Tournament Games
Yuchong Zhang, University of Toronto, Canada

3:00-3:25 Title Not Available
Zhaoyu Zhang, University of California, Santa Barbara, U.S.

Wednesday, June 5

MS10

Systemic Risk: Stochastic Games, Policies, and Economic Incentives - Part II of II

1:30 p.m.-3:30 p.m.

Room: Room 330

For Part 1 see MS4

The objective of this minisymposium is to gather experts in the area of systemic risk, games, and financial stability to illuminate on the latest advances on systemic risk modeling. The emphasis will be on (I) the assessment of policies aiming for financial stability, such as design of stress-testing and determination of systemic capital requirements; (II) the concept of systemic diversification and the banks' incentives in choosing diversified portfolios while running away from fire-sale externalities of other banks in the network; (III) the provision of regulatory incentives to rescue distressed banks in the network; (IV) disruptions in supply chain networks; (V) the selection of portfolios in the face of systemic events; (VI) the use of interacting particle systems to model network formation and propagation of contagion; (VII) the use of graphons to identify systemically important nodes; and (VIII) the design of capital allocations under the Fundamental Review of Trading Books.

Organizer: Agostino Capponi
Columbia University, U.S.

1:30-1:55 Systemic Risk Efficient Portfolio Selection
Alexey Rubtsov, Ryerson University, Canada

2:00-2:25 Dynamic Fragility and Stability of Large Credit Networks
Sergey Nadtochiy, Illinois Institute of Technology, U.S.

2:30-2:55 Graphons and Contagion
Selman Erol, Carnegie Mellon University, U.S.

3:00-3:25 Capital Allocation under the Fundamental Review of Trading Book
Hao Xing, London School of Economics and Political Science, United Kingdom

Wednesday, June 5

MS11

Quantitative Methods in Insurance Market Modelling - Part II of II

1:30 p.m.-3:30 p.m.

Room: Room 380

For Part 1 see MS5

This minisymposium presents recent advancements in insurance markets modelling. The presentations encompass a variety of problems from the pricing problem of a pure endowment contract under limited information on the mortality intensity of the policyholder to the quantification of informational risks in credit risk and life insurance and martingale techniques in credit risk valuation. Furthermore, a machine learning approach to portfolio risk management and a class of complex problems related to integrated insurance/financial models and GARCH(p,q) processes will be presented.

Organizer: Francesca Biagini
Ludwig-Maximilians-Universität München, Germany

1:30-1:55 Quantification of Informational Risks in Credit Risk and Life Insurance
Tahir Choulli, University of Alberta, Canada

2:00-2:25 Efficient Computational Methods for Risk Processes Governed by Stochastic Fixed Point Equations
Jeffrey Collamore, University of Copenhagen, Denmark

2:30-2:55 Optimal Reinsurance and Investment Problems under Partial Information
Claudia Ceci, University of Pescara, Italy

3:00-3:25 Linear Credit Risk Models
Damir Filipovic, École polytechnique Fédérale de Lausanne and Swiss Finance Institute, Switzerland

Wednesday, June 5

MS12

Dynamic Equilibrium Models

1:30 p.m.-3:30 p.m.

Room: Room 320

Equilibrium asset pricing and optimal contracting are two of the basic building blocks of economic theory. The speakers in this minisymposium will present a number of novel equilibrium models from Financial Economics, with the goal of fostering both interdisciplinary research and collaboration within the SIAM community. Topics covered will include asset pricing for non-dividend paying stocks, the implications of heterogeneous benchmarks in mutual-fund management, equilibrium foundations for the term structures of dividend risk premia and interest rates, as well as agency problems for fund families contracting professional money managers.

Organizer: Johannes Muhle-Karbe
Carnegie Mellon University, U.S.

Organizer: Marcel Rindisbacher
Boston University, U.S.

Organizer: Scott Robertson
Boston University, U.S.

1:30-1:55 Asset Prices and No-Dividend Stocks
Adem Atmaz, Purdue University, U.S.

2:00-2:25 Institutional Investors, Heterogenous Benchmarks, and the Co-Movement of Asset Prices
Andrea Buffa, Boston University, U.S.

2:30-2:55 The Shape of the Term Structures
Michael Hasler, University of Toronto, Canada

3:00-3:25 Contracting Within Fund Families
Dmitry Orlov, University of Rochester, U.S.

Wednesday, June 5

CP6

Cyber Risk, News, and Rough Paths

1:30 p.m.-3:30 p.m.

Room: Room 350

Chair: Rodrigo S. Targino, FGV, Brazil

1:30-1:55 To Disconnect or Not: A Cybersecurity Game
Jin Hyuk Choi, Ulsan National Institute of Science and Technology, South Korea; Yunsik Choi, University of Texas at Austin, U.S.; Gene Moo Lee, University of British Columbia, Canada; Andrew Whinston, University of Texas at Austin, U.S.

2:00-2:25 Pricing of Cyber Insurance Contracts in a Network Model
Kerstin Weske, Leibniz Universität Hannover, Germany; Matthias Fahrenwaldt, Heriot-Watt University, United Kingdom; Stefan Weber, Leibniz Universität Hannover, Germany

2:30-2:55 Pricing and Hedging using Rough Path Signatures
Imanol Perez Arribas, Terry Lyons, and Sina Nejad, University of Oxford, United Kingdom

3:00-3:25 The Impact of the Freedom of the Press on Risk
Rodrigo S. Targino, FGV, Brazil; Diogo Duarte, Florida International University, U.S.; Yuri Saporito, FGV-EPGE, Brazil

Wednesday, June 5

CP7

Optimal Control with Applications to Investing and Taxation

1:30 p.m.-3:30 p.m.

Room: Room 370

Chair: Svein Olafsson, Columbia University, U.S.

1:30-1:55 Singular Perturbation Expansion for Utility Maximization with Order-Quadratic Transaction Costs
Shiva Chandra, Numerix LLC. U.S.

2:00-2:25 Optimal Investment and Consumption with Forward Preferences and Uncertain Parameters
Wing Fung (Alfred) Chong, University of Illinois at Urbana-Champaign, U.S.; Gechun Liang, University of Warwick, United Kingdom

2:30-2:55 Asymptotic Analysis of the Expected Utility Maximization Problem with Respect to Perturbations of the Numéraire
Oleksii Mostovyi, University of Connecticut, U.S.

3:00-3:25 Does Frequent Human-Machine Communication Increase the Value of an Investment?
Svein Olafsson, Columbia University, U.S.

Coffee Break

3:30 p.m.-4:00 p.m.

Room: Myhal Atrium

Wednesday, June 5

MS13

Machine Learning - Part III of III

4:00 p.m.-6:00 p.m.

Room: Myhal Auditorium (Room 150)

For Part 2 see MS7

This minisymposium will cover machine learning in quantitative finance, including models, numerical methods, and mathematical analysis. There will be a special focus on deep learning, which has recently produced breakthroughs for modeling financial data (e.g., loan and high frequency data) and solving high-dimensional partial differential equations. There are 3 sessions in total ("Machine Learning I, II, and III").

Organizer: Justin Sirignano
Imperial College London, United Kingdom and University of Illinois at Urbana-Champaign, U.S.

Organizer: Kay Giesecke
Stanford University, U.S.

Organizer: Vadim Linetsky
Northwestern University, U.S.

Organizer: Konstantinos Spiliopoulos
Boston University, U.S.

4:00-4:25 Deep Learning for Asset Pricing
Markus Pelger, Stanford University, U.S.

4:30-4:55 Deep Q-Learning for Stochastic Games
Sebastian Jaimungal, Brian Ning, and Philippe Casgrain, University of Toronto, Canada

5:00-5:25 Machine Learning Techniques for Stochastic Control with Probabilistic Constraints
Mike Ludkovski, University of California, Santa Barbara, U.S.

5:30-5:55 Inverse Reinforcement Learning for Financial Modeling
Igor Halperin, New York University, U.S.

Wednesday, June 5

MS14

Robust Methods in Finance

4:00 p.m.-6:00 p.m.

Room: Room 360

Over the past decade various novel methods were proposed to deal with stochastic control problems subject to model uncertainty that were motivated by a wide range of topics from mathematical finance. This minisymposium focuses on latest developments in this area, that will touch on such topics as robust, adaptive, adaptive robust methods.

Organizer: Igor Cialenco
Illinois Institute of Technology, U.S.

Organizer: Tomasz Bielecki
Illinois Institute of Technology, U.S.

4:00-4:25 Adaptive Robust Control
Igor Cialenco, Illinois Institute of Technology, U.S.

4:30-4:55 Robust XVA
Stephan Sturm, Worcester Polytechnic Institute, U.S.; Agostino Capponi, Columbia University, U.S.; Maxim Bichuch, Johns Hopkins University, U.S.

5:00-5:25 Statistical Uncertainty and Optimal Decision Making
Samuel Cohen, Oxford University, United Kingdom

5:30-5:55 The Robust Superreplication Problem: A Dynamic Approach
Johannes C. Wiesel, University of Oxford, United Kingdom; Laurence Carassus, Pole Universitaire Leonard de Vinci, France; Jan Obloj, Oxford University, United Kingdom

Wednesday, June 5

MS15

Mean Field Models in Mathematical Finance - Part III of III

4:00 p.m.-6:00 p.m.

Room: Room 315

For Part 2 see MS9

Over the past decade, mean field models have become increasingly prevalent in mathematical finance, not to mention a variety of other social-scientific and engineering disciplines. The mean field framework, including both descriptive models of interacting particle systems as well as their game-theoretic counterparts known as mean field games, naturally accommodates many otherwise intractable large-scale systems. Notable recent applications include systemic risk, algorithmic trading, bank runs, tournament games, income inequality, oligopoly markets, etc. New applications have in turned fueled theoretical research on the subject, pertaining in particular to questions of solvability, convergence, and network effects. This minisymposium will highlight both theory and applications of the mean field paradigm.

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University of California, Santa Barbara, U.S.

Organizer: Daniel Lacker
Columbia University, U.S.

Organizer: Marcel Nutz
Columbia University, U.S.

4:00-4:25 Weakly Interacting Markov Chains on Multicolor Graph in Multiple Regimes
Ruoyu Wu, University of Michigan, U.S.

4:30-4:55 Probabilistic Numerical Methods for MFC and MFG Based on Deep Learning
Mathieu Lauriere, Princeton University, U.S.

5:00-5:25 Systemic Risk and Mean Field Games with Heterogeneous Groups
Li-Hsien Sun, National Central University, Taiwan

5:30-5:55 Linear Quadratic Mean Field Games: from Asymptotic Solvability to the Fixed Point Approach
Minyi Huang, Carleton University, Canada

Wednesday, June 5

MS16

New Directions in Credit Modeling - Part I of II

4:00 p.m.-6:00 p.m.

Room: Room 330

For Part 2 see MS22

Credit modeling is an exciting field within mathematical finance. It is has historically been a highly interdisciplinary field allowing for interaction between practitioners and academics from both mathematics and finance. This session will allow for speakers to lecture on topics including but not limited to modeling regulatory requirements, measuring and managing counterparty risk, modeling recovery processes and the link to probability of default, and the modeling of new financial products that are based on credit quality. We expect the industry and academic speakers to talk about their current research, and the organizers will also ensure that participants will have ample opportunities to interact and discuss their work.

Organizer: Harvey Stein
Bloomberg LP, U.S.

Organizer: Albert Cohen
Michigan State University, U.S.

Organizer: Nick Costanzino
New York University, U.S.

4:00-4:25 Variable Volatility and Financial Failure
Peter Carr, New York University, U.S.

4:30-4:55 Spectral Expansions for Solvable Processes: Passage Times, Occupation Times, and Other Functionals for Structural Modeling
Giuseppe Campolieti, Wilfrid Laurier University, Canada

5:00-5:25 Inequality Modeling of Credit Risk
Pasquale Cirillo, Technische Universität Delft, Germany

5:30-5:55 Pricing CDOs with Stochastic Recovery via Structural Models
Albert Cohen, Michigan State University, U.S.

Wednesday, June 5

MS17

Portfolio Choice

4:00 p.m.-6:00 p.m.

Room: Room 380

Portfolio choice is where asset dynamics, investors' preference, and managers' incentives meet, creating complex interactions that often defy intuition. This minisymposium presents recent progress in this area, which includes (i) the role of reference-dependence in investors' preferences in shaping optimal portfolios and their payoffs; (ii) the effect of incentive fees with high-watermark provisions in altering managers' appetite for risk-taking; and (iii) the interplay between utility-based criteria and variants of mean-variance analysis. The talks involve a variety of approaches that include game-theoretical techniques, stochastic control, martingale methods, and asymptotics.

Organizer: Paolo Guasoni
Boston University, U.S. and Dublin City University, Ireland

4:00-4:25 Reference Dependence and Anchors in Complete Markets
Andrea Meireles Rodrigues, University of York, United Kingdom

4:30-4:55 High-Water Mark Fees with Stochastic Benchmark
Gu Wang, Worcester Polytechnic Institute, U.S.

5:00-5:25 Portfolio Optimisation with Semivariance
Kwok Chuen Wong, Dublin City University, Ireland

5:30-5:55 Trading Fractional Brownian Motion
Paolo Guasoni, Boston University, U.S. and Dublin City University, Ireland

Wednesday, June 5

MS18

New Developments in Markov Chain Approximation for Financial Mathematics

4:00 p.m.-6:00 p.m.

Room: Room 320

Many models in financial mathematics are based on continuous time Markov processes with continuous state spaces. In general, approximation methods are needed to handle these models. A useful idea is to approximate the original process by a continuous time Markov chain, for which tractability can be obtained for various types of problems. This approach offers a unified way to deal with different types of Markovian models and has been employed for miscellaneous problems in financial mathematics. This session features latest developments in this area which provide novel and computationally efficient solutions for a range of problems, including valuation of drawdown derivatives, convergence analysis for Markov chain approximation of diffusion models with non-smooth coefficients, simulation of stochastic local volatility models and computation of sticky diffusion models for interest rates.

Organizer: Lingfei Li
The Chinese University of Hong Kong, Hong Kong

4:00-4:25 A General Method for Valuation of Drawdown Risk under Markovian Models
Lingfei Li, The Chinese University of Hong Kong, Hong Kong; Gongqiu Zhang, The Chinese University of Hong Kong (Shenzhen)

4:30-4:55 Analysis of Markov Chain Approximation for Diffusion Models with Non-Smooth Coefficients
Gongqiu Zhang, The Chinese University of Hong Kong (Shenzhen)

5:00-5:25 Efficient Simulation of Stochastic Differential Equations Based on Markov Chain Approximations and Applications
Zhenyu Cui, Stevens Institute of Technology, U.S.; J. Lars Kirkby, Georgia Institute of Technology, U.S.; Duy Nguyen, Marist College, U.S.

5:30-5:55 Markov Chain Approximation of Sticky Diffusion Models for Interest Rates
Christian Meier, The Chinese University of Hong Kong, Hong Kong

Wednesday, June 5

CP8

Stochastic Volatility

4:00 p.m.-6:00 p.m.

Room: Room 350

Chair: Hoi Ying Wong, The Chinese University of Hong Kong, Hong Kong

4:00-4:25 Lifting the Heston Model
Eduardo Abi Jaber, Ecole Polytechnique, France

4:30-4:55 Dynamic Tail Inference with Log-Laplace Volatility
Gordon V. Chavez, University of California, San Francisco, U.S.

5:00-5:25 Sovereign-Bond Backed Securities as a New Safe Asset for the Eurozone: A Dynamic Credit Risk Perspective
Kevin Kurt, Ruediger Frey, and Camilla Damian, Vienna University of Economics and Business, Austria

5:30-5:55 Stochastic Volatility Asymptotics for Optimal Subsistence Consumption and Investment with Bankruptcy
Hoi Ying Wong and Kexin Chen, The Chinese University of Hong Kong, Hong Kong; Mei Choi Chiu, The Hong Kong Institute of Education, Hong Kong; Yong Hyun Shin, Sunkmyung Women's University, Korea

Wednesday, June 5

CP9

Limit Order Books and Model Risk

4:00 p.m.-6:00 p.m.

Room: Room 370

Chair: Jasdeep Kalsi, University of Oxford, United Kingdom

4:00-4:25 A Stochastic Stefan Problem as a Model for the Limit Order Book
Jasdeep Kalsi, University of Oxford, United Kingdom

4:30-4:55 A General Framework for Modeling Limit Order Books Dynamics
Lifan Xuan, Imperial College London, United Kingdom; Rama Cont, University of Oxford, United Kingdom; Pierre Degond, Imperial College London, United Kingdom

5:00-5:25 Model Risk in Mean-Variance Portfolio Selection: An Analytic Solution to the Worst-Case Approach
Roberto Baviera and *Giulia Bianchi*, Politecnico di Milano, Italy

5:30-5:55 Risk Layering Insurance Contract under Model Uncertainty
Corina Birghila and Georg Pflug, University of Vienna, Austria

Intermission

6:00 p.m.-6:15 p.m.

Wednesday, June 5

IP4

Managing the Libor Transition: A Quant Perspective

6:15 p.m.-7:00 p.m.

Room: Myhal Auditorium (Room 150)

Chair: Beatrice Acciaio, London School of Economics, United Kingdom

Investigations prompted by regulators found overwhelming evidence that some dealers were manipulating IBORs in an attempt to make profits in the derivatives market. Regulators, across the world, then started discussions on possible IBOR replacements to be used as new benchmarks in interest-rate cash and derivatives contracts, whose outstanding notional is in the hundreds of trillions of USD dollars. In June 2017, the US Alternative Reference Rates Committee announced that they had identified a Treasuries repo financing rate, which they called Secured Overnight Funding Rate (SOFR), as the best replacement for LIBOR. Starting on April 3, 2018, the New York Fed has published the SOFR every business day. Following this, the market began trading SOFR-based derivatives, such as SOFR futures and swaps, and cash instruments such as SOFR floating rate notes. The market quotes of SOFR-based contracts lead to the creation of a SOFR interest-rate curve. In this talk, we introduce a simple multi-curve interest-rate model that allows for the consistent calculation of the convexity adjustments for both SOFR futures and Eurodollar futures. We also show how the valuations of LIBOR-based swaps change because of the new LIBOR fallback introduced by ISDA. We then hint at the construction of SOFR-based volatility surfaces and cubes. Finally, we will summarize the main outstanding issues around the transition away from LIBOR.

Fabio Mercurio
Bloomberg LP, U.S.

Thursday, June 6

Registration

8:00 a.m.-6:30 p.m.

Room: Myhal Atrium

Thursday, June 6

MS19

Machine Learning and Reinforcement Learning in Finance

8:30 a.m.-10:30 a.m.

Room: Myhal Auditorium (Room 150)

Machine learning has drawn tremendous interests in various financial applications. The appeal of this method is largely due to its ability to efficiently discover complex structure that was not specified in advance from high dimensional data. This minisymposium aims to present several recent developments in this active area. It is well known that modeling of tail risk contained in asset price data is a very challenging task. The first speaker, Qi Wu from City University of Hong Kong, will discuss how to develop a long-short-term memory sequential neural network model to capture serial and cross-sectional tail dependencies. The second presentation by Jason Zhu from Stanford University proposes to analyze the effect of a large number of characteristics on expected stock returns with the ML technique known as random forest. He finds that his new approach adequately reflects the information contained the interaction of characteristics and leads to investment strategies that achieve yearly out-of-sample Sharpe ratios above 2. The third speaker, Di Wang from JD Finance, one of the largest e-commerce providers in China, will focus on the construction of a deep learning approach to model dependencies among consumer default risk. The fourth talk given by Nan Chen from Chinese University of Hong Kong develops a duality-based randomization method to guide exploration in reinforcement learning, targeting on data-based decision marking in investment and execution.

Organizer: Nan Chen
The Chinese University of Hong Kong, Hong Kong

8:30-8:55 Parsimonious Learning of Tail Dynamics

Qi Wu, City University of Hong Kong, Hong Kong; Xing Yan, The Chinese University of Hong Kong, Hong Kong

9:00-9:25 The Forest Behind the Trees: Trees in Asset Pricing

Svetlana Bryzgalova, London Business School, United Kingdom; Markus Pelger and *Jason Zhu*, Stanford University, U.S.

continued on next page

9:30-9:55 NeuCredit: Learning the Dynamics of Consumer Behaviors for Retail Credit Risk Management
Di Wang, Xiangru Fan, and Wen Zhang, JD Finance, Beijing, China; Qi Wu, City University of Hong Kong, Hong Kong

10:00-10:25 Duality-Based Exploration in Reinforcement Learning and its Financial Application
Nan Chen and Xiang Ma, The Chinese University of Hong Kong, Hong Kong

Thursday, June 6

MS20

Quantitative Risk Management

8:30 a.m.-10:30 a.m.

Room: Room 360

Risk management is an important area in mathematical finance, which has seen new challenges in recent years. Given the massive technological and economic changes, novel methods and techniques are required to better understand, quantify and regulate financial risks. The purpose of this minisymposium is to present different approaches to address current challenges in risk management and to provide a mathematical foundation for their modelling. The minisymposium will cover topics such as accurate estimation of risks in financial markets, development of mathematical frameworks related to credit risk, and the study of systemic risk in financial markets.

Organizer: Christoph Frei
University of Alberta, Canada

8:30-8:55 Price Bias and Common Practice in Option Pricing
Geneviève Gauthier, HEC Montréal, Canada; Jean-François Bégin, Simon Fraser University, Canada

9:00-9:25 Revisiting Contagion in Financial Networks
Tom Hurd, McMaster University, Canada

9:30-9:55 An Axiomatic Theory for Rating Structured Finance Securities
Ruodu Wang, University of Waterloo, Canada

10:00-10:25 On the Relation Between Banks' Default Risk and Their Trading Strategies
Christoph Frei, University of Alberta, Canada; Agostino Capponi, Columbia University, U.S.

Thursday, June 6

MS21

Network and Mean-Field Models in Systemic Risk - Part I of II

8:30 a.m.-10:30 a.m.

Room: Room 315

For Part 2 see MS26

Systemic risk is the risk that a large number of components of an interconnected financial system fail within a short time thus leading to the overall failure of the system itself. In addition to the explicit interaction between banks through liabilities, implicit interactions exist through, e.g., fire sales, confidence, and liquidity crises. Since the 2008-2009 financial crisis, there has been almost universal agreement that these interactions need to play a more significant role in how we quantify the risks of financial institutions. However, the literature on this issue remains in its infancy. Two major streams of literature exist: network models and mean-field models. Each of these distinct streams comes with its own advantages and shortcomings. The network models typically focus on finite number of heterogeneous institutions in static time, though analytical solutions to these models are often intractable. The mean-field models natively consider time dynamics and provide, often, tractable solutions, but at the cost of homogeneity of a continuum of agents. Our session aims to bridge the divide between these mathematical frameworks for studying systemic risk by bringing together experts in both fields. The specific focus is on the major challenges and recent development of mathematical frameworks to model the interactions between agents in the system and the simultaneous risk of default of a large part of the system.

Organizer: Zachary Feinstein
Washington University in St. Louis, U.S.

Organizer: Andreas Sojmark
Oxford University, United Kingdom

8:30-8:55 Systemic Risk Models in Network and Mean-Field Frameworks
Zachary Feinstein, Washington University in St. Louis, U.S.; Andreas Sojmark, Oxford University, United Kingdom

continued on next page

Thursday, June 6

MS21

Network and Mean-Field Models in Systemic Risk - Part I of II

continued

9:00-9:25 Pricing of Interbank Claims in an Eisenberg-Noe Network under Comonotonic Endowments
Tathagata Banerjee and Zachary Feinstein, Washington University in St. Louis, U.S.

9:30-9:55 Mean-Field of Optimal Stopping: A Relaxed Control Approach
Roxana Dumitrescu, King's College London, United Kingdom

10:00-10:25 Modeling Financial System with Interbank Flows, Borrowing, and Investing
Andrey Sarantsev, University of Nevada, Reno, U.S.

Thursday, June 6

MS22

New Directions in Credit Modeling - Part II of II

8:30 a.m.-10:30 a.m.

Room: Room 330

For Part 1 see MS16

Credit modeling is an exciting field within mathematical finance. It is has historically been a highly interdisciplinary field allowing for interaction between practitioners and academics from both mathematics and finance. This session will allow for speakers to lecture on topics including but not limited to modeling regulatory requirements, measuring and managing counterparty risk, modeling recovery processes and the link to probability of default, and the modeling of new financial products that are based on credit quality. We expect the industry and academic speakers to talk about their current research, and the organizers will also ensure that participants will have ample opportunities to interact and discuss their work.

Organizer: Harvey Stein
Bloomberg LP, U.S.

Organizer: Albert Cohen
Michigan State University, U.S.

Organizer: Nick Costanzino
New York University, U.S.

8:30-8:55 High Dimension, Low Sample Size Size Estimation of Credit Portfolios: Correcting the Dispersion Bias
Lisa Goldberg, University of California, Berkeley, U.S.

9:00-9:25 Jump Threshold Models for Credit Risk
Alec Kercheval, Florida State University, U.S.

9:30-9:55 Continuous-Time Distress Propagation in an Interbank Lending Model
Delia Coculescu, University of Zurich, Switzerland

10:00-10:25 A Unified Theory of Credit Modeling
Nick Costanzino, New York University, U.S.

Thursday, June 6

MS23

Modern Portfolio Optimization Problems - Part I of II

8:30 a.m.-10:30 a.m.

Room: Room 380

For Part 2 see MS28

This two-part minisymposium will discuss new directions in stochastic control motivated by portfolio optimization problems. These may come from traditional utility maximization, but where volatility or Sharpe ratios are stochastic; models incorporating transaction costs; forward performance processes; optimal execution of large sell orders; accelerated share repurchases; feedback of optimal strategies onto price dynamics; and arbitrage in stochastic portfolio theory. This leads to challenging mathematics involving fixed point problems, rank-based diffusions, HJB equations with singular terminal conditions, asymptotic approximations and computation. The session brings together international experts working in different branches of financial control problems, and it is designed to highlight to graduate student participants the range of research topics and challenges at the forefront of modern investment and trading science.

Organizer: Mykhaylo Shkolnikov
Princeton University, U.S.

Organizer: Ronnie Sircar
Princeton University, U.S.

8:30-8:55 Universal Portfolios and Model-Free Portfolio Optimization
Christa Cuchiero, Vienna University of Economics and Business, Austria

9:00-9:25 Rough Volatility and Portfolio Optimisation under Transaction Costs
Christoph Czichowsky, London School of Economics and Political Science, United Kingdom

9:30-9:55 Short and Long-Term Relative Arbitrage in Stochastic Portfolio Theory
Martin Larsson, ETH Zürich, Switzerland

10:00-10:25 Functional Portfolio Generation: Characterization and Randomization
Leonard Wong, University of Toronto, Canada

Thursday, June 6

CP10

Computational Finance

8:30 a.m.-10:30 a.m.

Room: Room 320

Chair: Christina Christara, University of Toronto, Canada

8:30-8:55 Quantization Error in Financial Pricing: Analysis and Remedies for Stable Order of Convergence
Christina Christara, University of Toronto, Canada; Nat Chun-Ho Leung, Toronto Dominion Bank and University of Toronto, Canada

9:00-9:25 Leave-One-Out Least Square Monte Carlo Algorithm for Pricing American Options
Jeechul Woo, University of Illinois at Urbana-Champaign, U.S.; Chenru Liu, Stanford University, U.S.; *Jaehyuk Choi*, Peking University, China

9:30-9:55 A Penalty Scheme and Policy Iteration for Stochastic Hybrid Control Problems with Nonlinear Expectations
Yufei Zhang, University of Oxford, United Kingdom; Christoph Reisinger, OCIAM, United Kingdom

10:00-10:25 Epsilon Monotone Numerical Methods for Stochastic Control Problems in Finance
Duy-Minh Dang, University of Queensland, Australia

Thursday, June 6

CP11

Rough Volatility

8:30 a.m.-10:30 a.m.

Room: Room 350

Chair: Jan Pospisil, University of West Bohemia, Pilsen, Czech Republic

8:30-8:55 Buy Rough, Sell Smooth
Pu He and Paul Glasserman, Columbia University, U.S.

9:00-9:25 Calibrating Rough Volatility Models: A Convolutional Neural Network Approach
Henry Stone, Imperial College London, United Kingdom

9:30-9:55 Rough Volatility: A Measure-Change Point of View
Aitor Muguruza Gonzalez and Antoine Jacquier, Imperial College London, United Kingdom

10:00-10:25 Decomposition Formula for Rough Volterra Stochastic Volatility Models
Jan Pospisil, University of West Bohemia, Pilsen, Czech Republic; Raul Merino, University of Barcelona, Spain; Tomas Sobotka, University of West Bohemia, Pilsen, Czech Republic; Tommi Sottinen, University of Vaasa, Finland; Josep Vives, University of Barcelona, Spain

Thursday, June 6

CP12

Systemic Risk

8:30 a.m.-10:00 a.m.

Room: Room 370

Chair: Yu-Sin Chang, Milwaukee School of Engineering, U.S.

8:30-8:55 Elicitability and Identifiability of Systemic Risk Measures
Jana Hlavinova, Vienna University of Economics and Business, Austria; Tobias Fissler, Imperial College London, United Kingdom; Birgit Rudloff, Vienna University of Economics and Business, Austria

9:00-9:25 Systemic Risk and the Dependence Structures
Yu-Sin Chang, Milwaukee School of Engineering, U.S.

9:30-9:55 The Unspanned Stochastic Volatility Property
Ralph Rudd, University of Cape Town, South Africa

Coffee Break

10:30 a.m.-11:00 a.m.

Room: Myhal Atrium

Thursday, June 6

IP5

On Fairness of Systemic Risk Measures

11:00 a.m.-11:45 a.m.

Room: Myhal Auditorium (Room 150)

Chair: Sebastian Jaimungal, University of Toronto, Canada

In our previous paper "A Unified Approach to Systemic Risk Measures via Acceptance Set" (Mathematical Finance 2018), we have introduced a general class of systemic risk measures that allow random allocations to individual banks before aggregation of their risks. In the present paper, we address the question of fairness of these allocations and propose a fair allocation of the total risk to individual banks. We show that the dual formulation of the minimization problem identifying the systemic risk measure provides a valuation of the random allocations, which is fair both from the point of view of the society/regulator and from the individual financial institutions. The case with exponential utilities which allows for explicit computation is treated in details.

Jean-Pierre Fouque
University of California, Santa Barbara, U.S.

Lunch Break

11:45 a.m.-1:15 p.m.

Attendees on own

Thursday, June 6

MS24

Algorithmic Trading

1:15 p.m.-3:15 p.m.

Room: Myhal Auditorium (Room 150)

Algorithmic trading has experienced rapid growth in recent years as trading moves towards electronic platforms and computation power increases. In this minisymposium, recent academic developments in this area will be highlighted. Specific topics which will be addressed are optimal execution algorithms, analysis of high frequency trade data, and applications of modern machine learning techniques towards the design of trading algorithms. These topics are impactful through the possibility of implementation as well as considerations of regulations with respect to high frequency trading.

Organizer: Ryan Donnelly
University of Washington, U.S.

Organizer: Alvaro Cartea
University of Oxford, United Kingdom

1:15-1:40 Augmenting FX Market Making Strategies with Mid-Book Liquidity
Jason Ricci, Morgan Stanley, U.S.

1:45-2:10 Algorithmic Trading: A Reinforcement Learning Approach
Iuliia Manziuk, Université Paris 1 Panthèon-Sorbonne, France; Olivier Gueant, Université Paris-Diderot, France

2:15-2:40 Optimal Order Placement with Random Measures
Leandro Sánchez Betancourt and Alvaro Cartea, University of Oxford, United Kingdom; Sebastian Jaimungal, University of Toronto, Canada

2:45-3:10 On Detecting Spoofing Strategies in High Frequency Trading
Samuel Drapeau, Xuan Tao, and Ling Lan, Shanghai Jiao Tong University, China; Andrew Day, Western University, Canada

Thursday, June 6

MS25

Curse of Dimensionality in Quantitative Finance - Part I of II

1:15 p.m.-3:15 p.m.

Room: Room 360

For Part 2 see MS30

In recent years the amount of data and external information available in finance increased exponentially in particular in terms of heterogeneity, dimensionality as well as frequency. In other areas, this problem has been widely embraced and made significant novel advances in terms of machine learning techniques using high performance computing clusters. However, the peculiar situation in finance bears its own challenges. Indeed, the underlying human nature of financial networks differs fundamentally from physical problems: Uncertainty of observations as well as probability models, endogenous driving forces in terms of games or equilibrium situations, impact of exogenous factors. Therefore, innovative ideas and techniques are active topics of research to tackle high dimensional dynamics in terms of: * Models; * Algorithm and numerical computations of those; * Calibration to large heterogeneous and dynamical data sets in face of uncertainty. This minisymposium intends to present some of the actual problems and advanced techniques in heterogeneous and large dimensional problems in mathematical finance, from machine learning and neural network to monte carlo and stochastic optimization methods.

Organizer: Samuel Drapeau
Shanghai Jiao Tong University, China

1:15-1:40 Stochastic Games with Impulse Control
Xin Guo, University of California, Berkeley, U.S.

1:45-2:10 Multivariate Gaussian Process Regression for Portfolio Risk Modeling: Application to CVA
Matthew F. Dixon, Illinois Institute of Technology, U.S.

2:15-2:40 Neural Network based Approximation Algorithm for Semilinear Parabolic PDEs with Application to Pricing
Ariel Neufeld, ETH Zürich, Switzerland

2:45-3:10 Computational Methods for Martingale Optimal Transport Problems
Guaoyue Guo, University of Michigan, U.S.

Thursday, June 6

MS26

Network and Mean-Field Models in Systemic Risk - Part II of II

1:15 p.m.-3:15 p.m.

Room: Room 315

For Part 1 see MS21

Systemic risk is the risk that a large number of components of an interconnected financial system fail within a short time thus leading to the overall failure of the system itself. In addition to the explicit interaction between banks through liabilities, implicit interactions exist through, e.g., fire sales, confidence, and liquidity crises. Since the 2008-2009 financial crisis, there has been almost universal agreement that these interactions need to play a more significant role in how we quantify the risks of financial institutions. However, the literature on this issue remains in its infancy. Two major streams of literature exist: network models and mean-field models. Each of these distinct streams comes with its own advantages and shortcomings. The network models typically focus on finite number of heterogeneous institutions in static time, though analytical solutions to these models are often intractable. The mean-field models natively consider time dynamics and provide, often, tractable solutions, but at the cost of homogeneity of a continuum of agents. Our session aims to bridge the divide between these mathematical frameworks for studying systemic risk by bringing together experts in both fields. The specific focus is on the major challenges and recent development of mathematical frameworks to model the interactions between agents in the system and the simultaneous risk of default of a large part of the system.

Organizer: Zachary Feinstein
Washington University in St. Louis, U.S.

Organizer: Andreas Sojmark
Oxford University, United Kingdom

1:15-1:40 A Mean-Field Perspective on the Interplay Between Common Exposures and Contagion
Andreas Sojmark, Oxford University, United Kingdom

1:45-2:10 Interaction Through Hitting Times: from Systemic Risk to Supercooled Stefan Problems
Mykhaylo Shkolnikov, Princeton University, U.S.

2:15-2:40 An Integrated Model for Fire Sales and Default Contagion in Financial Systems
Nils Detering, University of California, Santa Barbara, U.S.; Thilo Meyer-Brandis, Konstantinos Panagiotou, and Daniel Ritter, University of Munich, Germany

2:45-3:10 Optimal Bailouts with the Doom Loop and Financial Contagion
Felix C. Corell, European University Institute, Italy; Agostino Capponi, Columbia University, U.S.

Thursday, June 6

MS27

Post-Crisis Financial Mathematics: Counterparty Risk, Funding and Central Counterparties

1:15 p.m.-3:15 p.m.

Room: Room 330

As a consequence of the 2007-2009 financial crisis academics and practitioners are revisiting the valuation of financial products in several aspects. In particular the value of a product should account for the possibility of default of any agent involved in the transaction. Also the trading activity is be funded by resorting on different sources of liquidity which results in the interest rate multi-curve phenomenon, so that the existence of a unique source of funding growing at a risk-free interest rate no longer represents a realistic assumption. Financial regulations such as Basel III/IV are also driving the methodological development. Regulations on collateral imply an increasingly important role of central counterparties. All these issues are represented at the level of valuation equations by introducing value adjustments, which are further terms to be added or subtracted to an idealized reference price computed under idealized conditions, in order to obtain the final value of the transaction. The aim of the minisimposium is to investigate recent developments in the pricing of counterparty risk and funding.

Organizer: Alessandro Gnoatto
University of Verona, Italy

1:15-1:40 BSDEs of Counterparty Risk in the Presence of Multiple Discounting Rules and Aggregation Levels
Alessandro Gnoatto, University of Verona, Italy; Francesca Biagini, Ludwig Maximilian University of Munich, Germany; Immacolata Oliva, University of Florence, Italy

1:45-2:10 Integrated Structural Approach to Counterparty Credit Risk with Dependent Jumps
Laura Ballotta, University of London, United Kingdom; Gianluca Fusai, Cass Business School, United Kingdom and Università degli Studi del Piemonte Orientale, Italy; *Daniele Marazzina*, Politecnico di Milano, Italy

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Thursday, June 6

MS27

Post-Crisis Financial Mathematics: Counterparty Risk, Funding and Central Counterparties

continued

2:15-2:40 Deeply Learning Derivatives
Ryan Ferguson, Riskfuel Analytics, Canada; Andrew Green, Scotiabank, U.S.

2:45-3:10 XVA Analysis from the Balance Sheet
Stephane Crepey, Evry University, France; Claudio Albanese, Global Valuation Limited, United Kingdom

Thursday, June 6

MS28

Modern Portfolio Optimization Problems - Part II of II

1:15 p.m.-3:15 p.m.

Room: Room 380

For Part 1 see MS23

This two-part minisymposium will discuss new directions in stochastic control motivated by portfolio optimization problems. These may come from traditional utility maximization, but where volatility or Sharpe ratios are stochastic; models incorporating transaction costs; forward performance processes; optimal execution of large sell orders; accelerated share repurchases; feedback of optimal strategies onto price dynamics; and arbitrage in stochastic portfolio theory. This leads to challenging mathematics involving fixed point problems, rank-based diffusions, HJB equations with singular terminal conditions, asymptotic approximations and computation. The session brings together international experts working in different branches of financial control problems, and it is designed to highlight to graduate student participants the range of research topics and challenges at the forefront of modern investment and trading science.

Organizer: Mykhaylo Shkolnikov
Princeton University, U.S.

Organizer: Ronnie Sircar
Princeton University, U.S.

1:15-1:40 Hedging Non-Tradable Risks with Transaction Costs and Price Impact
Ryan Donnelly, University of Washington, U.S.

1:45-2:10 Equilibrium Asset Pricing with Transaction Costs
Johannes Muhle-Karbe, Carnegie Mellon University, U.S.

2:15-2:40 Forward Rank-Dependent Performance Processes: Time-Consistent Investment under Probability Distortion
Thaleia Zariphopoulou, University of Texas at Austin, U.S.

2:45-3:10 Trading, Market Impact and Nonlinear Systems
Ronnie Sircar, Princeton University, U.S.

Thursday, June 6

CP13

Portfolio Optimization

1:15 p.m.-3:15 p.m.

Room: Room 320

Chair: Jari Toivanen, University of Jyvaskyla, Finland

1:15-1:40 Outperformance and Tracking Via Convex Analysis
Ali Al-Aradi and Sebastian Jaimungal, University of Toronto, Canada

1:45-2:10 Dynamically Optimal Portfolio Selection with Transaction Costs
Zi Ye and Chi Seng Pun, Nanyang Technological University, Singapore

2:15-2:40 Optimal Investment with Transient Price Impact
Moritz Voss, University of California, Santa Barbara, U.S.; Peter Bank, Technische Universität Berlin, Germany

2:45-3:10 Monte Carlo Mean-Variance Portfolio Optimization
Jari Toivanen and Raino Mäkinen, University of Jyvaskyla, Finland

Thursday, June 6

CP14

Mean-Field Games

1:15 p.m.-3:15 p.m.

Room: Room 350

Chair: Dena Firoozi, University of Toronto, Canada

1:15-1:40 Relative Arbitrage Opportunities in *N* Investors and Mean-Field Regimes
Tianjiao Yang, University of California, Santa Barbara, U.S.; Tomoyuki Ichiba, University of California, Santa Barbara, U.S.

1:45-2:10 Mean-Field Leader-Follower Games with Terminal State Constraint
Guanxing Fu, Humboldt University at Berlin, Germany; Ulrich Horst, Humboldt University Berlin, Germany

2:15-2:40 Extended Mean-Mean Field Control and Mean-Field-Type Game of Optimal Traders
David Evangelista, King Abdullah University of Science & Technology (KAUST), Saudi Arabia

2:45-3:10 Major-Minor Mean Field Games with Latent Factors
Dena Firoozi and Sebastian Jaimungal, University of Toronto, Canada; Peter E. Caines, McGill University, Canada

Thursday, June 6

CP15

Machine Learning in Finance I

1:15 p.m.-3:15 p.m.

Room: Room 370

Chair: Natasa Tagsovska, University of Lausanne, Switzerland

1:15-1:40 Multi-Objective Genetic Algorithms under Uncertainty
Esteve Borras Mora, EDF Energy R&D UK Centre, IDCORE, United Kingdom; James Spelling, EDF Energy R&D UK Centre, United Kingdom; Harry van der Weijde, University of Edinburgh, United Kingdom

1:45-2:10 Implementation of Supervised Learning Approach in MTPL Claim Assessment
Mervan Aksu and Ayse Sevtap Selcuk-Kestel, Middle East Technical University, Turkey

2:15-2:40 Double Deep Q-Learning for Optimal Execution
Xin Ning, Franco Lin, and Sebastian Jaimungal, University of Toronto, Canada

2:45-3:10 Auto-Encoded Scenario Generation
Natasa Tagsovska, University of Lausanne, Switzerland; Damien Ackerer, Swissquote Bank, Switzerland; Thibault Vatter, Columbia University, U.S.

Coffee Break

3:15 p.m.-3:45 p.m.

Room: Myhal Atrium

Thursday, June 6

MS29

Recent Advances in Fractional Volatility Models

3:45 p.m.-5:45 p.m.

Room: Myhal Auditorium (Room 150)

Fractional stochastic volatility models (both rough and long-memory) are a cutting-edge research area in financial mathematics. The goal of this minisymposium is to explore different aspects of fractional stochastic volatility models, including, but not limited to, pricing, hedging, estimation, and filtering.

Organizer: Alexandra Chronopoulou
University of Illinois at Urbana-Champaign, U.S.

3:45-4:10 Deep Learning Volatility
Blanka N. Horvath, Imperial College London, United Kingdom; Aitor Muguruza, Imperial College, London, U.K. and Natixis, U.S.; Mehdi Tomas, Ecole Polytechnique, France

4:15-4:40 Volatility Options in Rough Volatility Models
Antoine Jacquier, Imperial College London, United Kingdom

4:45-5:10 On Smile Properties of Volatility Derivatives and Exotic Products: Understanding the VIX Skew
Elisa Alos, Universitat Pompeu Fabra, Spain; David García-Lorite, CaixaBank, Spain; *Aitor Muguruza*, Imperial College, London, U.K. and Natixis, U.S.

5:15-5:40 Portfolio Optimization under Fractional Volatility Models
Ruimeng Hu, Columbia University, U.S.

Thursday, June 6

MS30

Curse of Dimensionality in Quantitative Finance - Part II of II

3:45 p.m.-5:45 p.m.

Room: Room 360

For Part 1 see MS25

In recent years the amount of data and external information available in finance increased exponentially in particular in terms of heterogeneity, dimensionality as well as frequency. In other areas, this problem has been widely embraced and made significant novel advances in terms of machine learning techniques using high performance computing clusters. However, the peculiar situation in finance bears its own challenges. Indeed, the underlying human nature of financial networks differs fundamentally from physical problems: Uncertainty of observations as well as probability models, endogenous driving forces in terms of games or equilibrium situations, impact of exogenous factors. Therefore, innovative ideas and techniques are active topics of research to tackle high dimensional dynamics in terms of: * Models; * Algorithm and numerical computations of those; * Calibration to large heterogeneous and dynamical data sets in face of uncertainty. This minisymposium intends to present some of the actual problems and advanced techniques in heterogeneous and large dimensional problems in mathematical finance, from machine learning and neural network to monte carlo and stochastic optimization methods.

Organizer: Samuel Drapeau
Shanghai Jiao Tong University, China

3:45-4:10 Model-Uncertain Value-at-Risk, Expected Shortfall and Sharpe Ratio, Using Stochastic Approximation
Emmanuel Gobet, Ecole Polytechnique, France

4:15-4:40 Robust Finance with Neural Networks, Duality and Penalization
Stephan Eckstein, University of Konstanz, Germany

4:45-5:10 Conditional Monte Carlo Learning for Diffusions
Lokman Abbas Turki, Babacar Diallo, and Gilles Pagès, Laboratoire de Probabilités, Statistique et Modélisation (LPSM), France

5:15-5:40 The Universality Problem in Dynamic Machine Learning with Applications to Realized Covolatilities Forecasting I
Juan Pablo Ortega, University of Sankt-Gallen, Switzerland; Lukas Gonon, University of St. Gallen, Switzerland; Lyudmila Grigoryeva, University of Konstanz, Germany

continued in next column

Thursday, June 6

MS31

Systemic Risk: Sourcing, Measuring, and Allocation

3:45 p.m.-5:45 p.m.

Room: Room 315

The inevitably complex structure of dependencies among institutions is one of the most defining characteristics of the modern financial environment. While this tremendous blend of dependencies and interactions provides the members with a great number of opportunities, it is also the source of an enormous threat: the interlocking and pervasive structures make the system in large parts or even as a whole fragile to possible initial local shock events. The problem of modeling, understanding, and managing this notion of systemic risk has been an important research topic after the strike of the global financial crisis in the years 2007/08. The minisymposium intends to present some recent advances in analysing systemic risk, where in particular it addresses two main aspects. The first one is to understand and model sources of systemic risk, that is to analyse causes and amplification of local shocks to the system that can lead to a financial crisis. Here, the information dynamics in financial networks as well as the integration within the global macroeconomic system are important aspects. Secondly, the question of how to design suitable measures of systemic risk and how to allocate total systemic risk to individual institutions will be addressed. In particular, the identification of systemic risk allocation that can be considered fair both from the society as well as the single institution point of view is a challenging but important task.

Organizer: Thilo Meyer-Brandis
University of Munich, Germany

3:45-4:10 Systemic Risk Measures: Random Capital Allocation and Fair Risk Allocation
Thilo Meyer-Brandis, University of Munich, Germany

4:15-4:40 Systemic Risk and Capital Allocation Risk Transfer Equilibria
Marco Frittelli, Universita' degli Studi di Milano, Italy

continued on next page

4:45-5:10 Dynamic Information Regimes in Financial Markets
Paul Glasserman, *Yiwen Shen*, and Harry Mamaysky, Columbia University, U.S.

5:15-5:40 Banking Networks and the Circuit Theory of Money
Matheus R. Grasselli, McMaster University, Canada

Thursday, June 6

MS32

New Challenges and Mathematical Models in Energy and Commodity Markets - Part I of III

3:45 p.m.-5:45 p.m.

Room: Room 330

For Part 2 see MS37

Recent developments and on-going changes across commodity markets have attracted the interest of researchers from many different backgrounds, applying a wide range of mathematical techniques. The energy industry in particular faces many challenges as it adapts to new types of supply, changing demand patterns, regulatory constraints, environmental concerns and technological advances. Now more than ever, opportunities abound for the creation and implementation of innovative mathematical models to tackle these problems, or to efficiently manage the associated financial risks. Unlike more traditional financial markets, the initial step of modeling spot or forward prices on oil, natural gas, electricity or other commodities is still much researched, with improvements frequently proposed in light of structural changes and complex inter-dependencies. In addition, the application of such models to practical valuation and risk management problems throws up many other interesting issues. Forecasting, derivative pricing, hedging, management of physical assets and market design are important topics in modern commodity markets. This minisymposium will explore a broad spectrum of current research in such areas, ranging from shipping to mining to power generation and trading. Bringing academics and practitioners together, advanced mathematical techniques will complement practical real-world insight to facilitate stimulating discussions on the future of energy and commodity finance.

Organizer: Nina Lange
Technical University of Denmark, Denmark

Organizer: Michael Coulon
University of Sussex, United Kingdom

3:45-4:10 Wind Park Valuation and Risk Management in German Intraday Power Markets
Michael Coulon, University of Sussex, United Kingdom; Jonas Ströjby, Alpiq, Sweden

4:15-4:40 Real Switching Options in Peaking Power Plants: The Effect of Capacity Payments
Stein-Erik Fleten, Norwegian University of Science and Technology, Norway; Benjamin Fram, Norwegian School of Economics, Norway; Ledsaak Magne, Mehl Sigurd, and Røssum Ola, Norwegian University of Science and Technology, Norway; Carl Ullrich, James Madison University, U.S.

4:45-5:10 Stress Testing Methods for the Energy Industry
Facundo Zapata, Capital Power, Canada; Zachary Moyer, ICE NGX, Canada

5:15-5:40 Forecasting Conditional Volatility of Crude Oil using Intra-Day Curves
Yuqian Zhao, University of Waterloo, Canada

continued in next column

Thursday, June 6

MS33

Portfolio Selection Driven by Behavioral Finance Studies

3:45 p.m.-5:45 p.m.

Room: Room 380

Behavioral finance studies show that investors are not fully "rational" and uniformly risk averse as characterized by the classical expected utility theory (EUT). The cumulative prospect theory (CPT), proposed by Kahneman and Tversky, provides alternative and convincing explanations on risk attitudes and preferences. In addition, the widely used exponential discounting violates the dominant "decreasing impatience" found by behavioral studies. The growing interests in behavioral finance demand new research in behavioral portfolio selection problems, and this minisymposium aims to advance and share the latest findings in this research direction.

Organizer: Bin Zou
University of Connecticut, U.S.

3:45-4:10 Cumulative Prospect Theory with Skewed Return Distribution
Traian A. Pirvu, McMaster University, Canada; Minsuk Kwak, Korea Advanced Institute of Science and Technology, Korea

4:15-4:40 Optimal Investment in Illiquid Markets for Investors with CPT Preferences
Miklos Rasonyi, Renyi Alfred Mathematical Institute of the Hungarian Academy, Hungary; Ngoc Huy Chau, Hungarian Academy of Sciences, Hungary

4:45-5:10 Behavioral Finance Driven Investment Strategies
Rudi Zagst, Technische Universitaet Muenchen, Germany

5:15-5:40 Strong and Weak Equilibria for Time-Inconsistent Stochastic Control in Continuous Time
Zhou Zhou, University of Sydney, Australia; Yu-Jui Huang, University of Colorado Boulder, U.S.

Thursday, June 6

CP16

Optimal Stopping and Price Design

3:45 p.m.-5:45 p.m.

Room: Room 320

Chair: David A. Edwards, University of Delaware, U.S.

3:45-4:10 Roll-Over Risk with a Foreign Exchange Analogy
David Skovmand, University of Copenhagen, Denmark; Andrea Macrina, University College London, United Kingdom; Alex Backwell, University of Cape Town, South Africa; Erik Schlogl, University of Technology, Sydney, Australia

4:15-4:40 Spatially Determined Optimal Price Design in a Ride Sharing Economy
Meichun Lin, University of British Columbia, Canada; Samuel Drapeau, Shanghai Jiao Tong University, China

4:45-5:10 Optimal Governmental Control of the Debt-to-GDP Ratio in a Regime-Switching Economy
Neofytos Rodosthenous, Queen Mary University of London, United Kingdom; Giorgio Ferrari, Bielefeld University, Germany

5:15-5:40 An Optimal Mortgage Refinancing Strategy with Stochastic Interest Rate
David A. Edwards, University of Delaware, U.S.; Xiaoxia Wu, University of Texas at Austin, U.S.; Dejun Xie, Xi'an Jiaotong University, P.R. China

Thursday, June 6

CP17

Optimal Control and Utility Maximization

3:45 p.m.-5:45 p.m.

Room: Room 350

Chair: Nicola Secomandi, Carnegie Mellon University, U.S.

3:45-4:10 Diffusion Approximations for Expert Opinions and Power Utility Maximization in a Financial Market with Gaussian Drift
Ralf Wunderlich, Brandenburg University of Technology Cottbus-Senftenberg, Germany

4:15-4:40 Stochastic Control and Differential Games with Path-Dependent Controls
Yuri Saporito, Fundacao Getulio Vargas, Brazil

4:45-5:10 Epstein-Zin Utility Maximization on Random Horizons
Joshua Aurand and Yu-Jui Huang, University of Colorado Boulder, U.S.

5:15-5:40 Optimization of Option Exercise Policies in Incomplete Markets with Quadratic Hedging
Nicola Secomandi, Carnegie Mellon University, U.S.

Thursday, June 6

CP18

Machine Learning in Finance II

3:45 p.m.-5:45 p.m.

Room: Room 370

Chair: Oleksandr Romanko, IMA/IBM T.J. Watson Research Center, U.S.

3:45-4:10 Assessing Calibration Risk of Option Pricing Models
Gianluca Fusai, Cass Business School, United Kingdom and Università degli Studi del Piemonte Orientale, Italy

4:15-4:40 Deep Smoothing of the Implied Volatility Surface
Damien Ackerer, Swissquote Bank, Switzerland; Natasa Tagsovska, University of Lausanne, Switzerland; Thibault Vatter, Columbia University, U.S.

4:45-5:10 Exploration Versus Exploitation in Reinforcement Learning: A Stochastic Control Approach
Haoran Wang, Columbia University, U.S.; Thaleia Zariphopoulou, University of Texas at Austin, U.S.; Xunyu Zhou, Columbia University, U.S.

5:15-5:40 Artificial Intelligence-Driven Financial Risk Analytics and Portfolio Optimization
Oleksandr Romanko, IMA/IBM T.J. Watson Research Center, U.S.

Intermission

5:45 p.m.-6:00 p.m.

Thursday, June 6

IP6

New Trends in Optimal Execution

6:00 p.m.-6:45 p.m.

Room: Myhal Auditorium (Room 150)

Chair: Harvey Stein, Bloomberg LP, U.S.

For two decades now, a lot of academics are following the road opened by Almgren, Chriss, Bertsimas and Lo. Their frameworks proposed to combine liquidity costs and inventory risk to obtain optimal trade schedules driven by a trading speed. Different improvements have been proposed: modifications of the value functions led to different shapes of optimal trading speed, U-shaped or L-shaped, deterministic or stochastic. Controls have been extended to incorporate trading directly in an orderbook, using market or limit orders, or dark orders. This talk will try to foresee the qualitative improvements to be made to these frameworks. Thanks to recent papers, I will mostly underline few trends: first of all a better understanding of game theoretic aspects started to provide new kind of results, allowing to take into account liquidity costs a very dynamic way. On another hand execution signals like imbalances emerged in the literature; as a consequence we should be able to provide standard ways to take them into account inside a trading strategy. Last but not least, the understanding of market impact improved, it should be great to include impact decay and cross-impact into the frameworks.

Charles-Albert Lehalle
Capital Fund Management, France

Intermission

6:45 p.m.-7:00 p.m.

SIAG/FME Business Meeting

7:00 p.m.-8:00 p.m.

Room: Myhal Auditorium (Room 150)

Complimentary refreshments will be served.

Friday, June 7

Registration

8:00 a.m.-1:30 p.m.

Room: Myhal Atrium

Friday, June 7

MS34

Numerical Methods and Machine Learning for Finance - Part I of III

8:30 a.m.-10:00 a.m.

Room: Myhal Auditorium (Room 150)

For Part 2 see MS39

Recent results from an emerging field where combined techniques from classical numerical analysis and learning algorithms are developed to efficiently solve computational problems in finance. These approaches promise to benefit from proven advantages of classical numerical analysis and machine learning. High efficiency and understandability of numerical analysis and recent breakthroughs in parametric complexity reduction and machine learning for large-scale computational problems boost the potential of computational methods for finance. The techniques presented cover online-offline decomposition, interpolation, model order reduction techniques, combination of classical numerical methods such as discretisation of Partial Differential Equations (PDEs) with Neural Networks (NNs), and deepen the understanding of the performance of NNs. Applications to finance include Bermudan style option pricing, CVA computation, pricing of high-dimensional basket options, and solvency capital requirements.

Organizer: Kathrin Glau
Queen Mary University of London, United Kingdom

8:30-8:55 Learning Boosts Numerical Methods for Finance: From Classical PDEs to Statistical Learning and Magic Points in Finance
Kathrin Glau, Queen Mary University of London, United Kingdom; Maximilian Gau and Maximilian Mair, Technical University of Munich, Germany

9:00-9:25 Machine Hedging for Economic Competitiveness
Dilip Madan, University of Maryland, College Park, U.S.

9:30-9:55 Low Rank Tensor Approximation for Chebyshev Interpolation in Parametric Option Pricing
Francesco Statti, École Polytechnique Fédérale de Lausanne, Switzerland; Kathrin Glau, Queen Mary University of London, United Kingdom; Daniel Kressner, École Polytechnique Fédérale de Lausanne, Switzerland

Friday, June 7

MS35

High-Frequency Driven Methods: Econometrics, Liquidity, Algorithmic Trading - Part I of III

8:30 a.m.-10:30 a.m.

Room: Room 360

For Part 2 see MS40

In today's stock market, most stock exchanges have adopted electronic trading systems, where buyers and sellers can trade securities, foreign exchange or financial derivatives electronically. This has led to the development of algorithmic trading. More generally, high frequency trading (HFT) is a recent trend with a focus on short time scales. Estimates of HFT exceeds 50% of the U.S.-listed equities trading volume. There are many challenging problems arising in high frequency markets and these problems often involve more sophisticated stochastic processes and analysis. Also, some phenomena in these markets are not fully understood and modeled yet. In this minisymposium, we discuss various issues in the high frequency market, such as order book dynamics, optimal order placement strategies, liquidity costs, statistical inference, and algorithmic trading.

Organizer: Jose Figueroa-Lopez
Washington University, St. Louis, U.S.

Organizer: Kiseop Lee
Purdue University, U.S.

8:30-8:55 From Market Microstructure to Macrostructure and Financial Bubbles
Philip Protter, Columbia University, U.S.

9:00-9:25 Trade Duration, Volatility and Market Impact
Francesco Capponi, Imperial College London, United Kingdom; Rama Cont, University of Oxford, United Kingdom; Amir Sani, Simudyne Ltd.

9:30-9:55 Optimum Thresholding using Mean and Conditional Mean Squared Error
Jose Figueroa-Lopez, Washington University, St. Louis, U.S.

10:00-10:25 Statistical and Probabilistic Properties of Hawkes Processes and their Application to the Large Variations of Financial Assets Prices
Cecilia Mancini, University of Florence, Italy

Friday, June 7

MS36

Central Counterparties (CCPs) - Part I of III

8:30 a.m.-10:30 a.m.

Room: Room 315

For Part 2 see MS41

In the aftermath of the global financial crisis of 2008-09, regulators undertook a number of initiatives to cope with counterparty risk. One major evolution is the generalization and incentivization of central counterparties (CCPs). The mandates of the CCP are to centralize the collateralization and settlement of transactions and to rewire or liquidate, in the few days following the default, the CCP portfolio of a defaulted clearing member. On top of collateral in the usual sense, the clearing members contribute to a mutualized default fund set against extreme and systemic risk. However, the benefits of centrally cleared trading are controversial. In terms of: -Transparency: The clearing members suffer from the unpredictability of the evolution of their default fund contributions; -Netting: CCP operated financial networks entail a multilateral netting benefit across clients, but also a loss of bilateral netting across asset classes; -Systemic risk: With about 30 major CCPs today and only a few prominent ones, CCPs represent a major concentration risk; -Efficiency: For the clearing members, default fund contributions are capital at risk not remunerated at a hurdle rate, and raising collateral can be quite costly. The minisymposium "central counterparties" is intended to cover these different issues raised by the advent of centrally cleared trading.

Organizer: Stephane Crepey
Evry University, France

8:30-8:55 Systemic Aspects of Central Clearing-SilaMoney and Numeraire Financial
Alexander Lipton, Massachusetts Institute of Technology, U.S. and EPFL, Switzerland

9:00-9:25 Firm Capital Dynamics in Centrally Cleared Markets
Agostino Capponi and *Allen Cheng*, Columbia University, U.S.

9:30-9:55 XVA Metrics for CCP Optimisation
Yannick Armenti, BNP Paribas, France; Stephane Crepey, Evry University, France

10:00-10:25 Systemic Risk and Central Clearing Counterparty Design
Hamed Amini, Georgia State University, U.S.

Friday, June 7

MS37

New Challenges and Mathematical Models in Energy and Commodity Markets - Part II of III

8:30 a.m.-10:30 a.m.

Room: Room 330

For Part 1 see MS32
For Part 3 see MS42

Recent developments and on-going changes across commodity markets have attracted the interest of researchers from many different backgrounds, applying a wide range of mathematical techniques. The energy industry in particular faces many challenges as it adapts to new types of supply, changing demand patterns, regulatory constraints, environmental concerns and technological advances. Now more than ever, opportunities abound for the creation and implementation of innovative mathematical models to tackle these problems, or to efficiently manage the associated financial risks. Unlike more traditional financial markets, the initial step of modeling spot or forward prices on oil, natural gas, electricity or other commodities is still much researched, with improvements frequently proposed in light of structural changes and complex inter-dependencies. In addition, the application of such models to practical valuation and risk management problems throws up many other interesting issues. Forecasting, derivative pricing, hedging, management of physical assets and market design are important topics in modern commodity markets. This minisymposium will explore a broad spectrum of current research in such areas, ranging from shipping to mining to power generation and trading. Bringing academics and practitioners together, advanced mathematical techniques will complement practical real-world insight to facilitate stimulating discussions on the future of energy and commodity finance.

Organizer: Nina Lange
Technical University of Denmark, Denmark

Organizer: Michael Coulon
University of Sussex, United Kingdom

8:30-8:55 Hedging of Bunker Fuel Cost with Futures Or Forwards: Trade-Off Between Liquidity and Correlation
Nina Lange, Technical University of Denmark, Denmark; Michael Coulon, University of Sussex, United Kingdom; Diana Prinzbach, Technical University of Munich, Germany

9:00-9:25 Crude Oil Options Higher Moment Risk: Determinants and Predictive Power
Sjur Westgaard, Norwegian University of Science and Technology, Norway; *Gabriel Power* and Marie-Hélène Gagnon, Université Laval, Canada

9:30-9:55 Impact of Financial Derivatives on Mine Production Planning (Cut-Off) Decisions
Matt Thompson, Queen's University, Canada

10:00-10:25 Optimal Behaviour of Regulated Firms in SREC Markets
Arvind Shrivats and Sebastian Jaimungal, University of Toronto, Canada

Friday, June 7

MS38

Topics in Portfolio Optimization

8:30 a.m.-10:30 a.m.

Room: Room 380

Portfolio Optimization has been a classical topic in Financial Mathematics. In this session we try to look on several directions in the topic and provide new perspectives. Transaction costs have been a topic of intense study for some years, but the case of multiple assets has seen limited progress so far. Equilibrium models have been a central point in recent years. State dependence of portfolio optimization is important in the real world, but has not attracted much attention from the financial mathematics community. Finally, while both managerial compensation and delegated portfolio optimization as well as taxation have drawn some interest in the past, a unifying perspective is needed.

Organizer: Stephan Sturm
Worcester Polytechnic Institute, U.S.

8:30-8:55 Asymptotic Optimal Strategy for Portfolio Optimization in a Stochastic Environment Driven by Two Correlated Factors
Maxim Bichuch, Johns Hopkins University, U.S.; Jean Pierre Fouque, University of California, Santa Barbara, U.S.

9:00-9:25 Equilibrium Option Price with Competing Market Makers
Ibrahim Ekren, Florida State University, U.S.; Sergey Nadtochiy, University of Michigan, Ann Arbor, U.S.; Yavor Stoev, University of Michigan, U.S.

9:30-9:55 Intertemporal Portfolio Optimization for Fund Managers under Taxation
Stephan Sturm, Gu Wang, and *Jiaxuan Ye*, Worcester Polytechnic Institute, U.S.

10:00-10:25 Optimal Portfolio Under State-Dependent Expected Utility
Carole Bernard, VU Brussel, Belgium and Grenoble EM, France; Steven Vanduffel and Jiang Ye, Vrije Universiteit Brussel, Belgium

continued in next column

Friday, June 7

CP19

Stochastic Control and Optimization Problems in Financial Mathematics

8:30 a.m.-10:30 a.m.

Room: Room 320

8:30-8:55 Stochastic Representations for Nonlocal Bellman Equations
Ruoting Gong, Illinois Institute of Technology, U.S.; Chenchen Mou, University of California, Los Angeles, U.S.; Andrzej J. Swiech, Georgia Institute of Technology, U.S.

9:00-9:25 Optimal Dynamic Futures Portfolio
Tim Leung, University of Washington, U.S.

9:30-9:55 Asymptotic Approximation of Optimal Portfolio for Small Time Horizons
Hussein Nasralah, Worcester Polytechnic Institute, U.S.

10:00-10:25 Random Horizon Principal-Agent Problem
Junjian Yang, Vienna University of Technology, Austria

Friday, June 7

CP20

Stochastic and Dynamic Equilibrium

8:30 a.m.-10:30 a.m.

Room: Room 350

Chair: Wei Wei, University of Waterloo, Canada

8:30-8:55 Robust Time-Inconsistent Stochastic Linear-Quadratic Control: An Open-Loop Approach
Bingyan Han, The Chinese University of Hong Kong, Hong Kong; Chi Seng Pun, Nanyang Technological University, Singapore; Hoi Ying Wong, The Chinese University of Hong Kong, Hong Kong

9:00-9:25 Non-Equilibrium Stochastic Dynamics on Complex Networks: A Spectral Analysis
Inbar Seroussi and Nir Sochen, Tel Aviv University, Israel

9:30-9:55 Open-Loop Equilibrium Strategy for Mean-Variance Portfolio Problem under Stochastic Volatility
Tingjin Yan and Hoi Ying Wong, The Chinese University of Hong Kong, Hong Kong

10:00-10:25 Failure of Smooth Pasting Principle and Nonexistence of Equilibrium Stopping Rules under Time-Inconsistency
Wei Wei, University of Waterloo, Canada; Xunyu Zhou, Columbia University, U.S.; Kenseng Tan, University of Waterloo, Canada

Friday, June 7

CP21

Backward SDEs and Portfolio Problems

8:30 a.m.-10:30 a.m.

Room: Room 370

Chair: Sotirios Sabanis, University of Edinburgh, United Kingdom

8:30-8:55 A Backward Simulation Method for Stochastic Control Problems
Zhiyi Shen and Chengguo Weng, University of Waterloo, Canada

9:00-9:25 Optimal Prediction Problems Driven by Lévy Processes
Monica B. Carvajal Pinto, The University of Manchester, UK; Kees van Schaik, University of Manchester, United Kingdom

9:30-9:55 XVA Valuation under Market Illiquidity
Weijie Pang and Stephan Sturm, Worcester Polytechnic Institute, U.S.

10:00-10:25 Portfolio Diversification Based on Ratios of Convex Risk Measures
Sotirios Sabanis and Mathias Barkhagen, University of Edinburgh, United Kingdom; Brian Fleming, Aberdeen Standard Investments, U.K.; Jacek Gondzio and Joerg Kalcsics, University of Edinburgh, United Kingdom; Jens Kroeske and Arne Staal, Aberdeen Standard Investments, U.K.; Sergio Garcia Quiles, University of Edinburgh, United Kingdom

Coffee Break

10:30 a.m.-11:00 a.m.

Room: Myhal Atrium

Friday, June 7

IP7

Rough Covariance Modeling

11:00 a.m.-11:45 a.m.

Room: Myhal Auditorium (Room 150)

Chair: Francesca Biagini, Ludwig-Maximilians-Universität München, Germany

The rough volatility paradigm asserts that the trajectories of assets' volatility are rougher than Brownian motion, a revolutionary perspective that has changed certain persistent views of volatility. It provides through stochastic Volterra processes a universal approach to capture important features of time series and option price data as well as microstructural foundations of markets. We view stochastic Volterra processes from an infinite dimensional perspective, which allows to dissolve a generic non-Markovanity of the at first sight naturally low dimensional volatility process. This approach enables to go beyond the univariate case considered so far and to treat the challenging problem of multivariate rough covariance models for more than one asset. We shed light on the multivariate situation from a statistical angle and provide modeling approaches via rough affine covariance models, in particular a multivariate rough Heston type model based on a rough Wishart process.

Christa Cuchiero
Vienna University of Economics and Business, Austria

Lunch Break

11:45 a.m.-1:15 p.m.

Attendees on own

SIAG/FME Conference Paper Prize Session

11:45 a.m.-1:15 p.m.

Room: Myhal Auditorium (Room 150)

Friday, June 7

MS39

Numerical Methods and Machine Learning for Finance - Part II of III

1:15 p.m.-3:15 p.m.

Room: Myhal Auditorium (Room 150)

For Part 1 see MS34
For Part 3 see MS44

Recent results from an emerging field where combined techniques from classical numerical analysis and learning algorithms are developed to efficiently solve computational problems in finance. These approaches promise to benefit from proven advantages of classical numerical analysis and machine learning. High efficiency and understandability of numerical analysis and recent breakthroughs in parametric complexity reduction and machine learning for large-scale computational problems boost the potential of computational methods for finance. The techniques presented cover online-offline decomposition, interpolation, model order reduction techniques, combination of classical numerical methods such as discretisation of Partial Differential Equations (PDEs) with Neural Networks (NNs), and deepen the understanding of the performance of NNs. Applications to finance include Bermudan style option pricing, CVA computation, pricing of high-dimensional basket options, and solvency capital requirements.

Organizer: Kathrin Glau
Queen Mary University of London, United Kingdom

1:15-1:40 Numerical Valuation of Bermudan Basket Options via Partial Differential Equations

Karel in 't Hout and Jacob Snoeijer, University of Antwerp, Belgium

1:45-2:10 Fast Pricing and Credit Exposure Calculation for Bermudan and Barrier Options using Chebyshev Interpolation

Christian Pötz and Kathrin Glau, Queen Mary University of London, United Kingdom; Mirco Mahlstedt, Technical University of Munich, Germany; Ricardo Pachon, Credit Suisse, United Kingdom

2:15-2:40 The Universality Problem in Dynamic Machine Learning with Applications to Realized Covolatilities Forecasting II

Lukas Gonon, University of St. Gallen, Switzerland; Lyudmila Grigoryeva, University of Konstanz, Germany; Juan Pablo Ortega, University of Sankt-Gallen, Switzerland

2:45-3:10 Machine Learning for Quantitative Finance: Fast Derivative Pricing

Sofie Reyners, Katholieke Universiteit Leuven, Belgium; Wim Schoutens, KU Leuven, Belgium; Dilip Madan, University of Maryland, College Park, U.S.; Jan De Spiegeleer, Katholieke Universiteit Leuven and RiskConcile, Belgium

continued in next column

Friday, June 7

MS40

High-Frequency Driven Methods: Econometrics, Liquidity, Algorithmic Trading - Part II of III

1:15 p.m.-3:15 p.m.

Room: Room 360

For Part 1 see MS35
For Part 3 see MS45

In today's stock market, most stock exchanges have adopted electronic trading systems, where buyers and sellers can trade securities, foreign exchange or financial derivatives electronically. This has led to the development of algorithmic trading. More generally, high frequency trading (HFT) is a recent trend with a focus on short time scales. Estimates of HFT exceeds 50% of the U.S.-listed equities trading volume. There are many challenging problems arising in high frequency markets and these problems often involve more sophisticated stochastic processes and analysis. Also, some phenomena in these markets are not fully understood and modeled yet. In this minisymposium, we discuss various issues in the high frequency market, such as order book dynamics, optimal order placement strategies, liquidity costs, statistical inference, and algorithmic trading.

Organizer: Jose Figueroa-Lopez
Washington University, St. Louis, U.S.

Organizer: Kiseop Lee
Purdue University, U.S.

1:15-1:40 Optimal High-Frequency Trading in Intraday Electricity Markets
Peter Tankov and Laura Tinsi, ENSAE ParisTech, France

1:45-2:10 A Ranking Methodology for Market Making Activity
Othmane Mounjid, Ecole Polytechnique, France; *Mathieu Rosenbaum*, CMAP, Ecole Polytechnique, France; Pamela Saliba, Ecole Polytechnique, France

2:15-2:40 Optimal Kernel Estimation of Spot Volatility with Leverage and Microstructure Noise
Bei Wu, Washington University, St. Louis, U.S.

2:45-3:10 Optimal Placement of a Small Order in a Diffusive Limit Order Book
Hyoeun Lee, University of Illinois at Urbana-Champaign, U.S.

Friday, June 7

MS41

Central Counterparties (CCPs) - Part II of III

1:15 p.m.-3:15 p.m.

Room: Room 315

For Part 1 see MS36
For Part 3 see MS46

In the aftermath of the global financial crisis of 2008-09, regulators undertook a number of initiatives to cope with counterparty risk. One major evolution is the generalization and incentivization of central counterparties (CCPs). The mandates of the CCP are to centralize the collateralization and settlement of transactions and to rewire or liquidate, in the few days following the default, the CCP portfolio of a defaulted clearing member. On top of collateral in the usual sense, the clearing members contribute to a mutualized default fund set against extreme and systemic risk. However, the benefits of centrally cleared trading are controversial. In terms of: -Transparency: The clearing members suffer from the unpredictability of the evolution of their default fund contributions; -Netting: CCP operated financial networks entail a multilateral netting benefit across clients, but also a loss of bilateral netting across asset classes; -Systemic risk: With about 30 major CCPs today and only a few prominent ones, CCPs represent a major concentration risk; -Efficiency: For the clearing members, default fund contributions are capital at risk not remunerated at a hurdle rate, and raising collateral can be quite costly. The minisymposium "central counterparties" is intended to cover these different issues raised by the advent of centrally cleared trading.

Organizer: Stephane Crepey
Evry University, France

1:15-1:40 The Pitfalls of Central Clearing in the Presence of Systematic Risk
Mila Getmansky Sherman, University of Massachusetts, Amherst, U.S.

1:45-2:10 Collateralized Networks
Samim Ghamami, Goldman Sachs, U.S. and University of California, Berkeley, U.S.

2:15-2:40 Liquidation Costs in CCP: Auction Versus Market Equilibrium
Mekonnen Tadese, Shanghai Jiao Tong University, China

2:45-3:10 Optimal Make Take Fees for Market Making Regulation
Thibaut Mastrolia, CMAP, Ecole Polytechnique, France; Omar El Euch, Mathieu Rosenbaum, and Nizar Touzi, Ecole Polytechnique, France

Friday, June 7

MS42

New Challenges and Mathematical Models in Energy and Commodity Markets - Part III of III

1:15 p.m.-3:15 p.m.

Room: Room 330

For Part 2 see MS37

Recent developments and on-going changes across commodity markets have attracted the interest of researchers from many different backgrounds, applying a wide range of mathematical techniques. The energy industry in particular faces many challenges as it adapts to new types of supply, changing demand patterns, regulatory constraints, environmental concerns and technological advances. Now more than ever, opportunities abound for the creation and implementation of innovative mathematical models to tackle these problems, or to efficiently manage the associated financial risks. Unlike more traditional financial markets, the initial step of modeling spot or forward prices on oil, natural gas, electricity or other commodities is still much researched, with improvements frequently proposed in light of structural changes and complex inter-dependencies. In addition, the application of such models to practical valuation and risk management problems throws up many other interesting issues. Forecasting, derivative pricing, hedging, management of physical assets and market design are important topics in modern commodity markets. This minisymposium will explore a broad spectrum of current research in such areas, ranging from shipping to mining to power generation and trading. Bringing academics and practitioners together, advanced mathematical techniques will complement practical real-world insight to facilitate stimulating discussions on the future of energy and commodity finance.

Organizer: Nina Lange
Technical University of Denmark, Denmark

Organizer: Michael Coulon
University of Sussex, United Kingdom

continued on next page

1:15-1:40 Polynomial Models for Energy Commodity Futures
Antony Ware, University of Calgary, Canada

1:45-2:10 Activity Based Modelling of Commodity Futures Markets
Svetlana Borovkova, Vrije Universiteit Amsterdam, The Netherlands; Sergiy Ladokhin, Probability, Netherlands; *Maren D. Schmeck*, Bielefeld University, Germany

2:15-2:40 Optimal Cross-Border Electricity Trading
Maria Flora, University of Verona, Italy; Alvaro Cartea, University of Oxford, United Kingdom; Tiziano Vargiolu, University of Padova, Italy; Georgi Slavov, Marex Spectron Ltd, United Kingdom

2:45-3:10 Managing Global Adjustment Penalties in the Ontario Electricity Market
Matt Davison and Arezoo Tahmabesi, Western University, Canada; Mark Somppi, Gold Corp, Canada

Friday, June 7

MS43

Applied Portfolio Optimization

1:15 p.m.-3:15 p.m.

Room: Room 380

This minisymposium will bring together speakers working on areas of applied financial portfolio management. Concepts sought by the minisymposium organizer include robust investment strategies, backtesting analysis, and numerical methods of rHJB equations.

Organizer: Andrew Papanicolaou
New York University, U.S.

1:15-1:40 Adaptive Robust Portfolio Optimization and Statistical Surrogates
Tao Chen, University of California, Santa Barbara, U.S.

1:45-2:10 A Mathematical Analysis of Technical Analysis
Bin Zou, University of Connecticut, U.S.; Matthew Lorig, University of Washington, U.S.; Zhou Zhou, University of Sydney, Australia

2:15-2:40 Stopping the Clock on Work: Practical Optimization for Retirement
James W Shearer, JW Shearer Consulting, U.S.; Harvey Stein, Bloomberg LP, U.S.

2:45-3:10 Nonlinear Filtering & Partial Information Portfolio Investment
Andrew Papanicolaou, New York University, U.S.

Friday, June 7

CP22

Dynamic Approach to Principal-Agent Problem

1:15 p.m.-3:15 p.m.

Room: Room 320

1:15-1:40 Optimal Remuneration of Correlated Consumers in Electricity Demand
Emma Hubert, Université Paris-Est Marne-la-Vallée, France

1:45-2:10 Contract Theory in a VUCA (Volatility, Uncertainty, Complexity and Ambiguity) World
Nicolas Hernández Santibáñez, University of Michigan, U.S.

2:15-2:40 On New Aspects of the Risk-Sharing Problem for Principal-Agent Contracting Models
Anthony Reveillac, INSA Toulouse, France

2:45-3:10 Continuous-Time Principal-Agent Problem in a Linear Partially Observed System
Kaitong Hu, Ecole Polytechnique, France

Friday, June 7

CP23

Risk Incentives, Levy Models, and Fake News

1:15 p.m.-2:15 p.m.

Room: Room 350

Chair: To Be Determined

1:15-1:40 How to Model Fake News

Dorje C. Brody, University of Surrey, United Kingdom

1:45-2:10 Black Economic Empowerment Contracts and Risk Incentives

Thomas A. Mcwalter, University of Cape Town and University of Johannesburg, South Africa; Peter Ritchken, Case Western Reserve University, U.S.

Friday, June 7

CP24

Dependence Modeling

1:15 p.m.-2:45 p.m.

Room: Room 370

Chair: Carole Bernard, VU Brussel, Belgium and Grenoble EM, France

1:15-1:40 Correlated Poisson Processes and Some Applications in Finance and Insurance

Michael Chiu and Ken Jackson, University of Toronto, Canada; Alexander Kreinin, IBM, Canada

1:45-2:10 Marginal and Dependence Uncertainty: Bounds, Optimal Transport, and Sharpness

Antonis Papapantoleon, National Technical University of Athens, Greece; Daniel Bartl, University of Vienna, Austria; Michael Kupper, Universität Konstanz, Germany; Thibaut Lux, Helvetia Insurance Group, Belgium

Coffee Break

3:15 p.m.-3:45 p.m.

Room: Myhal Atrium

Friday, June 7

MS44

Numerical Methods and Machine Learning for Finance - Part III of III

3:45 p.m.-5:45 p.m.

Room: Myhal Auditorium (Room 150)

For Part 2 see MS39

Recent results from an emerging field where combined techniques from classical numerical analysis and learning algorithms are developed to efficiently solve computational problems in finance. These approaches promise to benefit from proven advantages of classical numerical analysis and machine learning. High efficiency and understandability of numerical analysis and recent breakthroughs in parametric complexity reduction and machine learning for large-scale computational problems boost the potential of computational methods for finance. The techniques presented cover online-offline decomposition, interpolation, model order reduction techniques, combination of classical numerical methods such as discretisation of Partial Differential Equations (PDEs) with Neural Networks (NNs), and deepen the understanding of the performance of NNs. Applications to finance include Bermudan style option pricing, CVA computation, pricing of high-dimensional basket options, and solvency capital requirements.

Organizer: Kathrin Glau

Queen Mary University of London, United Kingdom

3:45-4:10 Understanding the Loss Surface of Neural Networks for Financial Time Series Forecasting

Anastasia Borovykh, Centrum Wiskunde & Informatica, Netherlands; Cornelis W. Oosterlee, Centrum voor Wiskunde en Informatica (CWI), Netherlands; Sander Bohte, Centrum Wiskunde & Informatica, Netherlands

4:15-4:40 Learning and Calibrating Financial Models Using Artificial Neural Networks

Shuaiqiang Liu, Delft University of Technology, Netherlands; Cornelis W. Oosterlee, Centrum voor Wiskunde en Informatica (CWI), Netherlands

continued on next page

4:45-5:10 Deep Calibration of Rough Volatility Models
Christian Bayer and Benjamin Stemper, Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany

5:15-5:40 Piecewise Constant Policy Approximations to Financial Control Problems
Christoph Reisinger, Oxford University, United Kingdom

Friday, June 7

MS45

High-Frequency Driven Methods: Econometrics, Liquidity, Algorithmic Trading - Part III of III

3:45 p.m.-5:45 p.m.

Room: Room 360

For Part 2 see MS40

In today's stock market, most stock exchanges have adopted electronic trading systems, where buyers and sellers can trade securities, foreign exchange or financial derivatives electronically. This has led to the development of algorithmic trading. More generally, high frequency trading (HFT) is a recent trend with a focus on short time scales. Estimates of HFT exceeds 50% of the U.S.-listed equities trading volume. There are many challenging problems arising in high frequency markets and these problems often involve more sophisticated stochastic processes and analysis. Also, some phenomena in these markets are not fully understood and modeled yet. In this minisymposium, we discuss various issues in the high frequency market, such as order book dynamics, optimal order placement strategies, liquidity costs, statistical inference, and algorithmic trading.

Organizer: Kiseop Lee
Purdue University, U.S.

Organizer: Jose Figueroa-Lopez
Washington University, St. Louis, U.S.

3:45-4:10 Optimal Execution with Liquidity Risk in a Diffusive Order Book Market
Kiseop Lee, Purdue University, U.S.

4:15-4:40 Market-Making by Reinforced Learning
Chuyi Yu, Washington University, St. Louis, U.S.

4:45-5:10 A Representative Agent Model Based on Risk-Neutral Prices: Ross Recovery
Hyungbin Park, Seoul National University, Korea

5:15-5:40 Equilibrium Model of Limit Order Book and Optimal Execution Problem
Eunjung Noh, Rutgers University, U.S.

Friday, June 7

MS46

Central Counterparties (CCPs) - Part III of III

3:45 p.m.-5:15 p.m.

Room: Room 315

For Part 2 see MS41

In the aftermath of the global financial crisis of 2008-09, banking regulators undertook a number of initiatives to cope with counterparty risk. One major evolution is the generalization and incentivization of central counterparties (CCPs). On top of collateral in the usual sense, the clearing members contribute to a mutualized default fund set against extreme and systemic risk. However, the benefits of centrally cleared trading are controversial. In terms of: -Transparency: The clearing members suffer from the opacity and unpredictability of the evolution of their default fund contributions; -Netting: CCP operated financial networks entail a multilateral netting benefit across clients, but also a loss of bilateral netting across asset classes; -Systemic risk: With about 30 major CCPs today and only a few prominent ones, CCPs represent a major concentration risk; -Efficiency: The way CCPs are designed today entails two major inefficiencies for the clearing members, one related to the fact that default fund contributions are capital at risk not remunerated at a hurdle rate and another one related to the cost of collateral. The minisymposium "central counterparties" is intended to cover these different issues raised by the advent of centrally cleared trading.

Organizer: Stephane Crepey
Evry University, France

3:45-4:10 Funding and Credit Risk with Locally Elliptical Portfolio Processes: An Application to CCPs
Andersen Leif, Bank of America Merrill Lynch, U.S.

4:15-4:40 How Safe Are Central Counterparties in Derivative Markets?
Mark Paddrik, Office of Financial Research, US Treasury Department, U.S.

4:45-5:10 The Tradeoff of Diversity and Diversification
Stefan Weber, Leibniz Universität Hannover, Germany; Agostino Capponi, Columbia University, U.S.; Kerstin Weske, Leibniz Universität Hannover, Germany

Friday, June 7

MS47

New Trends in BSDE Applications to Finance

3:45 p.m.-5:45 p.m.

Room: Room 330

Since their introduction about 30 years ago, the theory of (nonlinear) backward stochastic differential equations has been a very active field in stochastic analysis. This was mainly due to their applications to various problems in quantitative finance. Backward SDEs can be a formidable tool to deal with stochastic control problems, and have classically been used in finance to deal with utility maximization and equilibrium pricing problems. In the last few years, new, interesting (and for some, surprising) applications of backward SDEs to quantitative finance have emerged. The goal of the proposed minisymposium is to provide a venue to discuss some of them. The minisymposium will start with a talk introducing the theory of backward SDEs from an abstract point of view (but will be geared toward stability questions). The remaining three talks will be more financially oriented, and will discuss crucial problems, including questions of nonlinear incomplete markets, liquidity risk in imperfect markets and existence of Epstein-Zin utilities (which are popular in macro-economics). Backward SDEs will play a crucial role in the analyses of the above mentioned questions.

Organizer: Ludovic Tangpi
Princeton University, U.S.

3:45-4:10 The Stability Property of BSDEs under Mémin's Framework
Alexandros Saplaouras, The University of Michigan, Ann Arbor, U.S.

4:15-4:40 Option Pricing in a Non-Linear Incomplete Market with Default
Miryana Grigorova, University of Leeds, United Kingdom

4:45-5:10 Title Not Available
Dylan Possamaï, Columbia University, U.S.

5:15-5:40 Infinite Horizon Epstein-Zin Utility
Hao Xing and *Quoc Viet Dang*, London School of Economics and Political Science, United Kingdom

Friday, June 7

MS48

Aspects of High Dimensional Covariance Estimation for Equity Risk

3:45 p.m.-5:45 p.m.

Room: Room 380

Techniques for the statistical analysis of large data sets of returns to equities has attracted a substantial amount of interest from academia and industry. The topic is at the center of broad areas of research including econometric analysis, financial risk management and portfolio construction. This minisymposium examines the challenging aspects of high dimensional covariance estimation for factor modeling of equity risk. The advantage of these statistical techniques is that they can identify emerging drivers of correlation that are not accessible to the macroeconomic models that are more common in practice. However, serious limitations remain in the theoretical assumptions underpinning these techniques and in their applicability to real world data sets. In this session, we present the state of the art in the statistical methodology that addresses some of these numerous challenges.

Organizer: Alexander Shkolnik
University of California, Santa Barbara, U.S.

3:45-4:10 Dominant Factor Analysis
Raphael Douady, Stony Brook University, U.S. and Université Paris 1 Panthéon Sorbonne, France

4:15-4:40 Asymptotics of Emprical Eigenstructure for High Dimensional Spiked Covariance
Jianqing Fan, Princeton University, U.S.

4:45-5:10 State-Varying Factor Models of Large Dimensions
Markus Pelger and *Ruoxuan Xiong*, Stanford University, U.S.

5:15-5:40 The Dispersion Bias: Correcting a Large Source of Error in Minimum Variance Portfolios
Alexander Shkolnik, University of California, Santa Barbara, U.S.

Friday, June 7

CP25

Risk Models for Securities and Securities Options

3:45 p.m.-5:45 p.m.

Room: Room 320

3:45-4:10 Top-Down Valuation Framework for Employee Stock Options
Yang Zhou, University of Washington, U.S.

4:15-4:40 Conditional Heteroskedasticity in Log-Returns
Jennifer M. Foss, Options Clearing Corporation, U.S.

4:45-5:10 A Functional Analysis Approach to Static Replication of European Options
Sebastien Bossu, Courant Institute of Mathematical Sciences, New York University, U.S.

5:15-5:40 Detecting Meyer Growth Options in Securities Options Prices
Xinzhu Quan and Qinzheng Xu, University of Minnesota, U.S.

Friday, June 7

CP26

Forward-Backward SDES: Theory and Applications

3:45 p.m.-5:15 p.m.

Room: Room 350

Chair: Ruediger Frey, Vienna University of Economics and Business, Austria

3:45-4:10 Prospective Strict No-Arbitrage and the Fundamental Theorem of Asset Pricing under Transaction Costs
Alexander Molitor and Christoph Kühn, J.W. Goethe-Universität, Germany

4:15-4:40 Forward Performance Processes in Eve Correlation Models
Levon Avanesvan, Princeton University, U.S.

4:45-5:10 Higher-Order Discretization Methods of Forward-Backward SDEs using KLNV-Scheme and Their Applications to XVA Pricing
Yuji Shinozaki, SMBC Nikko Securities Inc and Tokyo Institute of Technology, Japan; Syoiti Ninomiya, Tokyo Institute of Technology, Japan

Friday, June 7

CP27

Asymptotic Analysis

3:45 p.m.-5:45 p.m.

Room: Room 370

Chair: Toshinao Yoshiba, Bank of Japan, Japan

3:45-4:10 Asymptotics for Volatility Derivatives in Multi-Factor Rough Volatility Models
Chloe Lacombe, Aitor Muguruza Gonzalez, and Henry Stone, Imperial College London, United Kingdom

4:15-4:40 Asymptotics of American Options and Implied Volatilities in Local Volatility Models
Florian Bourgey and Stefano De Marco, Ecole Polytechnique, France

4:45-5:10 Fast Interest Rate Option Pricing with Jumps and Stochastic Volatility
Allan Jonathan da Silva, CEFET/RJ, Brazil; Jack Baczynski, National Laboratory for Scientific Computing, Brazil; Estevão R. Junior, Laboratorio Nacional de Computacao Cientifica, Brazil

5:15-5:40 Value-at-Risk and Expected Shortfall of Stock Portfolio Using Skew-T Copulas
Toshinao Yoshiba, Bank of Japan, Japan

Intermission

5:45 p.m.-6:00 p.m.

Friday, June 7

IP8

Diamond Trees, Forests, and the Exponentiation Theorem

6:00 p.m.-6:45 p.m.

Room: Myhal Auditorium (Room 150)

Chair: Kay Giesecke, Stanford University, U.S.

We use the Itô Decomposition Formula of Alòs to express certain conditional expectations as exponentials of forests of trees. Each tree represents iterated applications of a new diamond operator. As one application, we compute an exact formal expression for the leverage swap for any stochastic volatility model expressed in forward variance form. As another, we show how to extend the Bergomi-Guyon expansion to all orders in volatility of volatility. Finally, we compute exact expressions under rough volatility, obtaining in particular the fractional Riccati equation for the rough Heston characteristic function. As a corollary, we compute a closed-form expression for the leverage swap in the rough Heston model.

Jim Gatheral
City University of New York, Baruch College, U.S.

Closing Remarks

6:45 p.m.-7:00 p.m.

Room: Myhal Auditorium (Room 150)

SIAM Conference on Financial Mathematics & Engineering

IP1

Market Microstructure Invariance: A Dynamic Equilibrium Model

Invariance relationships are derived in a dynamic, infinite-horizon, equilibrium model of adverse selection with risk-neutral informed traders, noise traders, risk-neutral market makers, and endogenous information production. Scaling laws for bet size and transaction costs require the assumption that the effort required to generate one bet does not vary across securities and time. Scaling laws for pricing accuracy and market resiliency require the additional assumption that private information has the same signal-to-noise ratio across markets. Prices follow a martingale with endogenously derived stochastic volatility. Returns volatility, pricing accuracy, market depth, and market resiliency are closely related to one another. The model solution depends on two state variables: stock price and hard-to-observe pricing accuracy. Invariance makes predictions operational by expressing them in terms of log-linear functions of easily observable variables such as price, volume, and volatility.

Albert S. Kyle
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IP2

Latency in Electronic Markets

Latency is the time delay between an exchange streaming market data to a trader, the trader processing information and deciding to trade, and the exchange receiving the order from the trader. Liquidity takers face a stochastic moving target problem as a consequence of their latency. They send market orders with a limit price that aim at a price and quantity they observed in the limit order book (LOB), and by the time their order is processed, prices could have worsened, so the order may not be filled, or prices could have improved, so the order is filled at a better price. We provide two modelling approaches to include latency in optimal trading for liquidity takers, compute the costs of improving the marksmanship of liquidity taking strategies, and show the tradeoff between execution certainty and the costs of reducing the adverse effects of latency. In our first approach, a trader targets a fill ratio and minimises the cost of walking the LOB. We derive the optimal strategy in closed-form and employ a proprietary data set to compute the shadow price of latency in FX markets. In our second approach, we employ marked point processes to model the interaction of a trader with the LOB when there is latency. We employ a variational analysis approach to derive optimal strategies, characterise them as solutions of a new class of FBSDEs, prove uniqueness and existence of the FBSDEs, and for particular examples, solve them numerically.

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IP3

Reservoir Computing, Rough Paths and Learning of Stochastic Dynamics in Finance

We connect paradigms of reservoir computing, fundamental insights of rough path theory (or the theory of regularity structures) and the theory of random projections to construct provably universal and remarkably easy to train dynamical systems for purposes of Finance, e.g. model free market scenario generation, prediction tasks, or hedging tasks.

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IP4

Managing the Libor Transition: A Quant Perspective

Investigations prompted by regulators found overwhelming evidence that some dealers were manipulating IBORs in an attempt to make profits in the derivatives market. Regulators, across the world, then started discussions on possible IBOR replacements to be used as new benchmarks in interest-rate cash and derivatives contracts, whose outstanding notional is in the hundreds of trillions of USD dollars. In June 2017, the US Alternative Reference Rates Committee announced that they had identified a Treasuries repo financing rate, which they called Secured Overnight Funding Rate (SOFR), as the best replacement for LIBOR. Starting on April 3, 2018, the New York Fed has published the SOFR every business day. Following this, the market began trading SOFR-based derivatives, such as SOFR futures and swaps, and cash instruments such as SOFR floating rate notes. The market quotes of SOFR-based contracts lead to the creation of a SOFR interest-rate curve. In this talk, we introduce a simple multi-curve interest-rate model that allows for the consistent calculation of the convexity adjustments for both SOFR futures and Eurodollar futures. We also show how the valuations of LIBOR-based swaps change because of the new LIBOR fallback introduced by ISDA. We then hint at the construction of SOFR-based volatility surfaces and cubes. Finally, we will summarize the main outstanding issues around the transition away from LIBOR.

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IP5

On Fairness of Systemic Risk Measures

In our previous paper A Unified Approach to Systemic Risk Measures via Acceptance Set (Mathematical Finance 2018), we have introduced a general class of systemic risk measures that allow random allocations to individual banks before aggregation of their risks. In the present paper, we address the question of fairness of these allocations and propose a fair allocation of the total risk to individual banks. We show that the dual formulation of the minimization problem identifying the systemic risk measure provides a valuation of the random allocations, which is fair both from the point of view of the society/regulator and from the individual financial institutions. The case with exponential utilities which allows for explicit computation is treated in details.

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IP6

New Trends in Optimal Execution

For two decades now, a lot of academics are following the road opened by Almgren, Chriss, Bertsimas and Lo. Their frameworks proposed to combine liquidity costs and inventory risk to obtain optimal trade schedules driven by a trading speed. Different improvements have been proposed: modifications of the value functions led to different shapes of optimal trading speed, U-shaped or L-shaped, deterministic or stochastic. Controls have been extended to incorporate trading directly in an orderbook, using market or limit orders, or dark orders. This talk will try to foresee the qualitative improvements to be made to these frameworks. Thanks to recent papers, I will mostly underline few trends: first of all a better understanding of game theoretic aspects started to provide new kind of results, allowing to take into account liquidity costs a very dynamic way. On another hand execution signals like imbalances emerged in the literature; as a consequence we should be able to provide standard ways to take them into account inside a trading strategy. Last but not least, the understanding of market impact improved, it should be great to include impact decay and cross-impact into the frameworks.

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IP7

Rough Covariance Modeling

The rough volatility paradigm asserts that the trajectories of assets' volatility are rougher than Brownian motion, a revolutionary perspective that has changed certain persistent views of volatility. It provides through stochastic Volterra processes a universal approach to capture important features of time series and option price data as well as microstructural foundations of markets. We view stochastic Volterra processes from an infinite dimensional perspective, which allows to dissolve a generic non-Markovanity of the at first sight naturally low dimensional volatility process. This approach enables to go beyond the univariate case considered so far and to treat the challenging problem of multivariate rough covariance models for more than one asset. We shed light on the multivariate situation from a statistical angle and provide modeling approaches via rough affine covariance models, in particular a multivariate rough Heston type model based on a rough Wishart process.

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IP8

Diamond Trees, Forests, and the Exponentiation Theorem

We use the It Decomposition Formula of Als to express certain conditional expectations as exponentials of forests of trees. Each tree represents iterated applications of a new diamond operator. As one application, we compute an exact formal expression for the leverage swap for any stochastic volatility model expressed in forward variance form. As another, we show how to extend the Bergomi-Guyon expansion to all orders in volatility of volatility. Finally, we compute exact expressions under rough volatility, obtaining in particular the fractional Riccati equation for the rough Heston characteristic function. As a corollary, we compute a closed-form expression for the leverage swap in the rough Heston model.

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CP1

Multi-Level Monte-Carlo Methods and Primal/Dual Estimates in Initial Margin Computations

The Multi-level Monte-Carlo (MLMC) method developed by Giles [2008] has been successfully applied in innumerous fields of stochastic simulation. Quoting Giles [2015], MLMC "reduces the computational cost [*with respect to standard Monte-Carlo*] by performing most simulations with low accuracy at a correspondingly low cost, with relatively few simulations being performed at high accuracy and a high cost". A natural application of this method is the evaluation of *nested* expectation of the form $E\big[g(E[f(X,Y)|X])\big]$, where f, g are given functions and (X,Y) a couple of independent random variables. Apart from the pricing of American-type derivatives, such computations arise in a large variety of risk valuations (VaR or CVaR of a portfolio, CVA), or in the assessment of margin costs of centrally cleared portfolios. In this work, we focus on the computation of Initial margins. We analyze the properties and asymptotically optimal choices of MLMC estimators in practical situations of limited regularity of the outer function g (with singularities in the first derivative). In parallel, we investigate upper and lower bounds for nested expectations as above, in the spirit of primal/dual algorithms for stochastic control problems.

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CP1

Exact Importance Sampling of Affine Processes

Affine processes are ubiquitous in finance due to their rich behavior and mathematical tractability. But for tail computations in a multivariate setting, this tractability has its limits. Importance sampling (IS) algorithms are a class of Monte Carlo methods to solve such tail estimation problems. However, a standard IS scheme entails an exponential change of measure (ECM) under which the affine process acquires a time-dependent drift. This prohibits exact sampling. We circumvent this problem by introducing an approximate ECM under which the drift coefficienct is a step function. This permits exact sampling of the

affine jump-diffusion skeleton under the proposed importance measure. As the (skeleton) discretization shrinks, the limiting measure coincides with that of the ECM and inherits all of its optimality properties. We illustrate the advantage of this exact importance sampling algorithm on a pricing application.

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CP1

Conditional Monte Carlo Methods under Stochastic Volatility Models

We develop conditional Monte Carlo methods for simulating the Heston, Stochastic Alpha Beta Rho (SABR), and Hull–White stochastic volatility models. Sampling from these models represents a nontrivial longstanding problem with various solution attempts in the literature, which are mainly based on time-discretization (or other) techniques with inherent biases, or some might be exact but with imbalanced runtimes. Our method relies on the integer moments of the conditional integrated variance. Besides the more standard case of path-independent derivatives, we exhibit the range of applicability of our methods to options whose payoff is dependent on the maximum (or minimum) value of some underlying asset, such as barrier, lookback and hindsight options, where alternative valuation approaches might even be unavailable under the asset price dynamics of interest. Numerical experiments highlight the accuracy-runtime benefits of our proposed methodologies.

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CP1

Parameter Estimation of Affine Term Structure

The econometric analysis of continuous-time affine asset pricing models requires the fast and accurate estimation of parameters. Parameter estimation on a large domain is a computationally challenging process. Singleton (2001) proposed a framework for parameter estimation using the Characteristic Function (CF) of a stochastic process. The functional form of CF for affine processes can be obtained by solving a system of Riccati equations. Solving stiff differential equations for each iteration of the estimator is computationally expensive. This is mainly because implicit methods surpass the explicit in terms of efficiency, despite the computational complexity of matrix inversion. Recently, for mildly stiff problems a class of Extended Stability Runge-Kutta (ESRK) methods have been introduced. They are less complex than their implicit counterparts, but still maintain superior efficiency over the explicit. One such class is the Runge-Kutta-Gegenbauer (RKG) stability polynomials proposed by O'Sullivan (2017). RKG have been shown to generate stability domains with imaginary extent which is crucial for non-symmetric problems. The polynomials have an arbitrarily high order of accuracy and the range of the stability domain in the imaginary direction is determined by the Gegenbauer parameter. We present our findings of applying these stabilized explicit solvers for our parameter estimation problem and compare the efficiency with the traditional implicit solvers.

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CP2

A Closed Formula for Illiquid Corporate Bonds and an Application to the European Market

We deduce a simple closed formula for illiquid corporate coupon bond prices when liquid bonds with similar characteristics (e.g. maturity) are present in the market for the same issuer. The key model parameter is the time-to-liquidate a position, i.e. the time that an experienced bond trader takes to liquidate a given position on a corporate coupon bond. The option approach we propose for pricing bonds illiquidity is reminiscent of the celebrated work of [Longstaff, 1995. How much can marketability affect security values?, The Journal of Finance, 50 (5), 1767-1774] on the non-marketability of some non-dividend-paying shares in IPOs. This approach describes a quite common situation in the fixed income market: it is rather usual to find issuers that, besides liquid benchmark bonds, issue some other bonds that either are placed to a small number of investors in private placements or have a limited issue size. The model considers interest rate and credit spread term structures and their dynamics. We show that illiquid corporate coupon bonds present an additional liquidity spread that depends on the time-to-liquidate aside from credit and interest rate parameters. We calibrate model parameters and provide a detailed application for two issuers in the European market.

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CP2

Shock Waves and Golden Shores: The Asymmetric Interaction Between Gold Prices and the Stock Market

Gold is considered a safe haven asset providing negative return correlation with the stock market in times of distress, while in more calm periods the correlation between the two is close to zero (Baur and Lucey, 2010; Bredin et al., 2015). We study the dynamic inter-linkage of gold prices and the stock market. The existing literature is extended by considering a two dimensional Hawkes process to model the

possible self- and cross-excitation of jumps across prices on gold and equities (Hawkes, 1971). Specifically, we model the log-prices of gold and a stock index as jump-diffusive processes with the jumps arriving with mutually exciting intensities. Hence, the occurrence of a negative shock to the stock index spills over into a higher probability of positive shocks to the gold price and vice versa. To perform the empirical analysis, we consider daily data on gold prices and daily closing prices on the S&P 500 index. Utilizing the knowledge that the moment conditions of the model are computed efficiently in closed form, we use the generalized method of moments to estimate the parameters of the model. We document the existence of cross-excitation between the stock index and gold prices, with the channel from the stock index to gold prices being the most pronounced. Finally, we study the power of the proposed jump model to predict future price jumps and find good performance.

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CP2

Probability Space of Regression Models and its Applications to Financial Time Series

We introduce a notion of a probability space of regression models and discuss its applications to the stress testing based on the macroeconomic scenarios provided by the Federal Reserve Bank (FRB). The probability space of regression models L=(M,P) consists of a set of regression models M and a probability measure P, which is based on the model quality, i.e. its ability to fit into historical data and to forecast the future values of the target variable. The set of regression models M is assembled by selecting various combinations of input variables with different lags, transformations, etc., and varying historical data sets that are used for model building and validation. It is assumed that the model set M is complete in the sense that it exhausts all the regression models that is possible to build given available historical data and independent variables. Each model m from the set M yields a scenario y(t;m) for the target variable y, and thus the probability space of regression models L=(M,P) allows to build a probability distribution for Y(t) for each projection time t. As an example, we demonstrate how those distributions can be used to estimate risk capital reserves required by the regulators for large U.S. banks.

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CP2

Detecting Long-Range Dependence in Financial Time Series

Various trading strategies use estimates of the fractional differencing parameter, which is an indicator of long-range dependence, for the calculation of buy and sell signals. Since conventional frequency-domain tests for this parameter require that both the length of the time series and the number of used periodogram ordinates are large, which is highly implausible in case of a rolling analysis, new small-sample tests are proposed. While the first test is based on cumulative sums of suitably transformed periodogram ordinates and is generally more powerful, the second test is based on truncated ratios of periodogram ordinates and is therefore more robust against conditional heteroscedasticity and outliers, which is of particular importance in financial applications. Both tests are applied to series of gold price returns and stock index returns in a rolling analysis. The results suggest that there is no long-range dependence, indicating that trading strategies based on fractal dynamics have no sound statistical basis.

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CP3

Contagious Defaults in a Credit Portfolio: A Bayesian Network Approach

Robustness of credit portfolio models is of great interest for financial institutions and regulators, since misspecified models translate to insufficient capital buffers and a crisis-prone financial system. In this paper, we propose a method to enhance credit portfolio models based on the model of Merton by incorporating contagion effects. While in most models the risks related to financial interconnectedness are neglected, we use Bayesian network methods to uncover the direct and indirect relationships between credits, while maintaining the convenient representation of factor models. A range of techniques to learn the structure and parameters of financial networks from real Credit Default Swaps (CDS) data is studied and evaluated. Our approach is demonstrated in detail in a stylized portfolio and the impact on standard risk metrics is estimated.

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CP3

A Closed Form Solution to the Markowitz Portfolio Problem

In 1952, Harry Markowitz transformed finance by framing the portfolio construction problem as a tradeoff between the mean and the variance of return. This application of quadratic optimization is at the basis of breakthroughs such as the Capital Asset Pricing Model (CAPM) and Arbitrage Pricing Theory (APT). The classical Markowitz problem may be solved in closed form. However, when the portfolio weights face inequality constraints, one has to resort to a numerical optimization routine. This occurs for constrains as simple and as useful in practice as the long only constraint. We show that it is still possible to obtain closed form solution to this and related constrained problems when we assume a factor model. This approach provides significant gains in either accuracy or computational efficiency. Through our closed-form formulae we are also able to study the structure of the composition and the sensitivity of constrained Markowitz portfolios in terms of various macroeconomic variables. We illustrate our results will several case studies.

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CP3

Portfolio Risk and the Quantum Majorization of Correlation Matrices

We propose quantum majorization as a way of comparing and ranking correlation matrices, with the aim of assessing portfolio risk in a unified framework. Quantum majorization is a partial order in the space of correlation matrices, which are evaluated through their spectra. We discuss the connections between quantum majorization and an important class of risk functionals, and we define two new risk measures able to capture interesting characteristics of portfolio risk.

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CP3

Bayesian Uncertainty Quantification of Local Volatility

Volatility is a very important quantity in empirical finance with a great impact on trading and pricing to avoid providing arbitrage into the market. Here we focus on estimating local volatility. Calibrating a local volatility to market prices is often very challenging as it is an inverse problem that involves estimating an unknown function from a noisy market data. While uncertainty quantification is vital for volatility, in the past there has not been much research effort in estimating the local volatility function from the option price data using probabilistic models. We propose a full Bayesian non-parametric method to estimate local volatility from the option prices. Bayesian method casts the inverse solution as the posterior distribution of the local volatility and uncertainty is attached naturally. A Gaussian process prior is used to model the local volatility as a function of price and time. The posterior is intractable as the likelihood will include the Dupires's PDE, hence MCMC is used to sample from the posterior. Direct MCMC is very expensive due to solving the PDE in each iteration using finite difference method. To reduce the computational burden of Markov Chain Monte Carlo algorithm, we use a low rank approximation of the Gaussian process with using Kahunen-Loéve expression and inference with two stage MCMC algorithm. We apply our methodology to two numerical experiments on two dataset: one synthetic and one using real data from S&P 500.

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CP4

Robust Bounds of Default Probabilities in Financial Networks

We focus on default probabilities in the Eisenberg-Noe network model with random shocks. In particular, we are interested in finding their robust bounds when financial networks are not fully observed. We first identify shock amplification caused by the network structure, which allows us to define the default probabilities in financial networks. Using mathematical programming, we then obtain their robust upper and lower bounds under partial network information. We provide two examples of the bounds. One is from a specific bank's perspective, and the other is from the regulators' perspective. Furthermore, we apply these results to computing systemic risk capital and its robust version. Numerical experiments are conducted for the verification of our theoretical results.

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CP4

Vanishing Contagion Spreads

We study default in a multi-firm equilibrium setting with incomplete information. Defaults are modeled to be consistent with the firm's balance sheet and aggregation over firms. Market prices and quantities of risk are derived in closed form. If the number of firms increases, the market prices of risk converge to a well-defined limit while the endogenous volatility and jump size of debt and equity generated by other firms' shocks vanish so that credit spreads depend asymptotically only on the firms' own cash flow risk. This novel contagion result calls into question recent results based on production economies, where quantities of risk are specified exogenously, that attribute credit spreads mostly to contagion.

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CP4

A Credit Risk Model with Liquidity and Solvency Risk

Structural approaches to credit risk modelling have traditionally focused on *solvency risk*, defined in terms of assets and liabilities of the firm. However, omission by these models of *liquidity risk* stemming from the inherent instability in funding and cash-flows results in underestimation of institutional default risk. The objective of this paper is to model these intricacies as the driving factor in default of financial firms. In particular, we propose a novel approach to the modelling of credit risk that emphasises the firm's liquidity risk and its relation with the firm's solvency. Our approach provides insights into the 'liquidity-solvency nexus' and the impact of margin requirements on default risk.

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CP4

Structural Option Pricing: A Test of Relative Pricing Between the Option and the CDs Markets

In this work we propose a new structural model of default inspired by the n-fold compound option model in Geske (1977). Here the stockholders are given the choice to default on bond reimbursements: at each payment date, the continuation value of the equity is compared with the face value of the bond due on that date. If the continuation value is larger than the payment due, the firm is kept alive and continues until the next payment date in which the same mechanism operates. Despite structural models have been mainly used in the literature for pricing risky bond and computing credit spreads, the structural model proposed herein is used instead for pricing the firm's equity. This allows to carry default risk in a new (structural) option pricing model in which the process driving the stock price is not a geometric Brownian motion but an 'extension' of the CEV model. This richer structure allows to capture some of the stylised facts observed in the option markets such as the leverage effect. After calibrating the model parameters on the firm's stock price and the series of risk-neutral probabilities of surviving extracted from the CDS spreads, a test of relative pricing is performed to assess whether the US derivative markets of equity (option market) and debt (CDS market) price default risk consistently.

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CP5

Risk-Based Optimal Portfolio of An Insurer with Regime Switching and Noisy Memory

In this talk, we consider a risk-based optimal investment problem of an insurer in a regime-switching jump-diffusion model with noisy memory. Using the model uncertainty modeling, we formulate the investment problem as a zero-sum, stochastic differential delay game between the insurer and the market, with a convex risk measure of the terminal surplus and the Brownian delay surplus. Then, by the BSDE approach, the game problem is solved. Finally, we derive analytical solutions of the game problem, for a particular case of a quadratic penalty function and a numerical example is considered.

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CP5

Static and Semi-Static Hedging, in the Dual Space

In this paper, we argue that, once the costs of maintaining the hedging portfolio are properly taken into account, semi-static portfolios should more properly be thought of as separate classes of derivatives, with non-trivial, *model-dependent* payoff structures. We derive new integral representations for payoffs of exotic European options in terms of payoffs of vanillas, different from Carr-Madan representation, and suggest approximations of the idealized static hedging/replicating portfolio using vanillas available in the market. We study the dependence of the hedging error on a model used for pricing and show that the variance of the hedging errors of static hedging portfolios can be sizably larger than the errors of variance-minimizing portfolios. We explain why the exact semi-static hedging of barrier options is impossible for processes with jumps, and derive general formulas for variance-minimizing semi-static portfolio. We show that hedging using vanillas only leads to larger errors than hedging using vanillas and first touch digitals. In all cases, efficient calculations of the weights of the hedging portfolios are in the dual space using new efficient numerical methods for calculation of the Wiener-Hopf factors and Laplace-Fourier inversion.

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CP5

A Sparse Learning Approach to Relative-Volatility-Managed Portfolio Selection

This paper proposes a self-calibrated sparse learning approach for estimating a sparse target vector, which is a product of a precision matrix and a vector, and investigates its application to finance to provide an innovative construction of relative-volatility-managed portfolios. The proposed iterative algorithm, called DECODE, jointly estimates a performance measure of the market and the effective parameter vector in the optimal portfolio solution, where the relative-volatility timing is introduced into the risk exposure of an efficient portfolio via the control of its sparsity. The portfolio's risk exposure level, which is linked to its sparsity in the proposed framework, is automatically tuned with the latest market condition without using cross-validation. The algorithm is efficient as it costs only a few computations of quadratic programming. We prove that the iterative algorithm converges and show the oracle inequalities of the DECODE, which provide sufficient conditions for a consistent estimate of an optimal portfolio. The algorithm can also handle the curse of dimensionality that the number of training samples is less than the number of assets. Our empirical studies of over-12-year backtest illustrate the relative-volatility timing feature of the DECODE and the superior out-of-sample performance of the DECODE strategy, which beats the equally-weighted strategy and improves over the shrinkage strategy.

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CP5

Eigen Portfolio Selection: A Robust Approach to Sharpe Ratio Maximization

In this paper, we study how to pick optimal portfolios by modulating the impact of estimation risk in large covariance matrices. We discover that if the expected returns vector lies in a subspace of the eigenvector space of

the sample covariance matrix, the sample-based maximum Sharpe ratio portfolio also lies in the same subspace. Due to the uneven distribution of estimation errors across different sample eigenvalues and eigenvectors, it is desirable that the portfolio estimator lies in a space spanned by a few sample eigenvectors that relatively well estimate their population counterparts. Therefore, we propose approximating the expected returns vector in a lower-dimensional subspace and use the approximation for the construction of portfolio. As long as the approximation is close to the original vector, we benefit from the reduced exposure to the estimation error without much loss in the information of the expected returns. We introduce two concrete regularization methods for approximating the expected returns vector. Extensive simulation and empirical studies are conducted to demonstrate the superiority of the two methods. Our results show that both methods mitigate the effect of the estimation error more effectively in a high-dimensional setting than a low-dimensional setting.

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CP6

Pricing and Hedging using Rough Path Signatures

We introduce signature payoffs, a family of path-dependent derivatives that are given in terms of the signature of the price path of the underlying assets. This family of derivatives is dense in the space of payoffs, a result that can be exploited to price derivatives. We also show that signatures allow us to reduce certain optimal hedging problems to finite-dimensional minimisation problems that are computationally easy to solve, by considering a specific linearised version of the optimal hedging problem. The proposed methodologies were tested on numerical experiments where we show the effectiveness of the approaches.

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CP6

The Impact of the Freedom of the Press on Risk

We provide empirical evidence that changes in the level of the freedom of the press have a substantial impact on certain risk measures. Using data from the *Freedom of the Press* annual report to capture how freely the news media can operate, we investigate how changes in the freedom of the press impact financial markets' volatility and the economic policy uncertainty index. Using data from eight of the OECD countries and the BRIC countries, we present empirical evidence that the effect of the freedom of the press shocks on the economic policy uncertainty index and on the financial markets' volatility are quite distinct, providing further support that both measures of risk capture different dimensions of uncertainty. In addition, we show that the freedom of the press deteriorates during economic recessions relative to economic expansions.

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CP6

Pricing of Cyber Insurance Contracts in a Network Model

We develop a novel approach for pricing cyber insurance contracts. The considered cyber threats, such as viruses and worms, diffuse in a structured data network. The spread of the cyber infection is modeled by an interacting Markov chain. Conditional on the underlying infection, the occurrence and size of claims are described by a marked point process. We introduce and analyze a new polynomial approximation of claims together with a mean-field approach that allows to compute aggregate expected losses and prices of cyber insurance. Numerical case studies demonstrate the impact of the network topology and indicate that higher order approximations are indispensable for the analysis of non-linear claims.

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CP6

Incomplete Equilibrium with a Stochastic Annuity

In this talk, I will present an incomplete equilibrium model to determine the price of an annuity. A finite number of agents receive stochastic income streams and choose between consumption and investment in the traded annuity. The novelty of this model is its ability to handle running consumption and general income streams. In particular, the model incorporates mean reverting income, which is empirically relevant but historically too intractable in equilibrium. The model is set in a Brownian framework, and equilibrium is characterized and proven to exist using a

system of fully coupled quadratic BSDEs. This work is joint with Gordan Zitkovic.

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CP7

Singular Perturbation Expansion for Utility Maximization with Order-Quadratic Transaction Costs

We present an expansion for portfolio optimization in the presence of small, instantaneous, quadratic transaction costs. Specifically, the magnitude of transaction costs has a coefficient that is of the order ϵ small, which leads to the optimization problem having an asymptotically singular Hamilton-Jacobi-Bellman equation, for which the solution can be expanded in powers of $\sqrt{\epsilon}$. In this paper we derive explicit formulae for the first two terms of this expansion. Analysis and simulation are provided to show the behavior of this approximate solution.

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CP7

Optimal Investment and Consumption with Forward Preferences and Uncertain Parameters

This talk solves the optimal investment and consumption strategies for an ambiguity-averse agent in an incomplete financial market. The agent seeks her best and robust strategies via optimizing her robust forward investment and consumption preferences. The market incompleteness arises from investment constraints of the agent. Her robust forward preferences and the associated optimal strategies are represented via infinite horizon BSDEs.

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CP7

Asymptotic Analysis of the Expected Utility Maximization Problem with Respect to Perturbations of the Numraire

In an incomplete model, where under an appropriate numraire, the stock price process is driven by a sigma-bounded semimartingale, we investigate the sensitivity of the expected utility maximization problem to small perturbations of the numraire. We establish a second-order expansion of the value function and a first-order approximation of the terminal wealth. Relying on a description of the base return process in terms of its semimartingale characteristics, we also construct wealth processes and corrections to optimal strategies that match the indirect utility function up to the second order. Finally, we relate the asymptotic expansions to the existence of the risk-tolerance wealth process.

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CP7

Does Frequent Human-Machine Communication Increase the Value of an Investment?

Automated investment platforms, or robo-advisors, have emerged as an alternative to the traditional financial advisor. Their viability depends in a crucial way on the efficiency of the communication passage between the human and the machine, in order for the actions of the machine to be in line with the human's best interest. We study a game-theoretic version of the mean-variance optimization problem, where the human's risk preferences evolve in time. In particular, we quantify the trade-off that the human faces between performing a costly update of risk-preferences, i.e. communicating with the machine, which in turn allows the machine to offer investment advice that is more tailored to the human's aptitude for risk.

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CP8

Dynamic Tail Inference with Log-Laplace Volatility

We propose a novel family of stochastic volatility models that enable predictive estimation of time-varying extreme event probabilities in time series with nonlinear dependence and power law tails. In contrast to other, similar stochastic volatility formalisms, ours has an explicit, closed-form expression for its conditional probability density function, which enables straightforward estimation of extreme event probabilities. The process and its volatility are conditionally power law-tailed, with tail exponent given by the reciprocal of the log-volatilitys mean absolute innovation. These models thus can accommodate conditional power law-tail behavior ranging from very weakly non-Gaussian to Cauchy-like tails. Closed-form expressions for the process conditional polynomial moments also allows for volatility modeling. We give a straightforward, probabilistic method-of-moments estimation procedure using an asymptotic result for the process conditional large deviation probabilities. We then give a simulation study and empirical applications to financial time series data, which show that this simple modeling method can be effectively used for computationally inexpensive, dynamic, and predictive tail inference in heavy-tailed time series.

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CP8

Sovereign-Bond Backed Securities as a New Safe Asset for the Eurozone: A Dynamic Credit Risk Perspective

The creation of a market in so-called European Safe Bonds (ESBies) is a highly debated proposal to improve the European monetary system. From a credit risk perspective, ESBies form the senior tranche of a CDO backed by a diversified portfolio of sovereign bonds from all members of the euro area. We propose a novel credit risk model for the hazard rates of the obligors to analyze price dynam-

ics and assess the market risk associated to such products. Our model captures salient features of the credit spread dynamics of euro area member states and is at the same time fairly tractable. We consider a reduced-form model with conditionally independent default times; the default intensities of the different obligors are modelled by CIR-type jump processes whose mean-reversion levels and jump intensities are functions of a common Markov process X. Two special cases, one where X is a finite Markov chain and another one where X is an affine process, give rise to semi-explicit (explicit up to the solution of ODE systems) pricing formulae. This in turn allows computationally tractable calibration of the underlying hazard rates via single-name credit products. The pricing of credit portfolio products is done by Fourier inversion methods. Additionally, we provide hedging results for the junior tranche of the underlying bond portfolio.

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CP8

Pricing Index Options by Static Hedging Under Finite Liquidity

We develop a model for indifference pricing in derivatives markets where price quotes have bid-ask spreads and finite quantities. The model quantifies the dependence of the prices and hedging portfolios on an investors beliefs, risk preferences and financial position as well as on the price quotes. Computational techniques of convex optimization allow for fast computation of the hedging portfolios and prices as well as sensitivities with respect to various model parameters. We illustrate the techniques by pricing and hedging of exotic derivatives on the S&P index using call and put options, forward contracts, and cash as the hedging instruments. The optimized static hedges provide good approximations of the options payouts and the spreads between indifference selling and buying prices are quite narrow as compared with the spread between superhedging and subhedging prices.

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CP8

Stochastic Volatility Asymptotics for Optimal Subsistence Consumption and Investment with Bankruptcy

Subsistence consumption and investment problems with bankruptcy are classic constrained stochastic optimal control problem in financial economic, where the consumption rate should be greater than a positive number and the investor faces a bankruptcy payment. We derive novel asymptotic solution to this problem under the fast mean-reverting stochastic volatility model. We rigorously prove that the zeroth-order approximation for the optimal pair of consumption and investment strategies leads to the first-order accuracy of the objective function. In addition, this zeroth-order suboptimal consumption-investment pair is asymptotically optimal in a class of admissible trading strategy pairs.

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CP9

Model Risk in Mean-Variance Portfolio Selection: An Analytic Solution to the Worst-Case Approach

In this paper we consider the worst-case model risk methodology described in [P. Glasserman and X. Xu, 2014. Robust risk measurement and model risk, QF 14, 29-58] for mean-variance portfolio selection. According to this methodology, one considers a class of alternative models and selects the portfolio in the worst-case scenario. The literature distinguishes between estimation and misspecification risk. In general, it is interesting to identify vulnerabilities to model error that result not only from parameter perturbations (estimation risk) but also from an error in the joint distribution of returns (misspecification risk). The deviation between statistical distributions can be measured by the Kullback-Leibler entropy. This approach has been studied in detail by Glasserman and Xu in minimal-variance portfolio optimization. Portfolio selection with model risk can be a challenging problem: it presents an additional optimization compared to the classical one. We find the analytical solution for the optimal mean-variance portfolio selection in the worst-case scenario approach. We prove that in the minimal-variance case the optimal worst-case portfolio is the same as the optimal nominal one and it is significantly different from the one found numerically by Glasserman and Xu. In the minimal-variance case, we also prove that model risk reduces to estimation risk, differently from what stated by Glasserman and Xu. A detailed numerical example is provided.

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CP9

Risk Layering Insurance Contract under Model Uncertainty

Extreme climatic events often pose significant risks on insurance companies, as well as on the insured entities. During the early development of insurance theory, the most common technique was to assume that the losses followed a known distribution and then the premium was computed using various premium principles. The assumption on full knowledge of the loss distribution is too narrow for rare events. Our approach is to challenge the accuracy of the underling model and consequently, to quantify the impact of model ambiguity on the (re)insurance contract design. We study the optimal risk allocation between an insurer and insured entity, when the decision is taken with respect to a class of alternative models. The risk is quantified

by a general distortion risk measure and the premium of the contract is computed as a distortion premium principle. If the set of feasible contracts is the set of increasing 1-Lipschitz functions, then using a distributionally robust approach, we are able to show that the optimal insurance contract is a layer-type function. Moreover, the resulting contract is robust under model misspecification. Furthermore, we study the dependence of the risk measure and the insurance premium on the set of alternative models. Numerical implementations are addressed and the performance is assessed using simulation experiments.

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CP9

A Stochastic Stefan Problem as a Model for the Limit Order Book

We prove the existence and uniqueness of solutions to a one-dimensional Stefan Problem for reflected SPDEs which are driven by space-time white noise. The solutions are shown to exist until almost surely positive blow-up times. Such equations can be thought of as a model for the limit order book, where the y axis represents order volume and the x-axis represents prices. The novel features for the equations are the presence of space-time white noise; the reflection measures, which maintain positivity for the competing profiles; and a sufficient condition to make sense of the Stefan condition at the boundary.

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CP9

A General Framework for Modeling Limit Order Books Dynamics

We present a general framework for modeling the dynamics oflimit order books, built on the combination of two modeling ingredients: the order flow -modeled as a general spatial point process- andmarket clearing, modeled via a deterministic mass transport operator acting on distributions of buy and sell orders. At the mathematical level, this corresponds to a natural decomposition of the infinitesimal generator describing the evolution of the limit order book into two operators: the generator of the order flow and the clearing operator. Our model provides a flexible framework for modeling and simulating order book dynamics and studying various scaling limits of discrete order book models. We show that our framework includes previous models, based on Poisson point processes and self-exciting point process, as special cases and yields insights into the interaction between order flow and price dynamics,the use of order book data for estimation of intraday volatility estimation and prediction of intraday price movements.

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CP10

Leave-One-Out Least Square Monte Carlo Algorithm for Pricing American Options

The least square Monte Carlo (LSM) algorithm proposed by Longstaff and Schwartz [2001] is widely used for for pricing American options. The LSM estimator contains look-ahead bias, and the conventional technique of removing it necessitates doubling simulations. This study proposes a new approach for efficiently eliminating, thereby measuring, look-ahead bias by using the leave-one-out cross-validation (LOOCV). With the leave-one-out LSM (LOOLSM) method, we show that the look-ahead bias is asymptotically proportional to the regressors-to-simulation paths ratio and the LSM estimator have overvalued the multi-asset claims. Analysis and computational evidence support our findings.

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CP10

Quantization Error in Financial Pricing: Analysis and Remedies for Stable Order of Convergence

In several PDE problems arising in finance or in other applications, the initial conditions exhibit either singularity (such as the Dirac-delta function), or discontinuity (such as the Heaviside function), or discontinuity of the derivative (such as the hockey-stick or ramp function), at certain points of the spatial domain, usually known in advance. These discontinuities render the standard error and convergence analysis results inapplicable, or at least not directly applicable. Furthermore, we may notice an erratic order of convergence, which makes any type of error estimation, as well as extrapolation of solution values difficult. We present an analysis of the error arising from certain types of non-smooth initial conditions in the numerical solution of a parabolic PDE. The analysis focuses on finite difference spatial discretization and Crank-Nicolson-Rannacher timestepping. We derive an explicit relation for the lower order terms of the error, and indicate the terms corresponding to the timestepping and quantization errors, the latter depending (linearly or quadratically) on the relative position of the point of non-smoothness in the discretization grid. We show that the order of convergence does not suffer from fluctuations, when the relative position is maintained at each refinement of the grid. We also study the effect of smoothing of the initial conditions on the order of conver-

gence.

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CP10

Epsilon Monotone Numerical Methods for Stochastic Control Problems in Finance

We discuss epsilon-monotone numerical methods for stochastic control problems in finance, with particular focus on mean-variance portfolio optimization under the jump-extended Heston model and Guaranteed Minimum Withdrawal Benefits (GMWBs) under jump diffusion models. We show that it is possible to prove convergence to the viscosity solution although the proposed methods are not strictly monotone in the viscosity sense. Numerical experiments indicating the accuracy and efficiency of the proposed methods are presented.

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CP10

A Penalty Scheme and Policy Iteration for Stochastic Hybrid Control Problems with Nonlinear Expectations

We propose a penalty method for mixed optimal stopping and control problems where the objective is evaluated by a nonlinear expectation. The solution and free boundary of an associated HJB variational inequality are constructed from a sequence of penalized equations, for which the penalization error is estimated. The penalized equation is then discretized by a class of semi-implicit monotone approximations. We further propose an efficient iterative algorithm with local superlinear convergence for solving the discrete equation. Numerical experiments are presented for an optimal investment problem under ambiguity to demonstrate the effectiveness of the new schemes. Finally, we extend the penalty scheme and its convergence analysis to stochastic hybrid control problems involving continuous and impulse controls.

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CP11

Buy Rough, Sell Smooth

Recent work has documented *roughness* in the time series of stock market volatility and investigated its implications for option pricing. We study a strategy for trading stocks based on measures of their implied and realized roughness. A strategy that goes long the roughest-volatility stocks and short the smoothest-volatility stocks earns statistically significant excess annual returns of 6% or more, depending on the time period and strategy details. The profitability of the strategy is not explained by standard factors. We compare alternative measures of roughness in volatility and find that the profitability of the strategy is greater when we sort stocks based on implied rather than realized roughness. We interpret the profitability of the strategy as compensation for near-term idiosyncratic event risk.

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CP11

Rough Volatility: A Measure-Change Point of View

We consider the family of changes of measure applicable to the RFSV model introduced by Gatheral, Jaisson and Rossembaum and further generalisations. In particular, we aim at understanding the consistent link between the physical (P) and pricing (Q) measures. We discover an unexpected short/long memory relation in rough volatility and discuss the range of change of measures that could produce realistic smiles in VIX options. Finally, we obtain a neat formula relating the risk premium inferred from the market, variance swap quotes and daily realized variance. Being the later two quantities observable, we analyse the empirical behaviour of the risk premium and propose a family of models that resembles such behaviour, yielding a $P-Q$ consistent model.

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CP11

Decomposition Formula for Rough Volterra Stochastic Volatility Models

In this talk we introduce a decomposition of the option pricing formula for the rough Volterra stochastic volatility models where the volatility process is modeled as the general exponential Volterra process, or in particular as the exponential rough fractional Brownian motion. We further derive an approximation for the price. Numerical comparison is performed against the Monte Carlo simulations results.

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CP11

Calibrating Rough Volatility Models: A Convolutional Neural Network Approach

In this paper we use convolutional neural networks to find the Hlder exponent of simulated sample paths of the rBergomi model, a recently proposed stock price model used in mathematical finance. We contextualise this as a calibration problem, thereby providing a very practical and useful application.

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CP12

Systemic Risk and the Dependence Structures

We propose a dynamic model of dependence structures between financial institutions within a financial system and we construct measures for dependence and financial instability. Employing Markov structures of joint credit migrations, our model allows for contagious simultaneous jumps in credit ratings and provides flexibility in modeling dependence structures. Another key aspect is that the proposed measures consider the interdependence and reflect the changes in the economic landscape as financial institutions evolve over time. In the final part, we give several examples, where we study various dependence structures and investigate their systemic instability measures. In particular, we show that subject to the same pool of Markov chains, the simulated Markov structures with distinct dependence structures generate different sequences of systemic instability. Keywords: Contagion; dependence structure; Markov structures; systemic risk; systemic instability measure. T. R. Bielecki, J. Jakubowski, and M. Nieweglowski. Intricacies of dependence between components of multivariate Markov chains: Weak Markov consistency and weak Markov copulae. Electronic Journal of Probability, 18(45):1-21, 2013. Y.-S. Chang. Markov chain structures: Markovian consistency. 2017. Submitted for publication.

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CP12

Elicitability and Identifiability of Systemic Risk Measures

Estimating different risk measures, such as Value at Risk or Expected Shortfall, is a common task in various financial institutions. The question of evaluating and comparing these estimates is closely related to two concepts already well known in the literature: elicitability and identifiability. A statistical functional is called elicitable if there is a strictly consistent scoring function for it, i.e. a function of two arguments, a forecast and a realization of a random variable, such that its expectation with respect to the second argument is minimized only by the correct forecast. It is called identifiable, if there is a strict identification function, i.e. again a function of two arguments such that the root of its expectation with respect to the second argument is exactly the correct forecast. We introduce these concepts for set-valued measures of systemic risk. A banking system with n participants is represented by a random vector Y and the quantity of interest is its aggregated outcome. The measure of systemic risk is defined as the set of n-dimensional capital allocation vectors k such that the aggregated outcome of $Y + k$ is acceptable under a given scalar risk measure. We establish the link between the elicitability and/or identifiability of the systemic risk measure and the underlying scalar risk measure, taking two perspectives on the measures of systemic risk that stem from their set-valued nature.

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CP12

The Unspanned Stochastic Volatility Property

Certain term structure models exhibit unspanned stochastic volatility (USV). This involves a source of stochastic variation - called an unspanned factor - that does not affect the model's interest rates directly, but does affect interest-rate volatility. We propose definitions of unspanned factors and USV, generalising ones tentatively proposed in the literature. For models based on Brownian motion, we show that unspanned factors (by our definition) are synonymous with model incompleteness, and that USV is synonymous with incompleteness in a stricter sense. Our definitions and proofs are accompanied by examples, remarks and lemmas that elucidate the USV property.

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CP13

Outperformance and Tracking Via Convex Analysis

We address a portfolio selection problem that combines active (outperformance) and passive (tracking) objectives using techniques from convex analysis. We assume a general semimartingale market model where the assets' growth rate processes are driven by a latent factor. Using techniques from convex analysis we obtain a closed-form solution for the optimal portfolio and provide a theorem establishing

its uniqueness. The motivation for incorporating latent factors is to achieve improved growth rate estimation, an otherwise notoriously difficult task. To this end, we focus on a model where growth rates are driven by an unobservable Markov chain. The solution in this case requires a filtering step to obtain posterior probabilities for the state of the Markov chain from asset price information, which are subsequently used to find the optimal allocation. We show that the optimal strategy is the posterior average of the optimal strategies the investor would have held in each state assuming the Markov chain remained in that state. Finally, we implement a number of historical backtests and simulation studies to demonstrate the performance of the optimal portfolio.

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CP13

Monte Carlo Mean-Variance Portfolio Optimization

Based on Monte Carlo sampled risky asset paths multi-period portfolio optimization is performed under realistic constraints on the investment policies. An efficient and simple optimization method is described employing a quasi-Newton method with adjoint gradient computation. Numerical examples show efficient frontiers together with optimal asset allocations computed in reasonable time. The method can be scalably and easily generalized for portfolios with many risky assets.

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CP13

Optimal Investment with Transient Price Impact

We introduce a price impact model which accounts for finite market depth, tightness and resilience. Its coupled bid- and ask-price dynamics induce convex liquidity costs. We provide existence of an optimal solution to the classical problem of maximizing expected utility from terminal liquidation wealth at a finite planning horizon. In the specific case when market uncertainty is generated by an arithmetic Brownian motion with drift and the investor exhibits constant absolute risk aversion, we show that the resulting singular optimal stochastic control problem readily reduces to a deterministic optimal tracking problem of the optimal frictionless constant Merton portfolio in the presence of convex costs. Rather than studying the associated Hamilton-Jacobi-Bellmann PDE, we exploit convex analytic and calculus of variations techniques allowing us to construct the solution explicitly and to describe the free boundaries of the action- and non-action regions in the underlying state space. As expected, it is optimal to trade towards the frictionless Merton position, taking into account the initial bid-ask spread as well as the optimal liquidation of the accrued position when approaching terminal time. It turns out that this leads to a surprisingly rich phenomenology of possible trajectories for the optimal share holdings.

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CP13

Dynamically Optimal Portfolio Selection with Transaction Costs

A mean-variance portfolio selection problem is considered in multi-period with proportional transaction costs under no-shorting constraint. By adopting dynamic programming and duality theory, we firstly derive the analytical solution of the optimal investment policy, which is a piecewise function, and find the boundaries of buying region, no-transaction region, selling region and selling-all region. In addition, with the developed concept of time consistency in efficiency (TCIE), our analysis then shows this policy is always TCIE, which means the investor has no incentive to change idea in the whole investment time horizon, besides we find no shorting constraint is a sufficient condition of TCIE for a no transaction costs model. Furthermore, we use the efficient frontier to illustrate the policy, it shows the allocation of the initial wealth and the proportional transaction cost rates would affect the investor's behavior, especially the width of the no-transaction region. The results have implications in the financial market that contains friction rates which should be taken into account in investment problems.

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CP14

Game Theoretic Models for Optimal Trade Execution

We study a stochastic N-player game of optimal traders that want to (independently) execute his own portfolio. In our setting, the reference price is (endogenously) affected permanently by the trading rates of optimal traders; similar to the [Cardaliaguet and Lehalle, *Mean-Field Games of Controls and an Application to Trade Crowding*, 2017] model. However, we consider the case with heterogeneous and identical preferences. In the case with heterogeneity on the market parameters and agents' preferences we solve the N-player mean-field-type game semi-explicitly by using the direct method. For the case with homogeneous market parameters and agent preferences, we solve the associated mean-field game limit; that is, the asymptotic game with an infinite number of indistinguishable players. Finally, we compare both methods of solutions and illustrate the flexibility of our approach with the direct method by solving the N-player game with risk aversion.

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CP14

Major-Minor Mean Field Games with Latent Fac-

tors

In many stochastic games stemming from financial models, the environment evolves with latent factors and there may be common noise across agents states.Twoclassic examplesare:(i) multi-agent trading on electronic exchanges, and (ii) systemic risk induced through inter-bank lending/borrowing. Moreover, agents actions oftenaffect the environment, and some agents may be small while others large. Hence sub-population of agents may act as minor agents, while another class may act as major agents. To capture the essence of such problems, here, we introduce a general class of non-cooperative heterogeneous stochastic games with one major agent and a large population of minor agents where agents interact with an observed common process impacted by the mean field. A latent Markov chain and a latent Wiener process modulates the common process, and agents cannot observe them. We use filtering techniques coupled with a convex analysis approach to (i) solve the mean field game limit of the problem, (ii) demonstrate that the best response strategies generate an ϵ-Nash equilibrium for finite populations, and (iii) obtain explicit characterisations of the best response strategies. As an example, we investigate a major-minor trading problem driven by latent factors.

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CP14

Relative Arbitrage Opportunities in N Investors and Mean-Field Regimes

This paper discusses optimal strategies to outperform both the market and the investors in the sense of the minimal proportion of initial capital for an individual. By introducing a less restricted definition of relative arbitrage than that in Stochastic Portfolio Theory, we construct the related portfolio generating functions to show the existence of relative arbitrage. Optimal trading strategies derive a replication of market and investors portfolio as the objective, in both finite and infinite population regimes. This objective is characterized by the smallest nonnegative continuous solution of a Cauchy problem when the number of investors is finite, and thus the Nash equilibrium strategy of a certain investor is achieved. The corresponding mean field game model is discussed when there are infinite investors.

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CP15

Implementation of Supervised Learning Approach in MTPL Claim Assessment

MPTL insurance allocates mostly the highest percentage in non-life branches, especially when the regulator requires it to be compulsory. In the nature of business, MTPL constitute the highest claim rate compared to the other branches. High frequency and, in aggregate, high claim amounts requires a well understanding of the risks associated to claim amounts. Therefore, during underwriting process of MTPL insurance, it gains importance to know the main sources of risks and their relative impact on the claim amounts. Such knowledge also increases companys competitive power and financial robustness. In this study we aim to develop a supervised learning algorithm which will enable company to rank the risks on policy base. A supervised learning algorithm achieves learning by analyzing a training data to generate an inferred function which can map the new examples to pre-determined labels. In an ideal setting when the algorithm faces with new example, it will be able to determine the class labels by itself. In case the decision makers problem can be solved with a labeling new instance, a supervised learning algorithm provides a dynamic decision supporting system. For the implementation we used traffic insurance policy records in Istanbul for a certain period. The traditional ranking (classification) methods are applied to rank and classify the policy holders within determined categories. We compare the performance of the all of the methods based on several performance metrics.

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CP15

Multi-Objective Genetic Algorithms under Uncertainty

Complex financial engineering and risk management tools cannot exploit the structure of the problems typically found in conventional stochastic programming problems, given that its behaviour is highly non-linear, multi-modal and multi-objective with its inputs being subjected to uncertainties characterised by probability distribution functions. Multi-objective Genetic Algorithms (MOGAs) coupled with uncertainty appear as a solution that strikes to find the right balance between reasonable optimal accuracy and computational time. The talk reviews the recent developments of MOGAs under uncertainty and place special emphasis on the transition from the well-known NSGA-II to its stochastic counterpart, by introducing slight modifications in its ranking selection; following the principles of Petrone, Compare and Baraldi. Then the MOGAs under uncertainty are not only benchmarked against several theoretical test functions but also applied to a real-world application in the offshore wind industry for decision-making. The contribution of the talk is not only to review the recent developments of MOGAs under uncertainty but also to discuss the challenges of applying this methodology to a real-world application for financial appraisal of offshore wind farms.

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CP15

Double Deep Q-Learning for Optimal Execution

Optimal trade execution is an important problem faced by essentially all traders. Much research into optimal execution uses stringent model assumptions and applies continuous time stochastic control to solve them. Here, we instead take a model free approach and develop a variation of Deep Q-Learning to estimate the optimal actions of a trader. The model is a fully connected Neural Network trained using Experience Replay and Double DQN with input features given by the current state of the limit order book, other trading signals, and available execution actions, while the output is the Q-value function estimating the future rewards under an arbitrary action. We apply our model to nine different stocks and find that it significantly outperforms a baseline approach. Moreover, the resulting optimal actions correspond to financially sound strategies.

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CP15

Auto-Encoded Scenario Generation

We present a new approach to generate high-dimensional scenarios for risk management purposes. The method builds on recent advances in sequential data modeling with artificial neural networks. Its high-level architecture has two entangled components. The first component is an encoder-decoder, also called autoencoder, which extracts the time series latent factors and links them to observable data in an highly nonlinear way. The second component is a time series model capturing the joint dynamics of latent factors. We extensively study our approach in the financial context of options and futures where hundreds of contracts are listed for each underlying stock or index. Derivatives risk management is a challenging task as the implied volatility surfaces, a representation of option prices familiar to traders, have complex and dependent dynamics with abrupt changes. We empirically validate our approach by backtesting risk measures on various portfolios.

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CP16

Spatially Determined Optimal Price Design i Ride Sharing Economy

In their price design, ride-sharing platforms have to sider two different aspects. On the one hand, guarant sufficient demand in terms of customers for rides to ove price. On the other hand, guarantee a sufficient suppl drivers to satisfy this demand in terms of revenue. price for a trip depends on a fixed and proportional fee pending on the ride distance. The gains of a ride is t shared between the platform and the driver. The platf needs therefore to set ride costs as well as the share to driver to maximize its revenue. To tackle this problem first derive a dynamic of the rides on a generic map depends on demand and available drivers. This dyna is non local since drivers may not be available for a s time due to long rides and be available on another loca in the map afterwards. We provide results showing the average amount of drivers available on the map verges to a steady state. This steady state depends on structure of the map as well as the overall demand. W this at hand we consider the optimal price design in following situations

- Monopolistic ride-sharing platform
- Oligopolistic ride-sharing platform

And derive from it how the price setting depends on demand and supply elasticity, the geometry of the as well as the related demand for rides. Joint work Samuel Drapeau (SJTU)

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CP16

An Optimal Mortgage Refinancing Strategy w Stochastic Interest Rate

Determining a borrower's optimal refinancing strateg important not only to the borrower, but also to the len who can better model prepayment losses. The analysi such strategies are complicated by the addition of stoc tic interest rates. A framework for assessing the opti refinancing strategy is presented. The optimal refinan time is obtained by minimizing the conditional expecta of the discounted total payment. A moment genera function is used to derive a closed-form approximatio the refinancing function with infinite maturity under Vasicek model. The approximation is studied both ana ically and numerically. The results indicate three diffe types of behavior in the refinancing function: two type dicate optimal refinancing in finite time. A strategy is lined by which a borrower can continually evaluate whe to refinance. By providing a systematic way to evaluate likelihood of refinancing, these results should be of inte to those trading mortgage-backed securities.

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CP16

Optimal Governmental Control of the Debt-to-GDP Ratio in a Regime-Switching Economy

We study the problem of a government wishing to control the country's debt-to-GDP ratio. The debt-to-GDP ratio evolves stochastically and the interest on debt is affected by an N-state continuous-time Markov chain, representing the country's credit ratings. The debt-to-GDP ratio can be reduced through fiscal interventions or increased by public investments. The government aims to choose a policy minimising the total expected cost of having debt and fiscal interventions counterbalanced by the gain from public investments. The problem is modelled by a bounded-variation stochastic control problem, that we explicitly solve through the analysis of an associated Dynkin game. This is joint work with Giorgio Ferrari.

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CP16

Roll-Over Risk with a Foreign Exchange Analogy

The Global Financial Crisis changed the perception of certain risks in the market and many of the standard "textbook arbitrage" relationships between spot, forward and swap markets no longer hold and swaps and forwards are quoted with substantially higher basis spreads than before the GFC.
To explain this phenomenon we construct a dynamic term structure model that includes interest rate risk, roll-over risk and credit risk. We incorporate these risk factors using an FX-analogy (see for example [Jarrow & Turnbull, A Unified Approach for Pricing Contingent Claims on Multiple Term Structures, RQFA, 1998]), where each (artificial) exchange rate plays the role of a specific risk factor. We apply the FX-analogy in a non-standard way since we construct the LIBOR rate dynamics from quanto-forward rates between two artificial economies with and without roll-over risk. This particular construction allows for, what we believe to be, a more useful and realistic specification of both the LIBOR-OIS spread and the basis-spread dynamics. In particular, the spreads will have an element of endogeneity, meaning that the model can be used to extrapolate basis spreads for non-traded bespoke tenors, which is particularly useful in markets with sparse liquidity.
Finally, we demonstrate the fitness of the model by calibrating it to a dataset of basis swaps.

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CP17

Epstein-Zin Utility Maximization on Random Horizons

This paper solves the consumption-investment problem with Epstein-Zin utility on a random horizon. In an incomplete market, we take the random horizon to be a stopping time adapted to the market filtration, generated by all observable, but not necessarily tradable, state processes. Contrary to prior studies, we do not impose any fixed upper bound for the random horizon, allowing for truly unbounded ones. Focusing on the empirically relevant case where the risk aversion and the elasticity of intertemporal substitution are both larger than one, we characterize optimal consumption and investment strategies through backward stochastic differential equations (BSDEs). Compared with classical results on a fixed horizon, our characterization involves an additional stochastic process to account for the uncertainty of the horizon. As demonstrated in a Markovian setting, this added uncertainty drastically alters optimal strategies from the fixed-horizon case.

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CP17

Stochastic Control and Differential Games with Path-Dependent Controls

In this paper we consider the functional Itô calculus framework to find a path-dependent version of the Hamilton-Jacobi-Bellman equation for stochastic control problems with path-dependence in the controls. We also prove a Dynamic Programming Principle for such problems. We apply our results to path-dependence of the delay type. We further study Stochastic Differential Games in this context.

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CP17

Optimization of Option Exercise Policies in Incom-

plete Markets with Quadratic Hedging

Quadratic hedging is a practically appealing approach for approximately replicating the random payoff of European options in incomplete markets. This work extends this methodology to the case of Bermudan options, for which an exercise policy needs to be optimized. This extension relies on constructing date specific approximate replicating portfolios. This modeling idea leads to a decomposition finding that enables adapting known quadratic hedging results to the date specific cash flows and formulating an option exercise policy optimization model. Optimal option exercise policies are in general time inconsistent. Time consistent option exercise policies can be optimized recursively.

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CP17

Diffusion Approximations for Expert Opinions and Power Utility Maximization in a Financial Market with Gaussian Drift

We consider portfolio selection problems for a financial market where stock returns depend on a hidden Gaussian mean reverting drift process. Information on the drift is obtained from returns and expert opinions in the form of noisy signals about the current state of the drift arriving at the jump times of a homogeneous Poisson process. We use Kalman filter techniques to derive drift estimates. The associated portfolio problem for power utility maximizing investors is solved using dynamic programming techniques. The dynamic programming equation for the value function appears as a partial integro-differential equation (PIDE) which can be solved only numerically. Diffusion approximations of the filter for high-frequency experts allow to simplify the portfolio problem and to derive more explicit solutions. They are based on the asymptotic behavior of the filter as the arrival intensity of expert opinions tends to infinity while the variance of expert opinions grows linearly. Our limit theorems state that the information obtained from observing high-frequency expert opinions is asymptotically the same as that from observing a certain diffusion process. References:
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CP18

Deep Smoothing of the Implied Volatility Surface

We present a new approach to interpolate and extrapolate the implied volatility surface in an arbitrage-free way. The method is extremely flexible as it builds on artificial neural networks. We show how to construct implied volatility surfaces which are free of static arbitrage opportunities by regularization of the optimization problem. Prior shape knowledge can be included to guide and stabilize the generalization to unobserved implied volatility values. This is in particular useful when only sparse or erroneous option data are available. We illustrate that deeper neural nets are more flexible and robust than shallow ones. We validate the flexibility and numerical efficiency of our approach with many numerical examples.

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CP18

Assessing Calibration Risk of Option Pricing Models

Substantial losses suffered by financial institutions, due to mispricing of financial derivatives, has lead regulators to address model risk. The Federal Reserve (2011) has drawn guidelines for an active management of model risk, suggesting that banks should employ sensitivity analysis in model development and validation to check the impact of small changes in inputs and parameter values on model outputs. In this paper, we focus on the estimation error of calibrated model parameters and carries over to the pricing of exotic products. We quantify the impact for some popular option pricing models through a parametric bootstrapping technique. From an econometric point of view, the calibration of the parameters of the preferred model to market quantities consists of a non linear least squares regression. Using asymptotic results, we obtain the bootstrap distribution of the exotic derivative prices. This allows us to compute confidence intervals of exotic option prices that contain the same information brought by the original sample, thus quantifying estimation risk. We provide empirical evidence of calibration risk for exotic options on a time series of EURO STOXX 50 implied volatility surfaces, covering a one year period. Furthermore, we perform a sensitivity analysis to detect the most important model parameters. Our procedure, that is theoretically sound and computationally feasible, can be of some value for regulators and risk-managers.

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CP18

Artificial Intelligence-Driven Financial Risk Analytics and Portfolio Optimization

Simulation and optimization algorithms are used in quantitative finance and risk management to model, evaluate, hedge and optimally re-balance portfolios of financial assets. The primary goal of simulation is to model uncertainty in asset values over time. Optimization techniques help to minimize risk and maximize performance of financial portfolios. As performance, numerical stability and practical applicability of simulation and optimization algorithms still remain a challenge in financial modeling,

we look at Machine Learning practice to improve accuracy of financial modeling. Moreover, we investigate how we can enhance formulating financial modeling and optimization problems with Artificial Intelligence algorithms such as Natural Language Processing and Neural Nets. Natural language understanding algorithms for portfolio stress-testing and for financial optimization problems such as sentiment analysis and chat-bots will be discussed and demoed.

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CP18

Exploration Versus Exploitation in Reinforcement Learning: A Stochastic Control Approach

We consider reinforcement learning (RL) in continuous time and study the problem of achieving the best trade-off between exploration of a black box environment and exploitation of current knowledge. We propose an entropy-regularized reward function involving the differential entropy of the distributions of actions, and motivate and devise an exploratory formulation for the feature dynamics that captures repetitive learning under exploration. The resulting optimization problem is a resurrection of the classical relaxed stochastic control. We carry out a complete analysis of the problem in the linear–quadratic (LQ) case and deduce that the optimal control distribution for balancing exploitation and exploration is Gaussian. This in turn interprets and justifies the widely adopted Gaussian exploration in RL, beyond its simplicity for sampling. Moreover, the exploitation and exploration are reflected respectively by the mean and variance of the Gaussian distribution. We also find that a more random environment contains more learning opportunities in the sense that less exploration is needed, other things being equal. As the weight of exploration decays to zero, we prove the convergence of the solution to the entropy-regularized LQ problem to that of the classical LQ problem. Finally, we characterize the cost of exploration, which is shown to be proportional to the entropy regularization weight and inversely proportional to the discount rate in the LQ case.

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CP19

Stochastic Representations for Nonlocal Bellman Equations

Stochastic representation formulas establish natural connections between the study of stochastic processes and partial differential equations or integro-partial differential equations (integro-PDEs). In this talk, we consider a stochastic optimal control problem for a general class of time and state-dependent controlled stochastic differential equations, driven by a Levy process. Our main focus is a stochastic representation formula for the unique viscosity solution to the Dirichlet terminal-boundary value problem for the associated degenerate HJB integro-PDE in a bounded domain. This is a classical problem which is very technical and whose full details are often omitted or overlooked, especially for problems in bounded domains. Under mild conditions on the regularity of the domain and the non-degeneracy of the controlled diffusions along the boundary, we identify the unique viscosity solution to the terminal-boundary value problem of the HJB integro-PDE as the value function of the associated stochastic optimal control problem. We also obtain the dynamic programming principle for the associated stochastic optimal control problem in the bounded domain.

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CP19

Optimal Dynamic Futures Portfolio

We study the problem of dynamically trading a portfolio of futures contracts under a number of stochastic multifactor models. A utility maximization approach is developed to determine the optimal futures trading strategies. By analyzing the associated HJB equations, we solve the investment problems explicitly. Applications to volatility and oil futures are discussed.

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CP19

Asymptotic Approximation of Optimal Portfolio for Small Time Horizons

We study the problem of portfolio optimization in a stochastic volatility model and under general assumptions on the investors utility function. By constructing classical sub- and super-solutions to the HJB PDE associated with the optimization problem at hand, we obtain a closed-form formula for a trading strategy which approximates the optimal portfolio on small time horizons. We end the talk with a heuristic scheme to extend our small-time approximation to any finite time horizon. This is a joint work with Professor Rohini Kumar.

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CP19

Random Horizon Principal-Agent Problem

We consider a general formulation of the principal-agent

problem with a continuous payment and a lump-sum payment on a random horizon. We first find the contract that is optimal among those for which the agents value process allows a dynamic programming representation, in which case the agents optimal effort is straightforward to find. We then show that the optimization over this restricted family of contracts represents no loss of generality. Using this approach, we reduced a non-zero-sum stochastic differential game to a stochastic control problem which may be solved by standard methods of stochastic control theory.

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CP20

Robust Time-Inconsistent Stochastic Linear-Quadratic Control: An Open-Loop Approach

This work studies a class of stochastic linear-quadratic control problems for an ambiguity-adverse agent with a time-inconsistent objective. On top of the framework in Hu et al. (2012), we introduce the robustness for the time-consistent controls. We extend the results in Hu et al. (2012, 2017) so as to reflect the agents ambiguity aversion on the model risks, especially the drift coefficient of the state process. We adopt an innovative two-step open-loop equilibrium control approach to characterize the robust time-consistent controls and simultaneously preserve the preference ordering. Under a general framework allowing random parameters, we derive a sufficient condition for finding the equilibrium controls using the forward-backward stochastic differential equation approach. Moreover, we prove the necessity of the sufficient condition for mean-variance portfolio problems and the uniqueness of the robust time-consistent mean-variance equilibrium strategies. We also provide analytical solutions to mean-variance portfolio problems for various settings.

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CP20

Black Economic Empowerment Contracts and Risk Incentives

After the fall of apartheid in South Africa, Black Economic Empowerment (BEE) emerged as the central government policy aimed at redressing the imbalances of the past by fairly transferring financial and economic resources to previously disadvantaged citizens. We develop a dynamic model of the firm in an environment where regulatory constraints are imposed on firms to incentivize them to draw in impoverished citizens, who, without subsidies, could not otherwise join the shareholder base. The firm must balance the effects of equity dilution and deal financing with the incentives offered by BEE regulation. By specifying a generic BEE scheme, we derive the post-deal equity value and identify how the optimal amount of vendor and bank financing required vary according to key parameters. We also identify the fair value for bank loan spreads, the total subsidy provided by the firm, and the value of the complex claims held by the BEE participants. Finally, we investigate how these structures affect risk-taking decisions in the firm and show that BEE regulations may induce risk-averse shareholder behavior as an unintended side-effect.

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CP20

Failure of Smooth Pasting Principle and Nonexistence of Equilibrium Stopping Rules under Time-Inconsistency

This paper considers a time-inconsistent stopping problem in which the inconsistency arises from non-constant time preference rates. We show that the smooth pasting principle, the main approach that has been used to construct explicit solutions for conventional time-consistent optimal stopping problems, may fail under time-inconsistency. Specifically, we prove that the smooth pasting principle solves a time-inconsistent problem within the intra-personal game theoretic framework if and only if a certain inequality on the model primitives is satisfied. We show that the violation of this inequality can happen even for very simple non-exponential discount functions. Moreover, we demonstrate that the stopping problem does not admit any intra-personal equilibrium whenever the smooth pasting principle fails. The "negative results" in this paper caution blindly extending the classical approaches for time-consistent stopping problems to their time-inconsistent counterparts.

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CP20

Open-Loop Equilibrium Strategy for Mean-Variance Portfolio Problem under Stochastic Volatility

We formulate the open-loop control framework for time-consistent mean-variance (TCMV) portfolio problems in incomplete markets with stochastic volatility (SV). We offer the existence and uniqueness results of the TCMV equilibrium controls for general SV models and derive explicit closed-form equilibrium controls for several popular models, including the Heston, Hull-White and 3/2 SV models. The uniqueness of the equilibrium controls are related to

the mean-reverting speed of the volatility and the investment horizon.

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CP21

Optimal Prediction Problems Driven by Lvy Processes

Optimal Prediction Problems (OPP) are related to classic optimal stopping problems used in finance or insurance, however, OPP allow for a non-adapted payoff process. This allows for instance to study the problem of prediction the time and value at which a financial price process attains its maximum. This work consists in formulating and studying OPP driven by Lvy Processes. The main difference with previous work(see for example [Du Toit and Peskir, Predicting the time of the ultimate maximum for Brownian motion with drift ,2008]) is the incorporation of jumps, i.e. discontinuities. This could be seen as an extension of the classical Cramer-Lundberg model in insurance and the jump-diffussion model. First we compare the result in[Baurdoux and van Schaik, Predicting the time at which a Lvy process attains its ultimate supremum,2014], where the problem of stopping near the global supremum was studied in time-domain, with an approach in space-domain, showing that the results are not equivalent. Then we formulate a new problem with a different payoff. We find an equation to describe the optimal stopping time and we show that in some cases it is optimal to stop immediately.

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CP21

XVA Valuation under Market Illiquidity

Before the 2008 financial crisis, most option pricing methods didnt consider the effects of counterparties default and funding illiquidity. Recently models were proposed to compute the total valuation adjustment (XVA) of a European claim, including funding costs, counterparty credit risk and collateralization. However, those models abstract from an important fact: the repo market froze during the 2008 financial crisis, because of the rarity of general collateral and loss of confidence in other collaterals. The frozen repo market led to a shutdown of short trades in stock. Thus, its very important to include the different behavior of repo and stock market in normal and financial crisis status. In our research we describe the switching between two financial status by an alternating renewal process, which switches between zero and one with inter-arrival times following exponential distributions. We develop a framework for pricing the XVA of a European claim in this state-dependent framework. We show the existence of a unique classical solution to the pricing BSDE based on a martingale decomposition theorem on a space generated by not-independent increment stochastic processes.

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CP21

Portfolio Diversification Based on Ratios of Convex Risk Measures

A new framework for portfolio diversification is introduced which goes beyond the classical mean-variance theory and other known portfolio allocation strategies such as risk parity. It is based on a novel concept around portfolio dimensionality and ultimately relies on the minimization of ratios of convex functions. The latter arises naturally due to the requirement that a diversification measure should be leverage invariant. This talk introduces this new framework and its relationship to standardized higher order moments of portfolio returns. Moreover, it addresses the main drawbacks of standard diversification methodologies which are based primarily on estimates of covariance matrices. Maximizing portfolio dimensionality leads to highly non-trivial optimization problems with objective functions which are typically non-convex with potentially multiple local optima. Two complimentary global optimization algorithms are thus presented. For problems of moderate size, a deterministic Branch and Bound algorithm is developed, whereas for problems of larger size a stochastic global optimization algorithm is given based on Gradient Langevin Dynamics. We demonstrate through numerical experiments that the introduced diversification measures possess desired properties as introduced in the portfolio diversification literature.

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CP21

A Backward Simulation Method for Stochastic Control Problems

A number of optimal decision problems with uncertainty can be formulated into a stochastic optimal control framework. The Least-Squares Monte Carlo (LSMC) algorithm is a popular numerical method to approach solutions of such stochastic control problems as analytical solutions are not tractable in general. In this paper, we develop a novel LSMC algorithm to solve general stochastic optimal control problems. Our algorithm has three pillars: a construction of auxiliary stochastic control model, an artificial simulation of post-action value of state process, and a shape-preserving sieve estimation method which equip the algorithm with a number of merits including obviating forward simulation and control randomization, evading extrapolating the value function, and alleviating computational burden of the tuning parameter selection. The efficacy of the algorithm is corroborated by an application to pricing equity-linked insurance products.

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CP22

Contract Theory in a VUCA (Volatility, Uncertainty, Complexity and Ambiguity) World

In this paper we investigate a Principal-Agent problem with moral hazard under Knightian uncertainty. We extend the seminal framework of Holmstrom and Milgrom (1987) by combining a Stackelberg equilibrium with a worst-case approach. We investigate a general model in the spirit of Cvitanic, Possamai, and Touzi (2017). We show that optimal contracts depend on the output and its quadratic variation by extending Mastrolia and Possama (2018) and Sung (2018). We compute the optimal effort of the Agent through the solution to a second order BSDE and we show that the value of the problem of the Principal is the viscosity solution of a Hamilton-Jacobi-Bellman-Isaacs equation, by using stochastic Perrons method.

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CP24

Correlated Poisson Processes and Some Applications in Finance and Insurance

Poisson processes have many important applications in Insurance, Finance, and many other areas of Applied Probability. Many attempts in the past to introduce correlated Poisson processes have been restrictive in the range of admissible correlations; in particular, most previous methods did not allow for negative correlation between the components of the multivariate process. Our approach, relying on Extreme Measures describing extremal joint distributions of the process allows for extreme correlations (both positive and negative) in the multidimensional setting and gives a semi-analytic representation of the extreme joint distribution. We discuss a novel approach to the calibration problem and describe the backward simulation method to construct the sample paths of the multivariate process given intensities of the components and their correlations.

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CP24

Generalized Fractional Brownian Motions as Scaling Limits of Non-Stationary Shot Noise Processes

We introduce generalized fractional Brownian motions (GFBMs) which have the self-similarity property but non-stationary increments. They arise naturally as the scaling limits of non-stationary shot noise processes with power-law distributed noises. The GFBMs can be potentially used to study rough volatility and portfolio optimization with transaction costs. To prove the weak convergence and establish the existence of such processes, we apply the new maximal inequalities for stochastic processes in the space D (Pang and Zhou, 2018), whose upper bounds involve finite set functions with a superadditive property, instead of finite measures in the classical results (Billingsley, 1999). This new approach may be useful to study weak convergence and existence of many other stochastic processes.

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CP24

Marginal and Dependence Uncertainty: Bounds, Optimal Transport, and Sharpness

Motivated by applications in model-free finance and quantitative risk management, we consider Fréchet classes of multivariate distribution functions where additional information on the joint distribution is assumed, while uncertainty in the marginals is also possible. We derive optimal transport duality results for these Fréchet classes that extend previous results in the related literature. These proofs are based on representation results for increasing convex functionals and the explicit computation of the conjugates. We show that the dual transport problem admits an explicit solution for the function $f = 1_B$, where B is a rectangular subset of $\mathbb{R}^d$, and provide an intuitive geometric interpretation of this result. The improved Fréchet–Hoeffding bounds provide ad-hoc upper bounds for these Fréchet classes. We show that the improved Fréchet–Hoeffding bounds are pointwise sharp for these classes in the presence of uncertainty in the marginals, while a counterexample yields that they are not pointwise sharp in the absence of uncertainty in the marginals, even in dimension 2. The latter result sheds new light on the improved Fréchet–Hoeffding bounds, since Tankov (JAP, 2011) has showed that, under certain conditions, these bounds are

sharp in dimension 2.

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CP24

Controlled SDEs with Reflections and Associated Stochastic HJB Equations

We shall consider one-dimensional reflected stochastic differential equations, whose coefficients may be path-dependent. The value function of this problem satisfies a stochastic Hamilton-Jacobi-Bellman equation with Neumann boundary conditions. We give the existence and uniqueness of a sufficiently regular solution, which is then used to construct the optimal feedback control. Some applications in optimal liquidations/executions will be discussed as well.

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CP25

A Functional Analysis Approach to Static Replication of European Options

The replication of any European contingent claim by a static portfolio of calls and puts with strikes forming a continuum, formally proven by Carr and Madan (1998), is part of the more general theory of integral equations. We apply spectral decomposition techniques to show that replication may also be achieved with a discrete portfolio of special options. We propose a numerical application for fast pricing of vanilla options that may be suitable for large option books or high frequency option trading, and we use a reflected Brownian motion model to show how pricing formulas for the special options may be obtained

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CP25

Conditional Heteroskedasticity in Log-Returns

Models for conditional variance in financial timeseries (such as GARCH) are very successful. Timeseries are inherently discretely sampled (stochastic) processes, such as daily log-returns. The discretization is typically consider arbitrary, but that assumes that the model can be compounded arbitrarily. Basrak and co-authors points out that even two-period compound GARCH returns fail to have all finite moments, which means that asset prices cannot be martingales for GARCH log-returns. The Klüppelberg-Lindner-Maller model for continuous-time stochastic processes with GARCH characteristics seems to present the same challenge. We would like to explore whether an almost-surely continuous stochastic process subject to an inhomogenous clock can simulate a GARCH process while maintaining thin-tailed increments.

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CP25

Top-Down Valuation Framework for Employee Stock Options

We propose a new valuation framework for employee stock options (ESOs). Our approach accounts for vesting period, multiple early exercises, and sudden job termination. To compute the ESO costs, we develop several numerical methods to solve the associated systems of PDEs. We implement and compare different numerical methods, and examine the effects of various contractual features.

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CP26

Forward Performance Processes in Eve Correlation Models

We consider the problem of optimal portfolio selection in an incomplete market. The incompleteness stems from the presence of multidimensional Brownian factors not characterized by the stock dynamics. An essential quantity in this framework is the correlation matrix ρ between the Brownian motions W_t driving the stocks and the Brownian motions B_t generating the extra factors. For a general correlation structure it is very hard to calculate the optimal portfolio both analytically and numerically. Moreover, in a noisy market with a large number of stocks, it is especially challenging to estimate these correlation matrices. To deal with both of these challenges, we introduce a new Eigenvalue Equality (EVE) class of correlation matrices. In this framework, for power utility functions we construct a large class of forward performance processes (FPPs) as well as solve the Merton problem. For Markovian factors, doing the former requires solving an associated non-linear parabolic partial differential equations (PDEs) posed in the "wrong" time direction, and thereby we establish on domains an explicit form of the generalized Widder's theorem of Nadtochiy and Tehranchi. For the non-Markovian case, such as rough volatility, we provide a probabilistic representation of both FPPs and classical value functions.

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CP26

Prospective Strict No-Arbitrage and the Fundamental Theorem of Asset Pricing under Transaction Costs

In discrete time markets with proportional transaction costs, Schachermayer (2004) shows that *robust no-arbitrage* is equivalent to the existence of a strictly consistent price system. In this paper, we introduce the concept of *prospective strict no-arbitrage* that is a variant of the *strict no-arbitrage* property from Kabanov, Rasonyi, and Stricker (2002). The prospective strict no-arbitrage condition is slightly weaker than robust no-arbitrage, and it implies that the set of portfolios attainable from zero initial endowment is closed in probability. A weak version of prospective strict no-arbitrage turns out to be equivalent to the existence of a consistent price system. In contrast to the fundamental theorem of asset pricing of Schachermayer (2004), the consistent frictionless prices may lie on the boundary of the bid-ask spread. On the technical level, a crucial difference to Schachermayer (2004) and Kabanov-Rasonyi-Stricker (2003) is that we prove closedness without having at hand that the null-strategies form a linear space.

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CP26

Recent Results on Quadratic BSDEs Arising in Incomplete Market Equilibrium Models

We present a system of fully coupled BSDEs with quadratic growth and a discontinuity in its driving term. The system is shown to characterise the price of a risky asset in an endogenous Radner equilibrium model of an exchange economy: agents trade in an incomplete market and prices are set to ensure that markets clear at any time. We show that this system admits a solution without any unnatural smallness assumptions on the norm of the data. The proof relies, in particular, on two techniques used in the study of partial differential equations, the unique continuation and the backward uniqueness of solutions to differential inequalities.

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CP26

Higher-Order Discretization Methods of Forward-Backward SDEs using KLNV-Scheme and Their Applications to XVA Pricing

New higher-order discretization methods of forward-backward stochastic differential equations will be presented. In particular, we consider the solution (X_s, Y_s) of the following equation:

$$\begin{aligned} X_s &= x + \sum_{i=0}^{d} \int_t^s V_i\left(X_u\right) \circ dB^i(u), \\ Y_s &= \Phi(X_T) + \int_s^T f(X_u, Y_u) du - \sum_{i=0}^{d} \int_s^T Z_u^{(i)} dB^i(u), \end{aligned}$$

where $x \in \mathbb{R}^N$, $V_0, V_1, \ldots, V_d \in C_b^\infty(\mathbb{R}^N; \mathbb{R}^N)$, $\Phi : \mathbb{R}^N \to \mathbb{R}$, and $f : \mathbb{R}^{N+1} \to \mathbb{R}$. The aim of this lecture is to propose a method for numerical calculation of Y_t by using the simulation. In the proposed method, the forward component is discretized using the Kusuoka–Lyons–Ninomiya–Victoir scheme with discrete random variables and the backward component using the higher-order numerical integration method consistent with the discretization method of the forward component. In addition, we use the tree based branching algorithm technique to conquer the nested simulation. In particular, we achieve the second and third order discretization methods and the applicability to the problems driven by multidimensional Brownian motion. The proposed methods are applied to the XVA pricing, in particular to the credit valuation adjustment. The numerical results show that the expected theoretical order and computational efficiency are achieved.

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CP27

Asymptotics of American Options and Implied Volatilities in Local Volatility Models

We derive short-time expansions for American put/call prices in local volatility models. Our building blocks are the asymptotics of the exercise boundary close to maturity, the well-known expansion for the transition density of time-homogeneous processes, and the application of the classical Laplace's method. As a consequence , we obtain the corresponding terms in the American implied volatility expansion for small time to maturity. Our results are illustrated by several numerical experiments.

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CP27

Asymptotics for Volatility Derivatives in Multi-Factor Rough Volatility Models

We present small-time implied volatility asymptotics for Realised Variance (RV) and VIX options for a number of (rough) stochastic volatility models via large deviations principle. We provide numerical results along with efficient and robust numerical recipes to compute the rate function; the backbone of our theoretical framework. Based on our results, we further develop approximation schemes for the density of RV, which in turn allows to express the volatility swap in close-form. Lastly, we investigate different constructions of multi-factor models and how each of them affects the convexity of the implied volatility smile.

Interestingly, we identify the class of models that generate non-linear smiles around-the-money.

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CP27

Buffered Probability of Exceedance (bPOE) Ratings for Synthetic Instruments

Credit ratings are widely used by investors to assess the credit risk of a security. The financial crisis of 2008 showed that credit ratings might not measure the risk appropriately for the synthetic instruments such as Collateralized Debt Obligations (CDOs). Recently, Buffered Probability of Exceedance (bPOE) emerged as a new topic in risk management. This paper presents a new rating assignment model based bPOE, that is an improvement over the current Probability of Exceedance (POE) based methodology. We demonstrate how bPOE ratings can be designed and used in portfolio optimization and structuring synthetic financial instruments. The structuring optimization problems are reduced to convex and linear optimization. The case study results are posted at a website.

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CP27

Value-at-Risk and Expected Shortfall of Stock Portfolio Using Skew-T Copulas

The multivariate Student-t copula is frequently used in financial portfolio risk management and other statistical areas when there is tail dependence in the data. It often is a good-fitting copula but can be improved on when there is tail asymmetry. We propose to use AzzaliniCapitanio (AC) and Generalized Hyperbolic (GH) skew-t copulas to incorporate asymmetric tail dependence of risk factors. We compare the parameters of the AC skew-t, GH skew-t, Student-t, Normal copulas using Akaike and Bayesian information criteria for the two types of daily stock portfolio returns estimated with the numerical implementation for maximum likelihood estimation in Yoshiba (2018). Both the two types of portfolios consist of three TOPIX sector indices. The first portfolio consists of financial sectors portfolio with high correlation including banking, insurance, and securities sectors. The second consists of banking, air transportation, electricity sectors with low correlation. With validating the skewness of skew-t copulas both for the unfiltered returns and for the filtered returns by GARCH and EGARCH models, we investigate the behavior of the value-at-risk and expected shortfall of the two types of stock portfolio by employing several backtesting methods.

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MS0

Machine Learning and Corporate Bond Trading

We demonstrate how machine learning based recommender systems can be effectively employed by market makers to filter the information embedded in Requests for Quote (RFQs) to identify the set of clients most likely to be interested in a given bond, or, conversely, the set of bonds that are most likely to be of interest to a given client. We consider several approaches known in the literature and ultimately suggest the so-called latent factor collaborative filtering as the best choice. We also suggest a scalable optimization procedure that allows the training of the system with a limited computational cost, making collaborative filtering practical in an industrial environment.

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MS0

New Approaches to Derivatives Valuation

We briefly survey some new approaches to derivatives valuation based on market models, machine learning, and abstract algebra.

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MS0

The Complexity of Bank Holding Companies: A Topological Approach

Large bank holding companies (BHCs) are structured into intricate ownership hierarchies involving hundreds or even thousands of legal entities. Each subsidiary in these hierarchies has its own legal form, assets, liabilities, managerial goals, and supervisory authorities. Such complex hierarchies may contribute to increased operational risk, greater opacity, and even difficulty should a firm need to be wound down or resolved. This paper develops a set of metrics to assess the complexity of a BHC hierarchy, based on its ownership structure. The measures are mathematically grounded, intuitive, and easy to implement. We illustrate the process with a case study of one large U.S. BHC.

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MS0

The Joint S&P 500/VIX Smile Calibration Puzzle Solved: A Dispersion-Constrained Martingale Transport Approach

Since VIX options started trading in 2006, many researchers and practitioners have tried to build a model that jointly and exactly calibrates to the prices of S&P 500 (SPX) options, VIX futures and VIX options. So far the best attempts, which used continuous-time jump-diffusion models on the SPX, could only produce an approximate fit. In this article we solve this puzzle using a discrete-time model. Given a VIX future maturity T_1, we build a joint probability measure on the SPX at T_1, the VIX at T_1, and the SPX at $T_2 = T_1 + 30$ days which is perfectly calibrated to the SPX smiles at T_1 and T_2, and the VIX future and VIX smile at T_1. Our model satisfies the martingality constraint on the SPX as well as the requirement that the VIX at T_1 is the implied volatility of the 30-day log-contract on the SPX. In particular, this proves that the SPX and VIX markets are jointly arbitrage-free. The discrete-time

model is cast as a dispersion-constrained martingale transport problem and solved using the Sinkhorn algorithm, in the spirit of De March and Henry-Labordere (2019). We explain how to handle the fact that the VIX future and SPX option monthly maturities do not perfectly coincide, and how to extend the two-maturity model to include all available monthly maturities.

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MS0

Netting Relationships in Payment Systems

We assess if banks coordinate the issuance of their credit obligations to jointly manage their funding liquidity and counterparty risk. Our methodology is developed in the context of a centralized payments exchange with deferred net settlement system. This allows us to simultaneously evaluate critical features of the financial system that are usually analysed in isolation, such as the issuance of secured and unsecured credit obligations and the use of collateral and capital requirements. Using intra-day data from the Canadian interbank payments system, we show that banks coordinate the issuance of secured and unsecured credit obligations, but do not see them as substitutes. Coordination allows banks to net credit exposures and to unencumber collateral that can be used to obtain future liquidity. Banks rely on multilateral coordination to manage secured exposures and use both bilateral and multilateral coordination to manage unsecured exposures. These differences arise because secured exposures only depend on the value of the underlying collateral, whereas unsecured exposures depend on the performance of a given counterparty. Coordination incentives increase with risk exposures and the cost of funding. We conclude that coordination disruptions could lead to higher counterparty risk, collateral shortages and funding constraints, particularly for small banks, who net less. In an extreme scenario, coordination disruptions could lead to gridlock and systemic risk.

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MS0

Chaos and the Garch SDE: Explicit Formulas and Financial Applications

We derive an efficient closed-form approximation for the moment generating function of the integral of a mean-reverting stochastic process, which follows a linear SDE that we call GARCH, and which is also referred to as inhomogeneous geometric Brownian motion. We then consider a financial application, namely the pricing of a quanto CDS under stochastic intensity of default and an FX devaluation model. Numerical results are finally showcased.

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MS0

Speeding up VaR with Virtual Dimensional Reduction

Monte Carlo and historical risk calculations such as value at risk (VaR) and expected shortfall (ES) require repricing each position in a portfolio 1,000 times or more. This makes risk calculations challenging when the pricing functions themselves are slow. To make such calculations tractable, shortcuts (such as matrix pricing or reducing the number of paths) are often taken. But these approaches tend to substantially reduce accuracy as well. Here we present what we call a virtual dimensional reduction (VDR) approach. This approach improves the accuracy of approximations by drastically reducing the volume of the domain, yielding the effect of dimensional reduction without reducing the actual dimension. This approach is as efficient as matrix pricing but is almost as accurate as full revaluation, enabling accurate risk calculations with as little as 50-100 pricing calculations, thus yielding a speed-up of 10-20x compared to full revaluation with 1,000 scenarios.

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MS1

Towards Explainable AI: Significance Tests for Neural Networks

Neural networks underpin many of the best-performing AI systems. Their success is largely due to their strong approximation properties, superior predictive performance, and scalability. However, a major caveat is explainability: neural networks are often perceived as black boxes that permit little insight into how predictions are being made. We tackle this issue by developing a pivotal test to assess the statistical significance of the feature variables of a neural network. We propose a gradient-based test statistic and study its asymptotics using nonparametric techniques. The limiting distribution is given by a mixture of chi-square distributions. The tests enable one to discern the impact of individual variables on the prediction of a neural network. The test statistic can be used to rank variables according to their influence. Simulation results illustrate the computational efficiency and the performance of the test. An empirical application to house price valuation highlights the behavior of the test using actual data. Joint work with Enguerrand Horel (Stanford).

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MS2

Utility Maximisation with Model-Independent Trading Constraints

Abstract not available

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MS2

Continuity of Utility Maximization under Weak Convergence

In this paper we find tight sufficient conditions for the continuity of the value of the utility maximization problem from terminal wealth with respect to the convergence in distribution of the underlying processes. We also establish a weak convergence result for the terminal wealths of

the optimal portfolios. Finally, we apply our results to the computation of the minimal expected shortfall (shortfall risk) in the Heston model by building an appropriate lattice approximation.

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MS2

Measure-Valued Martingales and Robust Pricing

Abstract not available

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MS3

Mean-Field Games with Differing Beliefs for Algorithmic Trading

Even when confronted with the same data, agents often disagree on a model of the real-world. Here, we address the question of how interacting heterogenous agents, who disagree on what model the real-world follows, optimize their trading actions. The market has latent factors that drive prices, and agents account for the permanent impact they have on prices. This leads to a large stochastic game, where each agents' performance criteria is computed under a different probability measure. We analyse the mean-field game (MFG) limit of the stochastic game and show that the Nash equilibria is given by the solution to a non-standard vector-valued forward-backward stochastic differential equation. Under some mild assumptions, we construct the solution in terms of expectations of the filtered states. We prove the MFG strategy forms an ϵ-Nash equilibrium for the finite player game. Lastly, we present a least-squares Monte Carlo based algorithm for computing the optimal control and illustrate the results through simulation in market where agents disagree on the model. (This is joint work with Philippe Casgrain, U. Toronto)

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MS3

Mean-Field and Tree Interactions for Stochastic Volatility

We shall discuss diffusions with mean-field interactions and interactions through a tree structure by introducing stochastic differential equations with distributional constraints. This class of system includes a system of directed chain stochastic differential equations, and it has an infinite-dimensional feature and so does the corresponding system of filtering equations we discuss. We approximate the system by particle systems and apply the limiting results for modeling stochastic volatility.

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MS3

Convergence to the Mean Field Game Limit: A Case Study

Mean field games are generally interpreted as approximations to n-player games with large n. Indeed, n-player Nash equilibria are known to converge to their mean field counterpart when the latter is unique. In this talk we study a specific stochastic game where both the finite and infinite player versions naturally admit multiple equilibria. It turns out that mean field equilibria satisfying a transversality condition are indeed limits of n-player equilibria, but we also find a complementary class of equilibria that are not limits, thus questioning their interpretation as large n equilibria. (Joint work with Jaime San Martin and Xiaowei Tan)

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MS3

Stationary Stochastic Local Volatility

We study an unusual class of stochastic differential equations of McKean-Vlasov type in which the coefficients depend on a conditional expectation given the solution itself. These equations arise naturally from attempts to invert the Markovian projection, and they enjoy frequent application in the calibration of stochastic local volatility models, despite very limited theoretical understanding. We prove existence and uniqueness for stationary solutions by studying the corresponding (nonlinear, non-local) elliptic partial differential equation. (Joint work with Daniel Lacker and Mykhaylo Shkolnikov)

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MS4

Bail-Ins and Bailouts: Incentives, Connectivity, and Systemic Stability

We develop a framework for analyzing how banks can be incentivized to make contributions to a voluntary bail-in in the presence of default contagion and price-mediated contagion. A bail-in is possible only when the regulator's threat to not bail out insolvent banks is credible. Incentives to join a rescue consortium are stronger for banks with a high exposure to default contagion and banks that hold similar assets as the insolvent banks. Our results reverse existing presumptions about the relative merits of different network topologies for moderately large shock sizes: while diversification effects reduce welfare losses in models without intervention, they inhibit the formation of bail-ins by introducing incentives for free-riding.

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MS4

Disruption and Rerouting in Supply Chain Networks

We study systemic risk in a supply-chain network where rms are connected through purchase orders. Each firm's short-term investment return is subject to a random shock leading to a default. The shock propagates through the supply-chain network via input-output linkages between buyers and suppliers. Firms endogenously take contingency plans to mitigate the impact generated from disruptions. They reroute undelivered orders to alternative buyers and switch excess demand to different suppliers. An equilibrium is reached when contagion from disruption stops. We develop an algorithm to recover the Pareto dominant equilibrium with the greatest amount of delivered orders. We show that lower concentration of orders results in a more fragile network if connectivity is high and firms are highly capitalized. If fi rms are lowly capitalized, however, lower concentration of orders reduces network fragility. Highly concentrated orders are always preferred in networks with low connectivity.

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MS4

Restructuring Failure and Optimal Capital Structure

The ability of firms to successfully renegotiate their debt is a function of bankruptcy costs. Increasing bankruptcy costs reduce creditors payoff in bankruptcy court, increasing the incentive for debtholders to overcome frictions in the bargaining process and settle out of court. Since firms with high bankruptcy costs can restructure out of court, the bankruptcy costs are never realized in equilibrium and thus these firms take on more debt, contradicting the classical tradeoff theory. Embedding multilateral bargaining with frictions into a dynamic capital structure model I find that optimal leverage is u-shaped in bankruptcy costs. Firms with medium bankruptcy costs might find it ex-ante optimal to write covenants to commit to enter renegotiations early where renegotiations can still succeed. Firms with low bankruptcy costs will optimally have a concentrated debt structure while firms with high bankruptcy costs maximize ex-ante firm value with dispersed debt.

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MS4

Systemic Portfolio Diversification

We study the implications of fire-sale externalities on balance sheet composition. Banks select their asset holdings to minimize expected execution costs triggered by the need to comply with regulatory leverage requirements. We show that if banks disregard the price impact caused by other banks' liquidation actions, they hold an excessively diversified portfolio. Banks seek systemic diversification when they account for the negative externalities imposed by other banks' liquidation actions. Social costs can be reduced by a tax on portfolio overlap, or by enforcing policies which mandate the split of a bank into smaller institutions with heterogeneous leverage ratios.

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MS6

Dynamic Mean-Variance Efficient Fractional Kelly Portfolios in a Stochastic Volatility Model

A fractional Kelly strategy bets a fixed fraction of the amount recommended by Kelly and is widely used in practice. We improve the dynamic mean-variance efficiency of such a strategy in a continuous-time stochastic volatility model by studying a mean-variance portfolio selection problem in which an agent achieves an expected return of her investment as high as that of the fractional Kelly strategy and minimizes the variance of her investment return. Because of time-inconsistency, we study and solve in closed form the equilibrium strategy for the agent and find that the return rate of this strategy has smaller variance than that of the fractional Kelly strategy at any time. Finally, we derive an implied risk aversion degree of the agent in our model and find that it is decreasing with respect to the market condition and exponentially decays with respect to the investment horizon.

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MS6

Time Inconsistency Induced by Model Uncertainty – The Stopping Case

In the literature, optimization under model uncertainty is dominated by worst-case analysis. Practical decision making, however, is rarely based on worst-case analysis alone. Empirically, an agent's objective under model uncertainty can be formulated as a convex combination of the worst-case and the best-case objectives. The more ambiguity-averse the agent is, the larger the weight of the worst-case objective in the convex combination. This practical objective, called the "α-maxmin preference" in economics, renders the optimization problem time-inconsistent. Under the strong formulation of model uncertainty, we characterize equilibrium stopping rules as fixed points of an operator, and show that every equilibrium rule can be found through a fixed-point iteration. To obtain our results, we particularly derive a new measurable projection theorem,

which does not require any a priori Borel structure.

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MS6

Dynamic Multivariate Programming

In this talk, I present a set-valued Bellman principle. As a first example, a famous vector optimization problem is considered: the dynamic mean-risk portfolio optimization problem. Usually, this problem is scalarized and it is well known that this problem is time-inconsistent. However, when we leave it in its original form as a vector optimization problem, the upper images, whose boundary is the efficient frontier, recurse backwards in time. Conditions are presented under which this recursion can be exploited directly to compute a solution in the spirit of dynamic programming. As a second example, the set-valued Bellman principle appears when considering time consistency of multivariate risk measures. One example is superhedging under transaction costs. Similar to the first example, one can show that a (fixed) scalarization of the problem does not satisfy the (scalar) Bellman principle, but a particular moving scalarization leads also to scalar time consistency. With our approach this moving scalarization is part of the solution and not needed as an input.

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MS6

Multi-Dimensional Optimal Equilibria for Time-Inconsistent Stopping Problems

We study an infinite-horizon optimal stopping problem under non-exponential discounting. Contrary to prior studies on time-inconsistent stopping problems, which mostly deal with one-dimensional diffusion processes, we take the state process to be a multi-dimensional continuous strong Markov process. An optimal equilibrium stopping rule, which generates larger values than any other equilibrium does on the entire state space, is shown to exist, when the discount function is log sub-additive. Note that this condition covers all discount functions that induce decreasing impatience. The key to achieving our multi-dimensional result is the use of the fine topology, instead of the standard topology, of the Euclidean space. This enables us to handle equilibria that are universally measurable and satisfy a mild regularity condition. The intersection of all such equilibria then yields an optimal equilibrium.

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MS7

Robo-Advising as a Human-Machine Interaction System

Robo-advising enhances a humans efficiency in investment decisions. We propose a human-machine interaction framework where the machine adaptively learns the investor's risk preferences by observing the investor's response to its investment recommendations. The objective of the machine is to maximize the human's risk-sensitive criterion. We show that this problem can be cast as a partially observable Markov decision problem (POMDP), for which an optimal solution is computationally infeasible. We exploit the special structure of our framework and develop linear time algorithms that produce near-optimal decisions.

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MS7

Reinforcement Learning in Portfolio Optimization

In this talk we propose a general deep reinforcement learning, policy-gradient based algorithm for tackling high-dimensional control problems with continuous state and action spaces, constraints, and complex dynamics. We demonstrate state-of-the-art performance on key benchmark problems in dynamic portfolio optimization and algorithmic trading. On some instances we see a provable near-zero optimality gap, compared to existing cutting-edge approaches.

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MS7

DGM: A Deep Learning Algorithm for Solving Partial Differential Equations

High-dimensional PDEs have been a longstanding computational challenge. We propose to solve high-dimensional PDEs by approximating the solution with a deep neural network which is trained to satisfy the differential operator, initial condition, and boundary conditions. Our algorithm is meshfree, which is key since meshes become infeasible in higher dimensions. Instead of forming a mesh, the neural network is trained on batches of randomly sampled time and space points. The algorithm is tested on a class of high-dimensional free boundary PDEs, which we are able to accurately solve in up to 200 dimensions. The

algorithm is also tested on a high-dimensional Hamilton-Jacobi-Bellman PDE and Burgers' equation. The deep learning algorithm approximates the general solution to the Burgers' equation for a continuum of different boundary conditions and physical conditions (which can be viewed as a high-dimensional space). We call the algorithm a "Deep Galerkin Method (DGM)" since it is similar in spirit to Galerkin methods, with the solution approximated by a neural network instead of a linear combination of basis functions. In addition, we prove a theorem regarding the approximation power of neural networks for a class of quasilinear parabolic PDEs. Joint work with Justin Sirignano.

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MS8

Wasserstein and Adapted Wasserstein Distances in Mathematical Finance

This talk focuses on the study of continuity and robustness of optimization problems in MathFinance; for example utility maximization or risk measures. We show that in a one period setting, the classical Wasserstein distance is traceable and even allows for (semi-) explicit formulas. In the multi period setting, we argue why an adapted counterpart to Wasserstein distance is the canonical replacement, and show that it preforms well for the study of multi period optimization problems. Based on joint works with J. Backhoff, M. Beiglböck, S. Drapeau, M. Eder, J. Obłój, L. Tangpi, J. Wiesel.

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MS8

Concentration of Dynamic Risk Measures in a Brownian Filtration

Motivated by liquidity risk in mathematical finance, D. Lacker introduced concentration inequalities for risk measures, i.e. upper bounds on the liquidity risk profile of a financial loss. We derive these inequalities in the case of time-consistent dynamic risk measures when the filtration is assumed to carry a Brownian motion. The theory of backward stochastic differential equations (BSDEs) and their dual formulation plays a crucial role in our analysis. Natural by-products of concentration of risk measures are a description of the tail behavior of the financial loss and transport-type inequalities in terms of the generator of the BSDE, which in the present case can grow arbitrarily fast.

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MS9

Mean Field Games with Finite States in the Weak Formulation, and Application to Contract Theory

Models for Mean Field Games (MFGs) with finite state spaces are typically introduced using controlled Markov chains and studied through the solutions of Hamilton-Jacobi-Belman and Fokker-Planck equations. We introduce the weak formulation based on change of measure techniques for stochastic integral equations and prove existence and uniqueness in this setting. We then apply these results to a contract theory problem in which a principal faces a field of agents interacting in a mean field manner. We reduce the problem to the optimal control of dynamics of the McKean-Vlasov type, and we solve this problem explicitly in a special case reminiscent of the linear - quadratic mean field game models. We conclude with a numerical example of epidemic containment.

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MS9

Beyond Mean Field Limits: Local Dynamics for Large Sparse Networks of Interacting Diffusions

We study large systems of stochastic processes (particles) in which each particle is associated with a vertex in a graph and interacts only with its neighbors. When the graph is complete and the numbers of particles grows to infinity, the system is well-described by a McKean-Vlasov equation, which describes the behavior of one typical particle. For general (sparse) graphs, the system is no longer exchangeable, and the mean field approximation is not valid. Nevertheless, if the underlying graph is locally tree-like, we show that a single particle and its nearest neighbors are characterized by a peculiar but autonomous set of "local dynamics." This work is inspired in part by recent mean field models of inter-bank lending, which capture several dynamic features of systemic risk but thus far lack realistic network structure. (Joint work with Kavita Ramanan and Ruoyu Wu)

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MS9

Deep Learning Methods for Mean Field Control Problems with Delay

We consider a general class of mean field control problems described by stochastic delayed differential equations of McKean-Vlasov type. Two numerical algorithms are provided based on deep learning techniques, one is to directly parameterizing the optimal control using neural networks, the other is based on numerically solving the McKean-Vlasov forward anticipated backward stochastic differential equation (MV-FABSDE) system. In addition, we establish the necessary and sufficient stochastic maximum principle of this class of mean field control problems with delay based on the differential calculus on function of measures, and the existence and uniqueness results are proved for the associated MV-FABSDE system under suitable conditions.

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MS9
Large Tournament Games

We consider a stochastic tournament game in which each player works toward accomplishing her goal and is rewarded based on her rank in terms of the time to completion. We prove existence, uniqueness and stability of the game with infinitely many players, and existence of approximate equilibrium with finitely many players. When players are homogeneous, the equilibrium has an explicit characterization. We find that the welfare may be increasing in the cost of effort in its low range, as the cost reduces players? eagerness to work too hard.

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MS10
Graphons and Contagion

We show that the outcome of threshold contagion process on a sequence of dense graphs converges to the outcome of threshold contagion on the limiting graphon. We illustrate that determining the outcome of contagion on the graphon is computationally much more tractable than on the limiting sequence of discrete graphs. We further introduce the notion of "sensitive infection points" that turn arbitrarily small shocks into large cascades and create systemic risk. We identify sensitive infection points on a given graphon from its geometry.

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MS10
Stability and Fragility of Dynamic Credit Networks

I will present some of the recent advances in the study of particle systems with threshold-type interaction, which appear naturally in the mathematical models for credit and computer networks, neuron cells, supercooled liquids, etc. First, I will show how to characterize the times of fragility of such systems (e.g. the times when a macroscopic part of the population defaults instantaneously) explicitly in terms of the dynamics of the driving process, the current distribution of the particles values, and the topology of the underlying network (represented by its Perron-Frobenius eigenvalue). Second, I will use such systems to describe a dynamic credit-network game and will show that, in equilibrium, the system regularizes: i.e., the times of fragility never occur, as the particles avoid them by adjusting their connections strategically. Remarkably, the resulting equilibrium is very explicit and allows us to compute numerically the future equilibrium interest rates and credit exposures for all (risk-neutral) market participants, given the expected returns on their individual investments, the constraints on credit exposures, and the initial distances-to-default. On the mathematical side, this work establishes a generalization of Schauder fixed-point theorem for the Skorokhod M1 topology and solves a de-centralized version of the network-flow problem via max-plus algebra. Joint work with M. Shkolnikov.

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MS10
Systemic Risk Efficient Portfolio Selection

We develop a model for the optimal portfolio selection in presence of systemic risk. In our modelling approach we use two risk measures: VaR and CoVaR (Adrian and Brunnermeir (2016)). Our investor maximizes portfolio's expected returns conditioned on a systemic event: financial system return being at (at most at) its VaR level and portfolio's returns below their CoVaR level. VaR and CoVaR quantiles allow our investor to control relative importance of "portfolio-system correlation" and "portfolio variance", respectively, when he determines the optimal portfolio. The model is shown to have superior performance at the times of market downturns when applied to the Canadian and US equity markets. We also find that portfolios that perform best in adverse market conditions are less diversifi ed as they tend to concentrate on few stocks that have relatively small correlation with the system.

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MS10
Capital Allocation under the Fundamental Review of Trading Book

Facing the FRTB, banks need to allocate their capital to each business units or risk positions to evaluate the capital efficiency of their strategies. This paper proposes two computationally efficient allocation methods which are weighted according to liquidity horizon. Both methods provide more stable and less negative allocations under the FRTB than under the current regulatory framework.

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MS12
Asset Prices and No-Dividend Stocks

We incorporate stocks that pay no dividends into an otherwise standard, parsimonious dynamic asset pricing framework. We find that such a simple feature leads to profound asset price implications, which are all supported empirically. In particular, we demonstrate that no-dividend stocks command lower mean returns, but also have higher return volatilities and higher market betas than comparable stocks that pay dividends. We also show that the presence of no-dividend stocks in the stock market leads to a lower correlation between the stock market return and aggregate consumption growth rate, a non-monotonic and even a negative relation between the stock market risk premium and its volatility, and a downward sloping term structure of equity risk premia. We provide straightforward intuition for all these results and the underlying economic mechanisms at play.

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MS12

Institutional Investors, Heterogenous Benchmarks, and the Co-Movement of Asset Prices

We study an equilibrium model of a multi-asset economy in which asset managers are each subject to a different benchmark. This source of heterogeneity (i.e., heterogeneous benchmarking) generates a mechanism through which fundamental shocks propagate across assets. In particular, fluctuations in asset managers capital invested for benchmarking purposes, scaled by the size of the economy, induce price pressure that can result in negative spillovers across asset returns. We highlight the ensuing cross-sectional implications for asset comovement, predictability and hedging portfolios. This is joint work with Idan Hodor.

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MS12

The Shape of the Term Structures

Empirical findings show that the term structures of dividend strip risk premium and volatility are downward sloping, while the term structure of interest rates is upward sloping. We investigate the general equilibrium relationships between the shape of these term structures, the dynamics of economic fundamentals, and the representative agent's preferences. We show that the observed shapes can be obtained simultaneously with simple, realistic dynamics and standard preferences. The only necessary feature is time variation in the expected economic growth rate. In this case, the observed term structures can be replicated simultaneously even when the agent has myopic or CRRA preferences This is joint work with Mariana Khapko.

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MS12

Contracting Within Fund Families

Most mutual funds are part of large fund families. The fund family charges investors a fee for allocating wealth into its fund and contracts a professional money manager to run it. The profit of the family is the difference between the total fund fees and the compensation paid to the manager. We show that such intermediation is profitable only if there is significant uncertainty about the manager's skill and the fund family is better informed than outside investors. The fund family channels investment towards skilled managers but captures much of the surplus by strategically compensating them. We characterize equilibrium dynamics of the family's profit flows as a function of managers' performance and the private information about them. The family profits more from the higher skilled managers and retains them for longer. Investors learn about the manager's skill from returns and turnover; as a result, funds within the family exhibit higher growth rates. To better bargain with the manager, it is optimal for the fund family to charge investors a lower fund fee. Our analysis applies to most professions where employee talent is essential such as consulting firms, legal partnerships, and universities. This is joint work with Ron Kaniel.

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MS13

Deep Q-Learning for Stochastic Games

Model-free learning for multi-agent stochastic games is an active area of research. Existing reinforcement learning algorithms, however, are often restricted to zero-sum games, and are applicable only in small state-action spaces or other simplified settings. Hu and Wellman (2003) introduce a Q-learning approach for obtaining Nash equilibria in stochastic games, but the approach is computationally infeasible for all but the simplest examples. Here, we develop a new efficient Deep-Q-learning methodology for model-free learning of Nash equilibria for general-sum multi-agent stochastic games. The algorithm is built on a local linear-quadratic expansion of the stochastic game, which leads to analytically solvable optimal actions, while simultaneously parameterized by deep neural networks to allow flexibility to learn the environment. We study symmetry properties of the algorithm stemming from label-invariant stochastic games and as a proof of concept, apply our algorithm to learning optimal trading strategies in competitive electronic markets.

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MS14

Adaptive Robust Control

We propose a new methodology for solving an uncertain stochastic Markovian control problem in discrete time, called the adaptive robust control. We apply this method to optimal portfolio allocation problem and prove that the uncertain control problem under consideration can be solved in terms of associated adaptive robust Bellman equation.

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MS14

Statistical Uncertainty and Optimal Decision Making

Making good decisions based on estimates is difficult, but of clear importance in many applications. This is particularly the case when the decisions made will affect the information available in the future. Formally, this means that the filtration of our problem is not fixed in advance, but depends on the control used. We will consider the 'simplest' problem of this type, a multi-armed bandit problem, while taking account of uncertainty aversion. We will see that an extension of the classical Gittins' index approach is possible in this framework, despite many dynamic consistency issues.

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MS14

Robust XVA

We introduce an arbitrage-free framework for robust valuation adjustments. An investor trades a credit default swap portfolio with a risky counterparty, and hedges credit risk by taking a position in the counterparty bond. The investor does not know the expected rate of return of the counterparty bond, but he is confident that it lies within an uncertainty interval. We derive both upper and lower bounds for the XVA process of the portfolio, and show that these bounds may be recovered as solutions of nonlinear ordinary differential equations. The presence of collateralization and closeout payoffs leads to fundamental differences with respect to classical credit risk valuation. The value of the super-replicating portfolio cannot be directly obtained by plugging one of the extremes of the uncertainty interval in the valuation equation, but rather depends on the relation between the XVA replicating portfolio and the close-out value throughout the life of the transaction.

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MS14

The Robust Superreplication Problem: A Dynamic Approach

In the frictionless discrete time financial market of Bouchard et al.(2015) we consider a trader who, due to regulatory requirements or internal risk management reasons, is required to hedge ξ in a risk-conservative way relative to a family of probability measures $\mathcal{P}$. We first describe the evolution of $\pi_t(\xi)$ - the superhedging price at time t of the liability ξ at maturity T - via a dynamic programming principle and show that $\pi_t(\xi)$ can be seen as a concave envelope of $\pi_{t+1}(\xi)$ evaluated at today's prices. Then we consider an optimal investment problem for the trader who is rolling over her robust superhedge and phrase this as a robust maximisation problem, where the expected utility of inter-temporal consumption is optimised subject to a robust superhedging constraint. This utility maximisation is carried out under a new family of measures $\mathcal{P}^u$, which no longer have to capture regulatory or institutional risk views but rather represent the trader's subjective views on market dynamics. Under suitable assumptions on the trader's utility functions, we show that optimal investment and consumption strategies exist and further specify when, and in what sense, these may be unique.

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MS15

Linear Quadratic Mean Field Games: from Asymptotic Solvability to the Fixed Point Approach

Mean field game theory has been developed largely following two routes: the direct approach and the fixed point approach. We investigate their relations in a linear quadratic setting. We introduce an asymptotic solvability problem for the direct approach and for analyzing its solubility we apply a multi-scale technique to derive the necessary and sufficient condition via a non-symmetric Riccati ODE. This provides a foundation to examine the relation and difference of the two approaches. We further study the long time behavior of the above non-symmetric Riccati ODE. This is joint work with Mengjie Zhou.

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MS15

Probabilistic Numerical Methods for MFC and MFG Based on Deep Learning

We propose two probabilistic numerical methods for mean field type problems based on deep learning. The first method amounts to solve mean field control problems (i.e., problems of optimal control of McKean-Vlasov dynamics) by learning the optimal control using Monte-Carlo samples and stochastic gradient descent. This can be done in a somewhat brute force fashion thanks to deep learning. The second method deals with forward-backward stochastic differential equation (FBSDE) systems of mean field type. As such, this method can be applied to both mean field control problems and mean field games. We rephrase the problem of finding a solution to a generic mean field FBSDE system as a certain mean field control problem, and we then apply a variant of the first method proposed. Several numerical examples will be provided. This is joint work with Rene Carmona (Princeton University).

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MS15

Systemic Risk and Mean Field Games with Heterogeneous Groups

We study the system of heterogeneous interbank lending and borrowing based on the relative average of log-capitalization through the linear combination of the average within groups and the ensemble average and describe the evolution of log-capitalization by a system of coupled diffusions. The model incorporates a game feature with homogeneity within groups and heterogeneity between groups where banks search for the optimal lending or borrowing strategies and intend to minimize the heterogeneous linear quadratic costs in order to remain survival in the system. We obtain the Markov Nash equilibria governed by

the mean-reverting term and the extra ensemble averages of individual groups given by heterogeneity. In addition, the corresponding heterogeneous mean filed game is also discussed.

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MS15

Weakly Interacting Markov Chains on Multicolor Graph in Multiple Regimes

We consider a weakly interacting particle system on multicolor random graphs over a finite state space. The evolution of each particle depends on its own state, and the empirical measure of all other particles' states and the corresponding edge colors. Different laws of large numbers are established for three regimes of the random graph dynamics: (1) the graph is evolving independently of the particles; (2) the graph evolution is coupled with that of particles; (3) the graph is evolving at a much faster speed while being coupled with the evolution of particles. The central limit theorem and the corresponding n-player game are discussed for each regime. This is joint work with Erhan Bayraktar.

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MS17

Trading Fractional Brownian Motion

In a market with an asset price described by fractional Brownian motion, which can be traded with temporary nonlinear price impact, we find asymptotically optimal strategies for the maximization of expected terminal wealth. Exploiting the autocorrelation in increments while limiting trading costs, these strategies generate an average terminal wealth that grows with a power of the horizon, the exponent depending on both the Hurst and the price-impact parameters. The resulting Sharpe ratios are bounded, insensitive to the horizon, and asymmetric with respect to the Hurst exponent.

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MS17

Reference Dependence and Anchors in Complete Markets

This work studies optimal portfolio decisions when investors exhibit the reference-dependent preferences of Koszegi and Rabin, in a general complete market setting with a no-bankruptcy constraint. If loss aversion or gain-loss sensitivity are weak, a unique personal equilibrium arises that qualitatively resembles the classical utility maximizer. By contrast, strong loss aversion and gain-loss aversion can generate multiple (in fact, infinitely many) coexisting personal equilibria, whose distributions are a combination of continuous and discrete parts. We also investigate the sensitivity of the personal equilibria to market and preference parameters, as well as their limiting behaviors.

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MS17

High-Water Mark Fees with Stochastic Benchmark

A hedge fund manager invests the fund in a constant investment opportunity, and receives high-water mark fees when the fund reaches a new maximum relative to a stochastic benchmark, aiming to maximize the expected power utility from fees in the long run. The manager's optimal portfolio includes a Merton component with the risk aversion parameter shifted towards one, and a hedging component against the risk in the benchmark, both of which depend on how the fund investment opportunity compares to the benchmark. A stochastic benchmark in the calculation of high-water mark fees introduces the moral hazard of risky fund investment with hedging motives, but also provides a possibility of regulating the manager's risk taking with a carefully chosen benchmark.

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MS17

Portfolio Optimisation with Semivariance

In this talk, I shall study dynamic portfolio management using semivariance of portfolio payoff as a portfolio risk measure. Comparing with variance which is widely used as a risk measure in the literature, semivariance is considered to be more plausible risk measure because semivariance penalizes adverse situations only. However, in the literature, it was shown that mean-semivariance optimisation under the Black-Scholes model has no optimal solution. Inspired by this non-existence result, I shall establish necessary and sufficient conditions under which the mean-semivariance optimisation possesses an optimal solution. I shall suggest the models under which such sufficient conditions are satisfied, thus, under these models, the explicit optimal solution to mean-semivariance optimisation can be obtained. Besides, apart from using expected payoff to assess investor's satisfaction, utility-semivariance model will be considered, and I shall established the existence of optimal solution to utility-semivariance optimisation, even under the Black-Scholes model. I will conclude this talk by investigating the extension to general downside deviation risk measures.

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MS18

Efficient Simulation of Stochastic Differential Equations Based on Markov Chain Approximations and Applications

In this paper, we propose a novel Monte Carlo simulation method for two-dimensional stochastic differential equation systems based on approximation through continuous-time Markov chains (CTMCs). As a representative application to illustrate the method, we consider the efficient simulation of asset prices for general stochastic local volatility models, which include the Heston stochas-

tic volatility model and the stochastic alpha beta rho (SABR) model as special cases. Compared with traditional time-discretization schemes and recent unbiased schemes, our method exhibits several advantages, including flexible boundary condition treatment and a second order convergence rate in the space grids of the approximating CTMC under suitable regularity conditions. Replacing the stochastic variance process with a discrete-state approximation greatly simplifies the direct sampling of the integrated variance, thus enabling a highly efficient semi-exact simulation scheme. Extensive numerical examples illustrate the accuracy and efficiency of our estimator, which outperforms *both biased and unbiased* simulation estimators existing in the literature in terms of root mean squared error (RMSE) and computational time. We believe that this new simulation approach has potential for applications in other contextual areas in operations research and computing that involve modeling and simulation of stochastic differential equations.

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MS18

A General Method for Valuation of Drawdown Risk under Markovian Models

Drawdown measures the price drop from the maximum price and drawdown derivatives are designed to protect investors from sharp price falls. Valuation of these derivatives requires the analysis of the first passage time of the drawdown process, which is a challenging task. Despite the success of some approaches for specific models, a general and computationally efficient method is still lacking. This paper develops a novel algorithm based on continuous time Markov chain approximation and numerical integration to price drawdown derivatives for general Markovian asset price models. Our method allows models with and without jumps to be treated in a unified way. We prove convergence of our algorithm for general Markovian models and provide sharp estimates of the convergence rates for a general class of jump-diffusion models. We also show how to design the grid of the Markov chain to accelerate convergence. Various numerical experiments document the computational efficiency of our method and its advantages over some popular alternatives. In an empirical study, we investigate the effectiveness of a list of drawdown derivatives for hedging the price risk of bitcoin. Our result offers a potential solution to ease concerns over extreme volatility risk in this market.

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MS18

Markov Chain Approximation of Sticky Diffusion Models for Interest Rates

We consider general one-dimensional sticky diffusions defined as weak solutions of SDEs and show that there exists a unique weak solution under rather mild conditions. We develop continuous time Markov chain (CTMC) approximation for sticky diffusions. Under the CTMC, computation of the action of Feyman-Kac operators becomes analytically tractable and we prove that it achieves second order convergence. We also propose a simulation scheme for sticky diffusions based on CTMC approximation and show that it attains a weak convergence order of two. In contrast, traditional time discretization methods such the Euler scheme completely fails. Applications to stick diffusion models for S-shaped yield curves are given to illustrate the accuracy of our method.

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MS18

Analysis of Markov Chain Approximation for Diffusion Models with Non-Smooth Coefficients

Diffusion models with non-smooth coefficients often appear in financial applications. To calculate the expected value of a discounted payoff under general state-dependent discounting and monitoring of barrier crossing, continuous time Markov chain (CTMC) approximation can be applied. In a recent work, Zhang and Li (2018, Operations Research, forthcoming) established sharp convergence rates of CTMC approximation for diffusion models with smooth coefficients but non-smooth payoff functions, and proposed grid design principles to ensure nice convergence behaviors. However, their theoretical analysis fails to obtain sharp convergence rates when model coefficients lack smoothness. In this paper, we introduce new ways for the theoretical analysis of CTMC approximation for general diffusion models with non-smooth coefficients. We prove that convergence of option price is only first order in general. However, strikingly, if all the discontinuous points of the model coefficients and the payoff function are in the midway between two grid points, second order convergence in the maximum norm is restored and in this case, delta and gamma have second order convergence at almost all grid points except those next to the discontinuous points. Numerical experiments are conducted that confirm the validity of our theoretical results. We also compare the CTMC approximation approach to a classical numerical PDE scheme with smoothing pasting. We show that our approach is superior to the latter.

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MS19

Duality-Based Exploration in Reinforcement Learning and its Financial Application

We develop a Boltzmann exploration approach to address the exploration-and-exploitation tradeoff in reinforcement learning problems. Based on a new concept of information

duality, the proposed approach will probabilistically choose under-explored states to guide exploration. Numerical implementations in some financial applications demonstrates the efficiency of the method.

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MS19

NeuCredit: Learning the Dynamics of Consumer Behaviors for Retail Credit Risk Management

Consumer credit risk modeling is a long-standing problem in finance. The recent migration of shopping activities from offline to online presents new challenges to this traditional field. As modern e-commerce platforms often provide comprehensive services from financing to shopping, more extensive and detailed consumer behaviors can be observed than before. While the behavioral pattern lying behind these actions is a blur, the issue of their usage in risk management remains untouched. Therefore, we design NeuCredit, a risk computing system that employs a novel hierarchical neural network to learn the dynamics of multi-view online shopping behaviors for credit risk estimation. The system handles the *irregularities* of actions in time and captures the *interactions* across different action streams. Besides, the system outputs *interpretable* credit risks via an innovative conditional loss that integrates the *willingness* and the *ability* of customer repaying into the system even though their ground-truths are missing. Extensive experiments are conducted on a real-life dataset which is collected on JD.com, one of the largest e-commerce platforms in China. Results show the superiority of NeuCredit over conventional and the state-of-the-art methods.

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MS19

Parsimonious Learning of Tail Dynamics

We propose a semi-parametric machine learning approach to capture the serial dependence of conditional distribution in asset returns, motivated by the study of tail risk forecast using finite sample. This approach combines the merits of a novel parameterization of conditional quantile function with the Long short-term memory (LSTM) sequential neural network model in machine learning. In our model, the baseline version of the quantile function represents well a wide range of asymmetrical tail heaviness with as few as four parameters, and the LSTM neural network is capable of learning their joint dynamics without any parametric restrictions. For a wide range of asset classes, the out-of-sample conditional quantile forecasts outperform the GARCH model and its variants in both coverage tests and independence tests. Our comprehensive empirical study shows that the dynamical structure of return distribution is not always auto-regressive in nature; further, drivers of higher moments' serial dependencies could contain risk factors that are independent of those responsible for volatility clustering. These findings should have important implications for financial risk management.

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MS19

The Forest Behind the Trees: Trees in Asset Pricing

Sorting-based strategy of building portfolios has been a default empirical approach in asset pricing for creating both test assets and factor-mimicking returns. One of the natural limitations of this technique, however, is its inability to adequately reflect the information contained in more than 2 characteristics and their interaction. We propose to analyze the effect of a large number of characteristics on expected stock returns with the machine learning technique known as random forest. As an ensemble learning method for classification, the new approach is particularly well-suited for building composite cross-sections of portfolios that reflect the rich conditional information contained in a large number of characteristics simultaneously, and can be viewed as a natural generalization of the conventional sorting-based strategies. We build decision trees for various sets of stock-specific characteristics, and demonstrate that the new approach is able to create cross-sections that a) reflect the information in a joint conditional distribution of characteristics, b) are challenging to price based on the conventional models, even when pitted against the tradable factors based on the underlying characteristics, and c) imply investment strategies that achieve yearly out-of-sample Sharpe ratios above 2.

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MS20

Managing Counterparty Risk in Over-the-Counter Markets

We study the trading and risk management decisions of banks operating in over-the-counter markets. Banks are heterogeneous in their initial exposure to an aggregate credit risk factor stemming from their nontradable loan portfolios. Banks transfer risk among themselves by optimally negotiating quantities and prices of credit default swaps (CDSs). Our model provides new implications which are supported by empirical evidence: (i) the main intermediaries are low-risk banks with medium initial exposure;

(ii) the risk-sharing capacity of the market is impaired, even when the limit on the CDS trading size is not binding; and (iii) intermediaries play the fundamental role of diversifying the idiosyncratic risk in CDS contracts, besides increasing the risk-sharing capacity of the market. Costly actions exerted by banks to reduce their default probabilities are inefficient. We show that negative externalities due to counterparty concentration may lead banks to reduce their default probabilities even below the social optimum.

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MS20

Price Bias and Common Practice in Option Pricing

Generally, the semiclosed-form option pricing formula for complex financial models depends on unobservable factors such as stochastic volatility and jump intensity. A popular practice is to use an estimate of these latent factors to compute the option price. However, in many situations, this plug-and-play approximation does not yield the appropriate price. This paper examines this bias and quantifies its impacts. We decompose the bias into terms that are related to the bias on the unobservable factors and to the precision of their point estimators. The approximated price is found to be highly biased when only the history of the stock price is used to recover the latent states. This bias is corrected when option prices are added to the sample used to recover the states best estimate. We also show numerically that such a bias is propagated on calibrated parameters, leading to erroneous values.

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MS20

An Axiomatic Theory for Rating Structured Finance Securities

Credit rating is ubiquitous in all forms of financial products, and in particular structured products. In view of its fundamental importance, this paper proposes a set of axioms on a credit rating system for structured financial products. A desirable rating system, satisfying the axioms of scale invariance, no-structuring arbitrage, and scenario relevance, is called coherent. In addition, we study the consistency with pooling effect for rating systems. In our framework, the probability of default criterion used by Standard & Poor's and Fitch does not satisfy the no-structuring arbitrage axiom, and it also fails to be consistent with pooling effect. On the other hand, the expected loss criterion used by Moody's is a coherent rating system consistent with pooling effect. As one of the main theoretical results, we show that a coherent rating system is characterized by a rating measure which admits a Choquet integral representation. Based on the theory, we propose some forms of coherent rating measures that can be used for practice. An empirical study on credit derivatives market data supports some of our theoretical considerations.

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MS21

Pricing of Interbank Claims in an Eisenberg-Noe Network under Comonotonic Endowments

We present formulas for the pricing of interbank claims in a financial network under comonotonic endowments. We demonstrate that the comonotonic setting provides a lower bound to the price of the interbank under Eisenberg-Noe (2001) financial networks with consistent marginal endowments. The proposed pricing formulas consider the realized, endogenous, recovery rate on the interbank claims. We give special consideration to the case where the firms invest in a risk-free bond and risky asset following a geometric Brownian motion. We provide a comparison of this setting to that taken by Merton (1974).

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MS21

Mean-Field of Optimal Stopping: A Relaxed Control Approach

We consider the mean-field game where each agent determines the optimal time to exit the game by solving an optimal stopping problem with reward function depending on the density of agents still present in the game. We place ourselves in the framework of relaxed optimal stopping, which amounts to look for the optimal occupation measure of the stopper rather than the optimal stopping time. This framework allows us to prove the existence of the relaxed Nash equilibrium and the uniqueness of the associated value of the representative agent under weak assumptions. Further, we prove a rigorous relation between relaxed Nash equilibria and the notion of mixed solutions introduced in earlier works on the subject, and provide a criterion under which the optimal strategies are pure strategies, that is, behave in a similar way to stopping times. Finally, we present a numerical method for computing the equilibrium in the case of potential games and show its convergence (joint work with Peter Tankov and Geraldine Bouveret).

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MS21

Systemic Risk Models in Network and Mean-Field Frameworks

Systemic risk is the risk that a large number of components of an interconnected financial system fail within a short time thus leading to the overall failure of the system itself. In addition to the explicit interaction between banks through liabilities, implicit interactions exist through, e.g., fire sales, confidence, and liquidity crises. Since the 2008-2009 financial crisis, there has been almost universal agreement that these interactions need to play a more significant role in how we quantify the risks of financial institutions.

Two major streams of literature exist: network models and mean-field models. Each of these distinct streams comes with its own advantages and shortcomings. The network models typically focus on finite number of heterogeneous institutions in static time, though analytical solutions to these models are often intractable. The mean-field models natively consider time dynamics and provide, often, tractable solutions, but at the cost of homogeneity of a continuum of agents. In this talk, we aim to provide an overview of these two mathematical frameworks with a specific focus on how both modeling frameworks describe the same phenomena.

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MS21

Modeling Financial System with Interbank Flows, Borrowing, and Investing

In our model, private actors with interbank cash flows similar to, but more general than that by Carmona et al. (2013) borrow from the non-banking financial sector at a certain interest rate, controlled by the central bank, and invest in risky assets. Each private actor aims to maximize its expected terminal logarithmic wealth. The central bank, in turn, aims to control the overall economy by means of an exponential utility function. We solve all stochastic optimal control problems explicitly. We are able to recreate occasions such as liquidity trap. We study the distribution of the number of defaults (net worth of a private actor going below a certain threshold).

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MS24

Algorithmic Trading: A Reinforcement Learning Approach

Market makers continuously set bid and ask quotes for the assets they have under consideration. Numerous models exist for tackling the optimization problem faced by market makers, i.e. proposing bid and ask prices to benefit from the bid-ask spread while mitigating the risk associated with price changes of inventories in possession. Most of these models tackle the single-asset case, but they often can be generalized to the multi-asset case. However, the problem of the numerical approximation of the solutions of the equations characterizing the optimal quotes is rarely tackled in the literature, especially in high dimension (when classical finite difference methods cannot be applied). In this work, we develop a method to solve the problem of market makers in high dimension by using actor-critic reinforcement learning with deep neural networks.

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MS24

Augmenting FX Market Making Strategies with Mid-Book Liquidity

The OTC nature of Foreign Exchange (FX) markets lends itself to a vast array of liquidity venues, each with their own advantages and disadvantages when executing different types of strategies (e.g. optimal liquidation, market making, or alpha seeking). We focus on one particularly interesting type of liquidity venue known as a "mid-book' that has the unique property that the trade price is set in the future after a match occurs. In the context of optimal market making, we show when it is optimal to post interest in such venues as a function of inventory aversion, volatility, market volume, and alpha. When considering the market impact associated with other controls in the problem (limit orders and market orders), we also show how these other controls change when the market maker receives mid-book fills but the trade price has yet to be established.

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MS24

Optimal Order Placement with Random Measures

We develop a strategy to choose the price limit of marketable orders sent by an agent who wishes to minimize the number of their trades that are rejected in electronic order driven markets. Due to latency, the exchange rejects trades when the price or quantities in the limit order book have worsened relative to the price limit and quantity specified in the order. We define latency as the time delay between an exchange streaming market data to a trader, the trader processing information and deciding to trade, and the exchange receiving the order from the trader. The strategy takes into account the cost incurred to minimize the rejection of trades, which depends on how keen the trader is to complete trades. We use marked point processes to model the activity of the trader and the random shocks in the limit order book over the latency window. We use Gâteaux derivatives to obtain a FBSDE that characterizes the optimal solution, which to the best of our knowledge is a new type of FBSDE. We prove existence and uniqueness of the FBSDE, and study the relationship with a weak formulation approach for the problem. Finally, similar to the work of Cartea and Snchez-Betancourt (2018), we employ this optimal strategy to compute the shadow price of latency that a trader would be willing to pay for co-location and hardware to reduce their latency in the marketplace.

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MS24

On Detecting Spoofing Strategies in High Fre-

quency Trading

The development of high frequency and algorithmic trading allowed to reduce considerably the bid ask spread by increasing liquidity in limit order books. Beyond the problem of optimal placement of market and limit orders, the possibility to cancel orders for free leaves room for price manipulation, in particular for spoofing strategies. It is an empirical evidence that volume imbalance on both side of the limit order book reflecting offer and demand has an impact on subsequent price movements. Spoofers use this effect to artificially modify the imbalance by posting limit orders and then execute market orders at subsequent better prices while canceling at a high speed their previous limit orders. In this work we set up a model to determine where a spoofer would place its limit orders to maximize its gains as a function of the imbalance impact on the price movement. We study the solution of this non local optimization problem as a function of the imbalance. With this at hand, we calibrate on real data from TMX the imbalance as a function of its depth and and recent history to a mixture binomial distribution of the resulting price movement. Based on this calibration and results, we then provide some methods as how to detect within the limit order book eventual spoofing behavior while the real trader ID is (partially) unknown. Joint work with Tao Xuan (SJTU), Ling Lan (SJTU) and Andrew Day (Western University)

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MS25

Multivariate Gaussian Process Regression for Portfolio Risk Modeling: Application to CVA

Modeling counterparty risk is computationally challenging because it requires the simultaneous evaluation of all the trades with each counterparty under both market and credit risk. We present a multi-Gaussian process regression for estimating portfolio risk, which is well suited for OTC derivative portfolios, in particular CVA computation. Our spatio-temporal modeling approach avoids nested MC simulation or simulation and regression of cash flows by learning a 'kernel pricing layer'. The pricing layer is flexible - we model the joint posterior of the derivatives as a Gaussian over function space, with the spatial covariance structure imposed only on the risk factors. Monte-Carlo (MC) simulation is then used to simulate the dynamics of the risk factors. Our approach quantifies uncertainty in portfolio valuation and CVA arising from the Gaussian process approximation. Moreover, we take advantage of recent advances in massively scalable GPs. Numerical experiments demonstrate the accuracy, convergence properties and scalability to high dimensions.

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MS25

Neural Network based Approximation Algorithm for Semilinear Parabolic PDEs with Application to Pricing

In this talk we present a deep learning based algorithm to approximately solve high-dimensional semilinear parabolic PDEs efficiently, which typically occur when pricing financial derivatives. The idea is to reformulate the PDE under consideration as a stochastic learning problem involving deep artificial neural network approximations for the solution of the PDE. Moreover, we discuss first convergence results of stochastic gradient descent type optimization algorithms, which are fundamental tools in machine learning applications.

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MS25

Stochastic Targeting for Derivatives Hedging

Electronic trading is spilling over to non-linear instruments such as option and lightweight exotics. On the sell side the hedging of the derivatives book will be relying not only on automated delta managements like gamma trading, but an automated management of the book as a whole. We apply stochastic targeting to solve delta hedging problem and show how this approach can be extended to the set of all Greeks in trader's book with a predefined set of trader's risk preferences.

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MS26

Optimal Bailouts with the Doom Loop and Financial Contagion

Banks usually hold large amounts of domestic public debt which makes them vulnerable to sovereign default risk. At the same time, governments often resort to costly public bailouts when their domestic banking sector is in trouble. These two tendencies give rise to the infamous "doom loop" that operated during the recent European sovereign debt crisis. We investigate how the structure of the interbank network and the distribution of sovereign debt holdings affect the optimal bailout policy in the presence of the doom loop. Surprisingly, we find that regulators may prefer to rescue banks with high rather than low domestic sovereign exposure, even though that requires a higher bailout volume. This outcome is especially likely if the highly exposed banks have poorly capitalized creditors. Bailouts are socially less costly if public debt is mostly held by healthy banks. Our model therefore provides a rationale for more stringent capital requirements in proportion to domestic sovereign debt exposure.

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MS26

An Integrated Model for Fire Sales and Default Contagion in Financial Systems

Fire sales and default contagion are two of the main drivers of systemic risk in financial networks. While default contagion spreads via direct balance sheet exposures between institutions, fire sales describe iterated distressed selling of assets and their associated decline in price which impacts all institutions invested in these assets. That is, institutions are indirectly linked if they have overlapping asset portfolios. In this paper, we develop a model that helps us understand the joint effect of the two contagion channels and investigate structures of financial systems that promote or hinder the spread of an initial local shock. We first consider the contagion process for an explicitly given system and then derive our main results for random ensembles of systems whose macroscopic statistical characteristics of defining parameters are close to each other. In particular, we model direct exposures by means of a random graph. Our approach ensures robustness to local uncertainties and changes in the system. We characterize resilient and non-resilient system structures by criteria that can be used by regulators to assess system stability. Moreover, we provide explicit capital requirements that secure the financial system against the joint impact of fire sales and default contagion.

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MS26

Interaction Through Hitting Times: from Systemic Risk to Supercooled Stefan Problems

Various questions in systemic risk, mathematical physics and neuroscience lead mathematically to the so-called supercooled Stefan problem. The latter poses major mathematical challenges due to the presence of blow-ups (corresponding to systemic crises), including even the definition of solutions. I will explain how the problem can be reformulated in probabilistic terms and how related particle system models lead to an appropriate notion of a solution. The solutions can be then studied by probabilistic techniques and a sharp description of the blow-ups/systemic crises can be established. Based on joint works with Francois Delarue and Sergey Nadtochiy

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MS26

A Mean-Field Perspective on the Interplay Between Common Exposures and Contagion

In this talk I will present a simple model of an interconnected financial system, where the institutions interact through common exposures and default contagion. Specifically, I will cover recent results on the convergence of this system to a large population mean-field limit, which has several interesting features that may be useful in attaching probabilities to certain 'systemic risk' events.

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MS27

XVA Analysis from the Balance Sheet

Since the 2008-09 financial crisis, derivative dealers charge to their clients various add-ons, dubbed XVAs, meant to account for counterparty risk and its capital and funding implications. As banks cannot replicate jump-to-default related cash flows, deals trigger wealth transfers from bank shareholders to bondholders and shareholders need to set capital at risk. On this basis, we devise a theory of XVAs, whereby the so-called contra-liabilities and cost of capital are sourced from bank clients at trade inceptions, on top of the fair valuation of counterparty risk, in order to compensate shareholders for wealth transfer and risk on their capital. The resulting all-inclusive XVA formula, meant incrementally at every new deal, reads (CVA+FVA+KVA), where C sits for credit, F for funding, and where the KVA is a cost of capital risk premium. All these XVAs are non-negative and, even though we do crucially include the default of the bank itself in our modeling, unilateral in a certain sense. The corresponding XVA policy ensures to bank shareholders a submartingale wealth process corresponding to a target hurdle rate h on their capital at risk, consistently between and throughout deals.

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MS27

Deeply Learning Derivatives

This paper uses deep learning to value derivatives. The approach is broadly applicable, and we use a call option on a basket of stocks as an example. We show that the deep learning model is accurate and very fast, capable of producing valuations a million times faster than traditional models. We develop a methodology to randomly generate appropriate training data and explore the impact of several parameters including layer width and depth, training data quality and quantity on model speed and accuracy.

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MS27

BSDEs of Counterparty Risk in the Presence of Multiple Discounting Rules and Aggregation Lev-

els

We propose an xVA framework using BSDEs techniques in a market described by diffusion processes. We revisit concepts such as the self-financing property, absence of arbitrage and replication of contingent claims in a market with frictions. Our replication BSDE, introduced under a classical enlarged filtration, is specified up to a random time horizon given by the smallest one between the default time of the counterparty, the default time of the bank, and the natural maturity of the contract. We discuss the well posedness of the BSDE by considering associated pre-default BSDEs under a reduced filtration. Given the xVA framework for a single transaction, we consider the consistency problem between xVA pricing equations and CSA discounting rules: CSA discounting rules originate from the quoting mechanism of market standard instruments. Such instruments are quoted under the assumption that they are perfectly collateralized transactions. Since a perfectly collateralized transaction is funded by the collateral provider, the discounting rate applied to evaluate market instruments is given by a collateral rate, which typically corresponds to an overnight interest rate. The presence of multiple assumptions on the collateral rate implies the coexistence of quotes with different discounting rates, which are in general at odds with the unique discounting rate dictated by the xVA pricing BSDE. We solve the consistency issue by relying on an invariance property of linear BSDEs.

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MS27

Integrated Structural Approach to Counterparty Credit Risk with Dependent Jumps

This talk proposes an integrated pricing framework for Credit Value Adjustment of equity and commodity products. The given framework, in fact, generates dependence endogenously, allows for calibration and pricing to be based on the same numerical schemes (up to Monte Carlo simulation), and also allows the inclusion of risk mitigation clauses such as netting, collateral and initial margin provisions. The model is based on a structural approach which uses correlated Lvy processes with idiosyncratic and systematic components; the pricing numerical scheme, instead, efficiently combines Monte Carlo simulation and Fourier transform based methods. We illustrate the tractability of the proposed framework and the performance of the proposed numerical scheme by means of a case study on a portfolio of commodity swaps using real market data.

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MS28

Forward Rank-Dependent Performance Processes: Time-Consistent Investment under Probability Distortion

In this talk, I will introduce the concept of forward rank-dependent performance processes, extending the original notion to forward criteria that incorporate probability distortions. A fundamental challenge is how to reconcile the time-consistent nature of the forward performance criterion with the time-inconsistent character of the probability distortion processes. I will discuss how this can be done, and how it gives rise to criteria that allow for real-time adjustment of both the risk-preferences and the probability distortions as market evolves. I will also discuss a striking equivalence between forward rank-dependent criteria and locally-riskless criteria in an auxiliary market. A byproduct of the work is a novel result on the so-called dynamic utilities and on time-inconsistent problems in the classical (backward) setting. (joint work with X. He and M. Strub)

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MS29

Deep Learning Volatility

On Pricing and Calibration of (Rough) Stochastic Volatility Models with Deep Neural Networks. We present a consistent neural network based calibration method for a number of volatility models-including the rough volatility family-that performs the calibration task within a few milliseconds for the full implied volatility surface. The aim of neural networks in this work is an off-line approximation of complex pricing functions, which are difficult to represent or time-consuming to evaluate by other means. We highlight how this perspective opens new horizons for quantitative modelling: The calibration bottleneck posed by a slow pricing of derivative contracts is lifted. This brings several model families (such as rough volatility models) within the scope of applicability in industry practice. We discuss how our approach addresses the usual challenges of machine learning solutions in a financial context (availability of training data, interpretability of results for regulators, control over generalisation errors). As a e also find that including the intermediate step of learning pricing functions of (classical or rough) models before calibration significantly improves network performance compared to direct calibration to data.

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MS29

Portfolio Optimization under Fractional Volatility Models

Rough stochastic volatility models have attracted a lot of attention recently, in particular for the linear option pricing problem. In this paper, starting with power utilities, we propose to use a martingale distortion representation of the optimal value function for the nonlinear asset allocation problem in a (non-Markovian) fractional stochastic environment (for all Hurst index H $\in$ (0,1)). We rigorously establish a first-order approximation of the optimal value, where the return and volatility of the underlying asset are functions of a stationary slowly varying fractional Ornstein-Uhlenbeck process. We prove that this approximation can be also generated by a fixed zeroth order trading strategy providing an explicit strategy which is asymptotically optimal in all admissible controls. Similar results are also obtained under fast mean-reverting fractional stochastic environment. Furthermore, we extend the discussion to general utility functions, and obtain the asymptotic optimality of this fixed strategy in a specific family of admissible strategies.

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MS29

On Smile Properties of Volatility Derivatives and Exotic Products: Understanding the VIX Skew

We develop a method to study the implied volatility for exotic options and volatility derivatives with European payoffs such as VIX options. Our approach, based on Malliavin calculus techniques, allows us to describe the properties of the at-the-money implied volatility (ATMI) in terms of the Malliavin derivatives of the underlying process. More precisely, we study the short-time behavior of the ATMI level and skew. As an application, we describe the short-term behaviour of the ATMI of VIX and realized variance options in terms of the Hurst parameter of the model, and most importantly we describe the class of volatility processes that generate a positive skew for the VIX implied volatility. In addition, we find that our ATMI asymptotic formulae perform very well even for large maturities. Several numerical examples are provided to support our theoretical results.

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MS29

Volatility Options in Rough Volatility Models

We discuss the pricing and hedging of volatility options in some rough volatility models. First, we develop efficient Monte Carlo methods and asymptotic approximations for computing option prices and hedge ratios in models where log-volatility follows a Gaussian Volterra process. While providing a good fit for European options, these models are unable to reproduce the VIX option smile observed in the market, and are thus not suitable for VIX products. To accommodate these, we introduce the class of modulated Volterra processes, and show that they successfully capture the VIX smile. Joint work with Blanka Horvath and Peter Tankov.

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MS30

Conditional Monte Carlo Learning for Diffusions

We present a new algorithm based on a One-layered Nested Monte Carlo (1NMC) to simulate functionals U of a Markov process X. The main originality of the proposed method comes from the fact that it provides a recipe to simulate $U_{t\geq s}$ conditionally on X_s. This recipe can be used for a large number of situations including: Backward Stochastic Differential Equations (BSDEs), Reflected BSDEs, risk measures and beyond. In contrast to previous works, our contribution is based on a judicious combination between regression and 1NMC used for localization purpose. Although the procedure is initially developed for diffusions, we also explain in which situations it can be applied to jump diffusions. The generality, the stability and the iterative nature of this algorithm, even in high dimension, make its strength. It is of course heavier than a straight Monte Carlo (MC), however it is far more accurate to simulate quantities that are almost impossible to simulate with MC. Moreover, the parallel suitability of 1NMC makes it feasible in a reasonable computing time. In this presentation, we explain this algorithm, study its convergence and complexity. We also provide various numerical examples with a dimension bigger than 100 that are executed in few minutes on one Graphics Processing Unit.

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MS30

Robust Finance with Neural Networks, Duality and Penalization

This talk presents a widely applicable approach to solving superhedging and distributionally robust optimization problems via neural networks. The core idea is to penalize the optimization problem in its dual formulation and reduce it to a finite dimensional one which corresponds to optimizing a neural network with smooth objective function. We present numerical examples related to martingale optimal transport and risk aggregation under dependence uncertainty, where for the latter case the uncertainty is expressed by a Wasserstein distance.

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MS30

Model-Uncertain Value-at-Risk, Expected Shortfall and Sharpe Ratio, Using Stochastic Approximation

VaR, ES, SR have as a common point the property of being the limit of Stochastic Approximation algorithm. In this work we discuss how to quantity the model uncertainty in these types of limits when some model parameters are unknown and modelled as random variables. The random limits are decomposed into chaos which coefficients are computed recursively. The resulting algorithm is an SA algorithm in increasing dimension. Convergence results are established and numerical experiments are conducted. Joint works with Stephane Crepey, Gersende Fort, Uladzislau Stazhynski and Linda Chamakh

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MS30

The Universality Problem in Dynamic Machine Learning with Applications to Realized Covolatilities Forecasting I

We will start by showing how a relatively recent family of dynamic machine learning paradigms known collectively as reservoir computing are capable of unprecedented performances in the forecasting of deterministic (chaotic attractors) and stochastic processes (financial realized covariance matrices). We will then focus on the universal approximation properties with respect to uniform and L^p criteria of the most widely used families of reservoir computers in applications. These results are a much awaited generalization to the dynamic context of the well-known static results obtained by Cybenko and Hornik et al in the context of neural networks.

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MS31

Systemic Risk and Capital Allocation Risk Transfer Equilibria

In the framework of a reinsurance market, Buhlmann (80) and (84) introduced the concept of an optimal risk exchange equilibrium. As a generalization of such concept, we introduce the notion of a Capital Allocation Risk Transfer Equilibrium, analyze its existence, uniqueness, and show its relevance in the context of systemic risk.

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MS31

Banking Networks and the Circuit Theory of Money

We consider a network of banks with interconnected balance sheets coupled with a macroeconomic model for households, firms, and the government sector. The key feature of the model is that money is created endogenously by the banking sector to satisfy the demand for loans and deposits of the other economic agents. The macroeconomic core model is driven by stochastic consumption, with firms adjusting investment according to realized profits and capacity utilization. Stock-flow consistency between savings of the different sectors in turn give the total amount of external loans and deposits for the banking sector. We then assume that these aggregate quantities are distributed among the banks using a preferential attachment mechanism and study the stability of the resulting network. Crucially, the amplification of shocks within the banking network can, by rationing of available credit, drive the macroeconomic model away from its stable equilibrium and provoke an economic crisis. This is joint work with Alex Lipton.

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MS31

Systemic Risk Measures: Random Capital Allocation and Fair Risk Allocation

We introduce a general class of systemic risk measures that are determined in terms of sufficient, possibly random capital allocations to individual banks before aggregation of their risks. We then focus on the question how to allocate the corresponding total systemic risk among institutions in a fair way. We show that the dual problem of the minimization problem which identify the systemic risk measure, provides a valuation of the random capital allocations which is fair both from the point of view of the society/regulator and from the individual financial institutions. The case with exponential utilities which allows for explicit computation is treated in details.

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MS31

Dynamic Information Regimes in Financial Markets

How do small shocks get amplified into market crashes? We propose and analyze a dynamic model in which stock market prices and volatility shift between higher and lower levels based on changes in the information available to investors about future dividends. The model evolves through overlapping generations. In each generation, investors decide whether to acquire information at a cost. The precision of available information is subject to exogenous shocks; in addition, more information becomes available as more investors choose to become informed. The model gives rise to multiple fixed points for the fraction of informed investors, corresponding to different price and volatility regimes. Investors rationally anticipate potential transi-

tions between regimes. We calibrate the model to historical data and find that the transitions can generate large price drops accompanied by large increases in volatility. This pattern may play a role in the onset of a financial crisis and in responses to changes in information disclosure. The model isolates the role of information dynamics in producing these effects. This is joint work with Harry Mamaysky and Yiwen Shen.

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MS32

Wind Park Valuation and Risk Management in German Intraday Power Markets

The rapid growth of renewables in Germany in the last decade has led to various new modeling challenges for many energy firms. Wind park owners and operators in particular require valuation and risk analysis techniques which capture the high volatility and intermittency of wind power generation, the dynamics of intraday prices and their correlation with changes in wind forecast levels. Under typical contract terms, owners of wind parks receive production volume times the spot price minus a premium p, while managers receive revenues dependent on how they nominate the power and rebalance their positions in the day-ahead and intraday markets. Here we present a trading and hedging strategy for determining a fair premium p, which can vary significantly across wind parks, for example due to their forecast variability and whether they are more or less correlated with overall wind in Germany, which drives market prices. This valuation problem is of significant interest to many market participants, including investors and policy makers looking to further grow the penetration of renewables.

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MS32

Real Switching Options in Peaking Power Plants: The Effect of Capacity Payments

This paper aims to study the effects of capacity payments on the operational decisions of plant managers for peaking units in the PJM Interconnection. We achieve this through a structural estimation of maintenance and switching costs between the operational state, the standby state and retirement of generating units. We have focused on the period from 2001 throughout 2016a period where we have identified some significant changes in the power market dynamics. We conduct a counterfactual analysis on the level of capacity payments to study the effects of introducing a capacity market in 2007. The reliability of the power system depends crucially on the availability of flexible peaking units to cover load in periods of high demand. Therefore, an understanding of the real costs facing the owners of these units is essential in order to enforce policies that ensure sufficient peak capacity in the power system. Our study aims to analyze the effects of this additional market on switching behavior. The empirical data shows less switching between states after the introduction of capacity remunerations. We find that the role of peaking units has changed, with the units being dispatched more often. In the counterfactual analysis, we find a clear connection between the level of capacity payments and switching. We conclude that the current level of capacity payments in PJM incentivizes peaking units to stay in the operational state.

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MS32

Stress Testing Methods for the Energy Industry

We will discuss commonly use stress testing techniques in the Energy Sector and their pros and cons. Also, we will be discussing how stress testing can help manage Risk Limits on trading desks.

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MS32

Forecasting Conditional Volatility of Crude Oil using Intra-Day Curves

In this paper, we assess the predictability of the recently developed Functional GARCH(p,q) model on the conditional volatility of Crude oil intra-day data. Methodologically, we improve the Functional GARCH model from two aspects. First, we introduce a constraint in the quasi-maximum likelihood estimation to guarantee the positivity of the intra-day conditional volatility process. Second, functional models are only accessible and computable under the dimensional reduction, selecting right projection bases is essential, here we do not rely on the uninspired Functional Principal Component Analysis method, but apply a predictive factor method by considering the heteroscedastic effect of conditional variance. The efficiency of these two methods is discussed under examples. Empirically, modeling dynamics of volatility curves allows us to forecast the inter-daily via integrating the predicted intra-day conditional volatility curves. A comparison between our methods and realized volatility related methods are provided.

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MS33

Cumulative Prospect Theory with Skewed Return Distribution

We investigate a one-period portfolio optimization problem of a cumulative prospect theory (CPT) investor with multiple risky assets and one risk-free asset. The returns of multiple risky assets follow multivariate generalized hyperbolic (GH) skewed t distribution. We obtain a threefund separation result of two risky portfolios and risk-free asset. Furthermore, we reduce the high dimensional optimization problem to two 1-dimensional optimization problems and derive the optimal portfolio. We show that the optimal portfolio composition changes as some of investor-specific parameters change. It is observed that the consideration of skewness of stock return distribution has considerable impact on the distribution of CPT investors wealth deviation, and leads to less total risky investment.

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MS33

Optimal Investment in Illiquid Markets for Investors with CPT Preferences

We consider a market model with instantaneous price impact and an investor with cumulative prospect theory preferences. We prove the existence of an optimal investment. This is achieved by techniques that resemble the construction of a weak solution to a stochastic differential equation. However, we need a particular version of the Skorohod representation theorem, due to A. Jakubowski, which works for certain non-metrizable topologies. We also discuss the role of randomized strategies in such optimization problems.

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MS33

Behavioral Finance Driven Investment Strategies

Portfolio insurance strategies, such as the constant-proportion portfolio insurance (CPPI), as well as liability-driven investment strategies (LDI) are economically important to investors like insurance companies and pension funds. However, non-anticipated shocks in stock prices, negative interest rates or overnight trading restrictions could drop portfolio values below desired levels making the application of a CPPI impossible or an LDI underfunded. We consider behavioral aspects from cumulative prospect theory (CPT), in particular, risk-averse behavior for gains, risk-seeking behavior for losses and probability distortion, and develop optimal investment strategies that allow for situations of falling short a given benchmark or being underfunded. We compare the optimal investment strategies to the standard CPPI and traditional LDI approaches.

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MS33

Strong and Weak Equilibria for Time-Inconsistent Stochastic Control in Continuous Time

A new definition of continuous-time equilibrium controls is introduced. As opposed to the standard definition, which involves a derivative-type operation, the new definition parallels how a discrete-time equilibrium is defined, and allows for unambiguous economic interpretation. The terms strong equilibria and weak equilibria are coined for controls under the new and the standard definitions, respectively. When the state process is a time-homogeneous continuous-time Markov chain, a careful asymptotic analysis gives complete characterizations of weak and strong equilibria. Thanks to Kakutani-Fans fixed-point theorem, general existence of weak and strong equilibria is also established, under additional compactness assumption. Our theoretic results are applied to a two-state model under non-exponential discounting. In particular, we demonstrate explicitly that there can be incentive to deviate from a weak equilibrium, which justifies the need for strong equilibria. Our analysis also provides new results for the existence and characterization of discrete-time equilibria under infinite horizon.

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MS34

Learning Boosts Numerical Methods for Finance: From Classical PDEs to Statistical Learning and Magic Points in Finance

Computationally intensive problems in finance are characterized by their intrinsic high-dimensionality which often is paired with optimizations leading to nonlinearities. For current tasks real-time evaluations are required. Moreover, as the outputs of computational methods often are directly linked to financial decision-making, guaranteed accuracy of an appropriate level is indispensible. These seemingly contradictory requirements put classical methods such as Monte Carlo and PDE methods under pressure. These methods either suffer from a low convergence rate or are exposed to the curse of dimensionality. This poses a major challenge for the development of new and adequate numerical methods for finance. Merging classical numerical techniques with learning methods promises to lead to major breakthroughs in this area. The use of machine learning tools allows to efficiently treat high-dimensionality. Their appropriate use within the framework of classical numerical problems and methods enables a straightforward interpretation of the results. It moreover allows the use of techniques from numerical analysis for error estimation. After a general perspective on this merging field, we will focus on Magic Points for Finance. We present key features of this numerical learning technique and demonstrate its capacity

for solving computational problems in finance.

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MS34

Low Rank Tensor Approximation for Chebyshev Interpolation in Parametric Option Pricing

Treating high dimensionality is one of the main challenges in the development of computational methods for solving problems arising in finance, where tasks such as pricing, calibration, and risk assessment need to be performed accurately and in real-time. Among the growing literature addressing this problem, Gass et al. [1] propose a complexity reduction technique for parametric option pricing based on Chebyshev interpolation. As the number of parameters increases, however, this method is affected by the curse of dimensionality. In this article, we extend this approach to treat high-dimensional problems: Additionally exploiting low-rank structures allows us to consider parameter spaces of high dimensions. The core of our method is to express the tensorized interpolation in tensor train (TT) format and to develop an efficient way, based on tensor completion, to approximate the interpolation coefficients. We apply the new method to two model problems: American option pricing in the Heston model and European basket option pricing in the multi-dimensional Black-Scholes model. In these examples we treat parameter spaces of dimensions up to 25. The numerical results confirm the low-rank structure of these problems and the effectiveness of our method compared to advanced techniques. [1] Gass, M.; Glau, K.; Mahlstedt, M.; Mair, M.: Chebyshev Interpolation for Parametric Option Pricing, Finance and Stochastics, 2018, 22(3), 701-731.

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MS35

Trade Duration, Volatility and Market Impact

We perform an empirical study of 'market impact' of trades using a large dataset of trades executed by institutional investors in the US equity market. We find that price variations during execution are mainly driven by the aggregate order flow imbalancerather than the direction or size of individual trades. We find the main determinants of the amplitude of these price variations to be market volatility and trade duration. In contrast, trade size and execution speed, as measured by the participation rate, are found to have little or no influence on 'market impact' for orderly trade executions. Conditional on trade duration, trade size is found to have little influence on price variations during execution. We find evidence for a square-root dependence of price changes on durationrather than trade size and propose a simple explanation for this dependence in terms of the well-known square-root scaling of volatility as a function of duration. Our explanation is consistent with previous empirical studies on market impact and provides a simple rationale for the ubiquity of the 'square-root law'. We also examine the role of the participation rate in determining 'market impact'. We show that conditional on duration, even large changes in participation rate have negligible influence on market impact. We also find that the slowerthe execution, the higherthe amplitude of price variations during the trade, contradicting a key assumption in many optimal execution models.

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MS35

Optimum Thresholding using Mean and Conditional Mean Squared Error

We consider a univariate semimartingale model for (the logarithm of) an asset price, containing jumps having possibly infinite activity. The nonparametric threshold estimator of the integrated variance (IV) is studied. It is well-known that all the threshold functions satisfying given conditions allow asymptotically consistent estimates of IV, however, the finite sample properties can significantly depend on the specific choice of the threshold in a finite sample setting. We aim here at optimally selecting the threshold by minimizing either the estimation mean squared error (MSE) or the conditional mean squared error (cMSE). The last criterion allows reaching a threshold which is optimal not in the mean but for the specific volatility and jumps paths at hand. A parsimonious characterization of the optimum is established, which turns out to be asymptotically proportional to the Levys modulus of continuity of the underlying Brownian motion. Moreover, minimizing the cMSE enables us to propose a novel implementation scheme for approximating the optimal threshold. Monte Carlo simulations illustrate the superior performance of the proposed method. This is joint work with Dr. Cecilia Mancini.

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MS35

Statistical and Probabilistic Properties of Hawkes Processes and their Application to the Large Variations of Financial Assets Prices

In this work, we study variables and events that can be exploited to forecast catastrophic episodes. Our objective is forecasting the occurrence of relevant depreciations of financial assets, given the observation of clusters of previous jumps in the series of the prices. In fact, we believe that in periods preceding catastrophic episodes the probability of a jump increases after the occurrence of some jumps. Assuming a jump diffusion model for the log returns of a given asset we filter out and study the point process counting the number of the occurred jumps. We find that the jumps of

the JPM asset price are well described by a Hawkes model with an exponential kernel, which is characterized by the ability of capturing self-excitation mechanisms. On the contrary, the jumps of the S&P500 index do not display self-excitation. We investigate the dependence properties of the durations between consecutive jump times, as well as the clusters length, and we furnish narrow bounds for the probability of the occurrence of a cluster as well as for the occurrence of a further jump after a cluster. The application of such formulas to the JPM jumps dataset shows that our model gives a quantification of the risk of jumps which can be useful for portfolio management and forecasting aims.

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MS35

From Market Microstructure to Macrostructure and Financial Bubbles

We show how can derive market macrostructure from its microstructure in such a way as to be able to detect financial bubbles. This builds on ideas of Mathieu Rosenbaum and co-authors, and we use order book date to illustrate the point. The talk is based on joint work with Shihao Yang.

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MS36

XVA Metrics for CCP Optimisation

Based on an XVA analysis of centrally cleared derivative portfolios, we consider two capital and funding issues pertaining to the efficiency of the design of central counterparties (CCPs). First, from the CCP perspective, we challenge the Cover 2 sizing and initial margin (IM) proportional rules, for the respective sizing and allocation of the default fund, by economic capital specifications based on expected shortfalls of the one year ahead loss and profit of the CCP. The default fund contributions of the clearing members would be pure "survivor pay' capital at risk, remunerated as such at a cost-of-capital hurdle rate. Second, from a clearing member perspective, we compare the margin valuation adjustments (MVAs) resulting from two different initial margin raising strategies: a standard approach where the initial margin is funded by unsecured borrowing by the clearing member and a strategy where the clearing member delegates the posting of its initial margin to a specialist lender with low funding costs. The alternative strategy results in a significant MVA compression. A numerical case study reveals that, unless efficient (such as specialist lender) IM raising strategies are implemented, the IM funding expenses are in fact the main contributor to an economical capital based default fund of a CCP. This is an illustration of the transfer of counterparty risk into liquidity risk triggered by extensive collateralization.

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MS36

Firm Capital Dynamics in Centrally Cleared Markets

We develop a tractable continuous time model for the dynamics of firm capital processes in a centrally cleared market. Our framework jointly models the strategic interactions between business operations of firms and their trading activities. We show that the endogenous allocation of firm capital between trading and operations corresponds to the unique fixed point of a system of quadratic equations. We show the existence of a super-linear relationship between margins and firm capital, which lies at the heart of the model's main implication. Our model predicts that (i) trading is more capital intensive for large clearing members, (ii) market collateral demand is positively correlated with size concentration, and (iii) size concentration is expected to increase over time. Using proprietary data on bilateral credit default swap exposures, we provide evidence that the super-linearity prediction is both economically and statistically significant.

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MS37

Hedging of Bunker Fuel Cost with Futures Or Forwards: Trade-Off Between Liquidity and Correlation

Fuel costs are a substantial component of the shipping industry, making bunker fuel price risk a major consideration for shipping firms. We analyse the hedging effectiveness of different proxy hedges with oil futures as well as OTC forwards for the bunker fuel market. Using different hedge ratios and a VECM-GARCH modeling approch it is found that oil futures' hedging effectiveness has significantly improved over the past 20 years. Despite this improvement, in the minimum-variance framework, the forward contracts' higher correlation still yields better hedging results. However, given the high amount of transaction costs for OTC products, the exchange-traded oil futures contracts can deliver higher mean-variance utilities and can thus be considered a viable candidate when hedging fuel for ships. We explore the tradeoff between liquidity and correlation that dominates this important energy market challenge.

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MS37

Crude Oil Options Higher Moment Risk: Determinants and Predictive Power

This paper investigates higher-order moment risk in Brent and WTI crude oil prices. Recovering distributional higher moments using historical data is challenging. Recent financial research suggests using options data to estimate implied (risk-neutral) moments of the distribution. These

moments are forward-looking, horizon-specific, and can be updated daily. Using this framework with a large database of Brent and WTI crude oil options on futures, we estimate daily observations of risk-neutral variance, skewness, and kurtosis. We use these moments to answer the following questions. 1) How are implied moments, capturing forward-looking risk, affected by physical, economic, and financial variables? 2) Using quantile regressions, how do the results vary by quantile? 3) How do these moments help predict the Brent-WTI price spread? 4) How do these moments help improve risk management at different horizons?

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MS37

Optimal Behaviour of Regulated Firms in SREC Markets

SREC markets are a relatively novel market-based system to incentivize the production of energy from solar means. A regulator imposes a floor on the amount of energy each regulated firm must generate from solar power in a given period, providing them with certificates for each generated MWh. Firms offset these certificates against the floor, paying a penalty for any lacking certificates. Certificates are tradable assets, allowing firms to purchase / sell them freely. In this work, we formulate a stochastic control problem for generating and trading in SREC markets for a regulated firm and discuss potential takeaways for both a regulated firm under this system and regulatory bodies in charge of designing them.

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MS38

Optimal Portfolio Under State-Dependent Expected Utility

We derive the optimal portfolio for an expected utility maximizer whose utility does not only depend on terminal wealth but also on some random benchmark (state-dependent utility). We then apply this result to obtain the optimal portfolio of a loss-averse investor with a random reference point (extending a result of Berkelaar et al. 2004). Clearly, the optimal portfolio has some joint distribution with the benchmark and we show that it is the cheapest possible in having this distribution. This characterization result allows us to infer the state-dependent utility function that explains the demand for a given (joint) distribution.

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MS38

Asymptotic Optimal Strategy for Portfolio Optimization in a Stochastic Environment Driven by Two Correlated Factors

We consider a portfolio optimization problem of terminal wealth in a market with stochastic volatility. The volatility is driven by multiple correlated factors. We establish an asymptotically optimal strategy in the correlation coefficient, around perfect correlation one, together with an asymptotic expansion of the value function. Moreover, we show that expected utility of the zeroth order suboptimal strategy matches the first order of the value function. Finally, we explain how this can be generalized to a market with multiple stocks driven by correlated stochastic volatility factors.

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MS38

Equilibrium Option Price with Competing Market Makers

In this talk, we present a market equilibrium between N option market makers that compete for the orders of their clients. The market makers can offset their risk in the stock market. However they face market illiquidity when trading the stock and manage their inventory optimally. In this framework, we exhibit a Nash equilibrium for the interaction of the market makers and compute the equilibrium price of the option. This is a joint work with Sergey Nadtochiy and Yavor Stoev.

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MS38

Intertemporal Portfolio Optimization for Fund

Managers under Taxation

We study a fund manager's intertemporal portfolio optimization under taxation in a complete market. Managers are forced to invest their earnings back to the fund. Based on method of concavification developed by Bichuch and Sturm (2014) and maximization of non-smooth utility functions by Seifried (2009), we develop an infinite time horizon model for CRRA utility. Applying a duality argument, we find that the fund manager's consumption depends on their total discounted income.

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MS39

The Universality Problem in Dynamic Machine Learning with Applications to Realized Covolatilities Forecasting II

We study dynamic machine learning for discrete-time stochastic processes by means of reservoir computing, putting particular emphasis on echo state networks. Recent theoretical results prove that these systems possess universal approximation capabilities and provide error bounds for learning tasks based on them. Motivated by these results, we use reservoir computing systems to forecast realized covariances of financial time series and compare the empirical performance to state-of-the-art methods.

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MS39

Numerical Valuation of Bermudan Basket Options via Partial Differential Equations

We study the efficient numerical valuation via partial differential equations of Bermudan basket options with a large number of underlying assets [K.J. In 't Hout & J. Snoeijer, Numerical valuation of Bermudan basket options via partial differential equations, to be submitted, 2018]. To deal with the high-dimensionality of the problem, we combine the principal component analysis from [C. Reisinger & G. Wittum, Efficient hierarchical approximation of high-dimensional option pricing problems. SIAM J. Sci. Comp. 29, 440-458, 2007] with modern alternating direction implicit schemes [K.J. In 't Hout & B.D. Welfert: Unconditional stability of second-order ADI schemes applied to multi-dimensional diffusion equations with mixed derivative terms. Appl. Numer. Math. 59, 677-692, 2009]. The convergence of this combined analytical-numerical approach is investigated in detail, and ample numerical experiments are presented illustrating the high performance it attains.

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MS39

Fast Pricing and Credit Exposure Calculation for Bermudan and Barrier Options using Chebyshev Interpolation

In this talk, we introduce a unified framework for the pricing and exposure calculation of Bermudan and barrier options. For both option types, the pricing problem is formulated as a dynamic programming problem and solved via backward induction. We approximate the value function using Chebyshev interpolation. In this case, the continuation value in each time step becomes the sum of conditional expectations of Chebyshev polynomials. These expectations contain all model dependent calculations and their computation can be shifted into an offline-phase prior to the time stepping. The proposed method is very generic and can be applied in a variety of models and for many payoff types. Depending on the model, different types of numerical techniques (e.g. quadrature, PDE or Monte-Carlo) are used in the offline step. For a process with normally distributed increments explicit expressions for the conditional expectations arising in the offline phase are available. We analyse the convergence behaviour of the algorithm theoretically and empirically. Numerical experiments confirm the efficiency of the method. Moreover, the polynomial approximation of the option value in every time step can be exploited in the computation of the options credit exposure as an ingredient of CVA. We compute exposure profiles of Bermudan and barrier options in three models (Black-Scholes, jump diffusion and local volatility). This is joint work with Kathrin Glau, Mirco Mahlstedt and Ricardo Pachon.

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MS39

Machine Learning for Quantitative Finance: Fast Derivative Pricing

In the derivatives world, daily zillion computations need to be done. Since financial models and instruments have

become more and more complex, this is not always trivial and one often has to rely on time-consuming techniques. We show how machine learning algorithms can be used in this context. For many classical computations, we arrive to speed-ups of several orders of magnitude by deploying Gaussian process regression models. The price we have to pay for this extra speed is some loss of accuracy. However, we show that this reduced accuracy is often well within reasonable limits and hence very acceptable from a practical point of view. In this talk, we focus on speeding up derivative pricing methods. In particular, we price European vanilla options, American options and exotic options under advanced market models like Heston's model and the Variance Gamma model.

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MS40

Optimal Placement of a Small Order in a Diffusive Limit Order Book

We study the optimal placement problem of a stock trader who wishes to clear his/her inventory by a predetermined time horizon t, by using a limit order or a market order. For a diffusive market, we characterize the optimal limit order placement policy and analyze its behavior under different market conditions. In particular, we show that, in the presence of a negative drift, there exists a critical time t0¿0 such that, for any time horizon t¿t0, there exists an optimal placement, which, contrary to earlier work, is different from one that is placed "infinitesimally" close to the best ask, such as the best bid and second best bid. We also propose a simple method to approximate the critical time t0 and the optimal order placement.

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MS40

A Ranking Methodology for Market Making Activity

The goal of this talk is to present a methodology enabling us to assess the contribution of the various market participants to market quality. To do so, we use a generalized order book model involving both state dependence and memory effects for the dynamics of the order flows. In this framework, we are able to compute the effect of each participant on important market quantities such as volatility or liquidity. This leads us to the possibility to rank market makers in term of the effect of their activity on market quality.

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MS40

Optimal High-Frequency Trading in Intraday Electricity Markets

We develop an optimal trading model for an intermittent renewable energy producer. The producer faces production uncertainty at the delivery date, for which an imperfect forecast is available, and uses the intraday electricity market to hedge the risk arising from this uncertainty. Our model includes both temporary and permanent price impact and provides an explanation of the observed correlation between renewable production forecasts and intraday electricity prices.

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MS40

Optimal Kernel Estimation of Spot Volatility with Leverage and Microstructure Noise

In the context of a general continuous Itøsemimartingale, the problem of optimal bandwidth and kernel selection of a kernel type estimator of the spot volatility is studied under the presence of leverage and microstructure noise. A feasible implementation of the proposed estimators is also developed and the performance of the estimators are illustrated by Monte Carlo experiments. This is joint work with Dr. Jose E. Figueroa-Lopez.

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MS41

The Pitfalls of Central Clearing in the Presence of Systematic Risk

Through the lens of market participants' objective to minimize counterparty risk exposure, we provide an explanation for the reluctance to clear derivative trades in the absence of a central clearing obligation. We develop a comprehensive understanding of the benefits and potential pitfalls with respect to a single market participant's counterparty risk exposure when moving from a bilateral to a clearing architecture for derivative markets. Previous studies suggest that central clearing is beneficial for single market participants in the presence of a sufficiently large number of clearing members. We show that three elements can render central clearing harmful for a market participant's counterparty risk exposure regardless of the

number of its counterparties: (1) correlation across and within derivative classes (i.e., systematic risk), (2) collateralization of derivative claims, and (3) loss sharing among clearing members. Our results have substantial implications for the design of derivatives markets, and highlight that recent central clearing reforms might not incentivize market participants to clear derivatives.

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MS41

Optimal Make Take Fees for Market Making Regulation

We consider an exchange who wishes to set suitable make-take fees to attract liquidity on its platform. Using a principal-agent approach, we are able to describe in quasi-explicit form the optimal contract to propose to a market maker. This contract depends essentially on the market maker inventory trajectory and on the volatility of the asset. We also provide the optimal quotes that should be displayed by the market maker. The simplicity of our formulas allows us to analyze in details the effects of optimal contracting with an exchange, compared to a situation without contract. We show in particular that it leads to higher quality liquidity and lower trading costs for investors.

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MS42

Managing Global Adjustment Penalties in the Ontario Electricity Market

In the Ontario Electricity Market large industrial users are subject to a Global Adjustment. In this, they are billed a substantial surcharge based on their power use in the top 5 hours of the May 1 Apr 30 year (hours must occur on different days). Some mining operations have the ability to shed load rather easily, for instance by idling a rock crusher which can catch up with mine demand later. However, the decision to idle is complicated by the fact that it is not known, in advance, which the top five demand hours will be! I will present a combination of analytical and heuristic work designed to help make these decisions.

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MS42

Optimal Cross-Border Electricity Trading

We show that electricity flows between interconnected locations in a power network have a direct and indirect impact on electricity prices in various locations. The direct price impact refers to how electricity prices in two locations are affected by the flow of power between the two locations. The indirect price impact refers to how the flows of power between two locations affect the price of power in other locations that are part of the interconnected electricity network. We propose a model of the joint dynamics of electricity prices where flows of electricity affect, directly and indirectly, prices in all locations, and model a common co-integration factor of prices. We solve the optimal control problem of an agent who uses the interconnector to take positions in a subset of locations that are part of the interconnected network. We analytically solve the Hamilton-Jacobi-Bellman equation satisfied by the value function of the investor, and obtain the optimal electricity trading strategy in closed-form. We show that including the indirect price impact in the price dynamics significantly improves the performance of the strategy relative to a naïve strategy that only considers the direct price impact of power flows. For example, for contracts with delivery of electricity at 3pm, we show that the optimal strategy delivers a profit that is approximately 4% more than the profit of a naïve strategy over a time horizon of one year.

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MS42

Incorporating Exogenous Factors in Point Process Models for the German Intraday Electricity Market

Due to the increasing production of renewable energies and the market participants responsibility for direct marketing of produced power, the German intraday electricity market has gained importance in recent years. The trading activity, in particular, the arrival of market orders, can be modeled by point processes. Intraday market data provide evidence that orders tend to arrive in clusters. Therefore, self-exciting processes are often used to account for this feature. In this talk, we will discuss an approach to incorporate exogenous factors, such as renewable energy forecasts, into a self-exciting point process model for order arrivals. We present first estimation results based on intraday trading data and quarter-hourly updated renewables forecasts.

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MS42

Polynomial Models for Energy Commodity Futures

Factor models are commonly used in the context of energy price modelling. More often than not the formation of prices from underlying factors involves an exponential map, and the mathematical convenience this offers means that this is no surprise. In this talk we will discuss different ways in which polynomial maps can play a similar role, if the underlying factor process is *polynomial*. Polynomial processes have the property that expectations of polynomial functions of the future state of the process, conditional on the current state, are themselves polynomial functions of the current state. It is this property that means that polynomial models - involving polynomial maps of polynomial factor processes - also provide a level of mathematical convenience (for forming futures prices) but with an additional freedom. This freedom means that they are capable of capturing the extreme dynamics that are commonly seen in energy market prices even with relatively tame dynamics in the underlying factor process.

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MS43

Adaptive Robust Portfolio Optimization and Statistical Surrogates

We study numerical implementation of the adaptive robust stochastic control method. In parametric Markovian control, reduction of model uncertainty is expressed via shrinking collections of potential true values of the underlying system parameters. In the discrete time setup, computation boils down to recursive multi-step optimization via a generic min-max formulation. Traditionally, the problem is about repeated optimization and it involves interpolation over gridded designs which is computationally expensive. We adopt the paradigm of statistical learning, recasting the task of approximating optimal value function and control as a machine learning problem. Our main strategy is to achieve substantial speed-ups by capturing the spatial dependence inherent in the min-max problem, so that we can leverage already obtained solutions of similar optimization problems. Such spatial borrowing of information is done via a Gaussian Process (GP) regression approach, which allows us to predict the optimal control without directly optimizing. This is a joint work with Michael Ludkovski.

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MS43

Nonlinear Filtering Partial Information Portfolio Investment

Latent states are filtered from financial data using the Zakai equation. However the ensuing portfolio optimization problem is a non-Markov decision process because the posterior distribution of states is path dependent. There are a number of ways to solve this type of optimization, including backward stochastic differential equations (BSDEs) or through polynomial basis approximation. This talk explores these methods.

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MS43

Stopping the Clock on Work: Practical Optimization for Retirement

Retirement planning attempts to build sufficient funds to retire at a fixed, predefined horizon. In that the only guaranteed way to hit a target wealth at a fixed horizon is by appropriate risk free investments, these strategies either have a large risk of falling short of the goal or require excessive savings. In this paper, we investigate what we consider to be a more useful approach. Instead of optimizing wealth at a fixed future time, we optimize on the stopping time at which one has sufficient wealth. This builds on an approach to retirement suggested by Bode in "Retirement Investing: A New Approach", 2001.

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MS43

A Mathematical Analysis of Technical Analysis

In this paper, we study trading strategies based on exponential moving averages (ExpMA), an important indicator in technical analysis. We seek optimal ExpMA strategies when the drift of the underlying is modeled by either an Ornstein-Uhlenbeck process or a two-state continuous-time Markov chain. Closed-form solutions are obtained under the logarithm utility maximization and the long-term growth rate maximization.

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MS44

Deep Calibration of Rough Volatility Models

Rough stochastic volatility models (see, for instance, [Gatheral, Jaisson, Rosenbaum, Quantitative Finance 18(6):933949, 2018], [Bayer, Friz, Gatheral, Quantitative Finance 16(6):887904, 2016] are a new paradigm in asset

pricing due to extremely good fits both to historical asset price data and to implied volatility surfaces with only few model parameters. Option pricing is, however, challenging from a computational point of view, as rough stochastic volatility models are not Markovian and many standard numerical techniques are either not available or much more expansive compared to diffusive stochastic volatility models. In this talk, we suggest to use non-linear regression by deep neural networks based on pre-computed option prices (or rather, implied volatilities) for calibration of rough stochastic volatility models. This allows us to drastically speed up the pricing during the on-line calibration phase, at the expense of a computationally expensive offline training phase of the involved neural network. We couple this machine learning approach with a Bayesian inference analysis of the calibrated model parameters at the end to learn more about the model parameters themselves as well as the calibration error.

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MS44

Understanding the Loss Surface of Neural Networks for Financial Time Series Forecasting

The loss surface of a neural network is typically a highly non-convex multi-dimensional object with both local minima and saddle points present. The optimization task when training such a network is to find the minima that have both a low train as well as test dataset error. Financial time series are known to have highly non-linear trends, heavy tails and noise present in the series. Extracting the meaningful temporal relationships using neural networks without overfitting on the noise is therefore a challenging task. In this talk we hope to gain insight into the usage of neural networks for financial time series by studying the loss surface of the network. We try to understand the effects of networks structure on the loss landscape and the resulting optimization task. We present insights into certain criteria that critical points must satisfy in order to be able to generalize well to unseen data. In this way we hope to understand better the capabilities of neural networks in forecasting noisy time series.

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MS44

Learning and Calibrating Financial Models Using Artificial Neural Networks

A data-driven approach, by means of an Artificial Neural Network (ANN), was proposed to learn the solutions of financial models and reduce their computation time significantly. This method trains an optimized ANN off-line on a data set generated by a sophisticated financial model and runs the trained ANN-solver on-line to accelerate original solvers. First, we test this approach on different types of classical numerical solvers, including the analytic solution for the Black-Scholes equation, the Heston stochastic volatility model and iterative root-finding algorithms for implied volatilities, and show that ANNs can calculate option prices or implied volatilities in a fast and efficient way. Second, this method is further extended to calibrate financial models. Specifically, finding the optimal value of model parameters is formulated as training hidden neurons within a machine-learning framework, namely CaNN. The rapid on-line computing of CaNN with a global searcher can provide fast and reliable calibration without getting stuck in local minima. For instance, the parameters of the high-dimensional Heston model can be recovered quickly by virtue of this data-driven approach.

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MS44

Piecewise Constant Policy Approximations to Financial Control Problems

In this talk, we analyse computable approximations to control problems arising in financial engineering, which are based on discretising the control process in time. We begin by reviewing a classical result by Krylov and derive an improvement to the approximation order. Moreover, we give an extension of the method from the diffusion setting to jump processes, optimal stopping problems, and control with non-linear expectations. Finally, we outline the construction of fully discrete approximation schemes and give applications to optimal investment problems. Based on joint work with Peter Forsyth; Athena Picarelli and Espen Jakobsen; and Yufei Zhang.

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MS45

Optimal Execution with Liquidity Risk in a Diffusive Order Book Market

We study optimal placement of an order using both limit and market orders in a market considering liquidity risk. A trader can split her order between market and limit orders. The trader will suffer from the liquidity cost from the market order, and the risk of non-execution in case of the limit order. We find an optimal placement strategy in multi-period case. This is a joint work with Hyoeun Lee.

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MS45

Equilibrium Model of Limit Order Book and Opti-

mal Execution Problem

We study a continuous time equilibrium model of limit order book (LOB) in which the liquidity dynamics follows a non-local, reflected mean-field stochastic differential equation (SDE) with evolving intensity. We argue that the frontier of the LOB (e.g., the best ask price) is the value function of a mean-field stochastic control problem, as the limiting version of a Bertrand-type competition among the liquidity providers. With a detailed analysis on the N-seller static Bertrand game, we formulate a continuous time limiting mean-field control problem of the representative seller. We then validate the dynamic programming principle (DPP), and show that the value function is a viscosity solution of the corresponding Hamilton-Jacobi-Bellman (HJB) equation. We argue that the value function can be used to obtain the equilibrium density function of the LOB. We then study an optimal execution problem under the equilibrium model of LOB. We shall first verify that the DPP remains true. We will then show that the value function is a viscosity solution of the corresponding HJB equation which is in the form of a mean-field type integro-partial-differential quasi-variational inequality. We also prove the existence and analyze the structure of the optimal strategy via a verification theorem argument, assuming that the PDE has a classical solution.

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MS45

A Representative Agent Model Based on Risk-Neutral Prices: Ross Recovery

In this study, we present a method for modeling the utility function of a representative agent in the consumption-based capital asset pricing model (CAPM). We derive an analytic model for the utility function from the risk-neutral information of a state variable. Our methodology is based on the concept used in the Ross recovery theorem, which also exploits the risk-neutral information of the state variable. We assume that the state variable is a one-dimensional time-homogeneous Markov diffusion and the utility function is an increasing, strictly concave function satisfying the Inada conditions. Under these assumptions, the primary contributions of this study are as follows: First, we provide a necessary and sufficient condition for the existence of a utility function in terms of the Feller boundary classification of the state variable. We show that a utility function exists if and only if the left boundary of the state variable is a natural boundary. Second, if we additionally assume that the state variable is non-attracted to the left boundary, then we show that the utility function can be described as a one-parameter model. In the specific case in which the short interest rate is a constant, the utility functions are fully described. Third, our method is used for Ross recovery. Last, we provide examples with explicit solutions.

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MS45

Market-Making by Reinforced Learning

A market-maker aims to optimize his/her cumulative reward by continuously updating his/her bid and ask quotes in a Limit Order Book. In this work, we propose a novel market-making algorithm via temporal-difference reinforced learning. Using real LOB data, a thorough comparison to other approaches in the literature is also carried out. This is joint work with Drs. Agostino Capponi and Jose E. Figueroa-Lopez.

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MS46

CCP CVA

We explore how to quantify the loss that a financial institution can expect due to central counterparty (CCP) membership. Losses are primarily due to mutualisation via the default fund and do not require the default of the CCP itself. This is different in principle to a bilateral exposure and is difficult to calculate as it depends on non-public details of all CCP member portfolios. Nevertheless, we show how a simple expression for CCP CVA can be derived based on publicly available information. The results are applied to the calculation of losses in stress scenarios as specified e.g. by the regulatory Comprehensive Capital Assessment and Review (CCAR). We show that a typical stressed expected loss ranges between 20bps and 40bps of the total posted initial margin.

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MS46

The Tradeoff of Diversity and Diversification

We consider a financial market in which trades impact asset prices. Leverage tracking of banks triggers deviations from fundamental values. Unless assets are homogeneous, full diversification does not minimize the distance of realized prices from their fundamental values. Instead, an optimal and nontrivial level of diversity can be computed. (The talk is based on joint work with Agostino Capponi and Kerstin Weske.)

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MS47

Characterization of Fully Coupled FBSDE in Terms of Portfolio Optimization

We provide a verification and characterization result of optimal maximal sub-solutions of BSDEs in terms of fully coupled forward backward stochastic differential equations. We illustrate the application thereof in utility optimization with random endowment under probability and discounting uncertainty. We show with explicit examples how to

quantify the costs of incompleteness when using utility indifference pricing, aswell as away to find optimal solutions for recursive utilities.

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PP1

XVA Principles, Nested Monte Carlo Strategies, and GPU Optimizations

We present a nested Monte Carlo (NMC) approach implemented on graphics processing units (GPU) to X-valuation adjustments (XVA), where X ranges over C for credit, F for funding, M for margin, and K for capital. The overall XVA suite involves five compound layers of dependence. Higher layers are launched first and trigger nested simulations on-the-fly whenever required in order to compute an item from a lower layer. If the user is only interested in some of the XVA components, then only the sub-tree corresponding to the most outer XVA needs be processed computationally. Inner layers only need a square root number of simulation with respect to the most outer layer. Some of the layers exhibit a smaller variance. As a result, with GPUs at least, error controlled NMC XVA computations are doable. But, although NMC is naively suited to parallelization, a GPU implementation of NMC XVA computations requires various optimizations. This is illustrated on XVA computations involving equities, interest rate, and credit derivatives, for both bilateral and central clearing XVA metrics.

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PP1

Optimal Timing of Investments and Divestment Associated with Perpetual American Options in a Levy Market

This paper examines the real options to invest and when to divest from a Build and Operate Transfer (BOT) project. The investment models formulated are special Levy processes including two correlated standard Brownian motions. The optimal investment or divestment times were obtained. The results obtained in this study shows the implications of the presence of jumps as implied by the dynamic business environment and are of great significance for investors for better investment decision making.

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PP1

Operator Splitting Schemes for the Two-Asset Merton Jump-Diffusion Model

The inherent risk diversification of rainbow options has made them increasingly popular over the recent years. The development of fast and accurate methods to compute a fair value for such options is a central topic in financial mathematics. Determining a (semi)closed-form analytical formula, as for example in [Boen, *European rainbow option values under the two-asset Merton jump-diffusion model*, 2018. Submitted, available at SSRN.] for best-/worst-of options, is not always possible. Hence, the derivation of reliable numerical methods to accurately approximate fair option values is of key importance. In this work, we consider rainbow options under the two-asset Merton jump-diffusion model ([Boen & in 't Hout, *Operator splitting schemes for the two-asset Merton jump-diffusion model*, 2018. Submitted, available at ArXiv.]). Under this model, the option value satisfies a two-dimensional time-dependent partial integro-differential equation (PIDE). We study a variety of novel operator splitting schemes when applied to this PIDE, with a keen focus on alternating direction implicit (ADI) methods. Each of these schemes conveniently treats the non-stiff, non-local, integral part in an explicit fashion. The structure of the resulting jump-matrix allows for an efficient computation of the integral part by means of FFT. Through ample numerical experiments, we investigate the convergence behavior of the different schemes and study their relative performance.

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PP1

A Penalty-Like Method for CVA Calculation by a PDE Model

Counterparty risk is the risk to each party of a contract that a counterparty will not live up to its contractual obligations. Counterparty risk must be evaluated properly, and the risk neutral value of a derivative must be adjusted accordingly. For the pricing of the credit valuation adjustment (CVA), we adopt a Black-Scholes PDE model with additional non-linear terms. For the discretization, we use standard second order differences in space and Crank-Nicolson timestepping. For the treatment of the non-linearity, we formulate a penalty-like iteration method. We present numerical experiments indicating that the penalty method converges in about two iterations per timestep, irrespectively of the discretization size, and that second order convergence is exhibited.

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PP1

Semi-Analytical Prices for Lookback and Barrier Options under the Heston Model

In this paper, we derive semi-analytical formulas under the Heston stochastic volatility model for the prices of a large class of path-dependent options whose payoffs are linked to the maximum or minimum value of the underlying asset

price over a certain period of time. In particular, we obtain prices of lookback and barrier options, but the methodology applies more generally. Following the general idea in [S. Griebsch and K. Pilz, A stochastic approach to the valuation of barrier options in Heston's stochastic volatility framework. *Working paper*, 2013] and [A. Drăgulescu and V. Yakovenko, Probability distribution of returns in Heston model with stochastic volatility. *Quantitative Finance*, 2(6):443-453, 2002], we show that, by conditioning with respect to the variance path, it is possible to obtain pricing formulas that can be related to their counterparts in the Black-Scholes model.

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PP1

Price Discovery in a Mean-Field Game of Optimal Execution

We study a price discovery mean-field game model in the context of optimal execution arising from a market clearing condition. The trading rate of optimal traders follows the classical problem of optimal execution of portfolio transactions due to [Almgreem and Chriss, Optimal Execution of Portfolio Transactions, 1999]. We use deep learning techniques to numerically solve the resulting system of partial differential equations (PDE). The idea behind the method, based on [Sirignano and Spiliopoulos, DGM: A deep learning algorithm for solving partial differential equations, 2018], is to define a loss function that involves the PDE system and the market clearing condition. Our results are consistent with the price discovery mechanism of [Duffie and Zhu, Size Discovery, 2017].

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PP1

Testing Risk Prices in Factor Models: Model Selection and Uniformly Valid Inference

Several risk factors have emerged in the recent Empirical Asset Pricing literature over the recent years. This poses questions of how to assess the pricing information carried by a given factor and how to estimate reduced-form discrete-time models is such a high-dimensional setting, without fitting noise and market microstructure. We explore the use of model selection techniques from the Machine Learning literature in the context of factor models for the SDF, such as the Lasso, Elastic Net and their variations. Non-uniformity in asymptotic approximations is a problem all these estimators face and one that we take seriously. This is specially important for statistical inference, something that is not considered very often by Machine Learning practitioners and is crucial for assessing newly proposed factors. We present theoretical and numerical results regarding non-uniformity and consider solutions derived from Belloni *et al.* (2014, Review of Economic Studies) and Feng *et al.* (2018, Working paper).

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PP1

Fuzzy Regime Switching Portfolio Selection with Capital Gain Tax

Fuzzy set theory has achieved a wide application in financial fields for its efficiency in dealing with the uncertainty and inadequacy of historical data in real applications. In this paper, we focus on a fuzzy portfolio selection problem within a predefined investment horizon considering that the exit time of each risky asset is uncertain. Compared with previous portfolio selection studies where the transaction cost is usually assumed to be constant in different investment periods, we introduce the capital gain tax of which the realized tax rate is decreasing with respect to the investment periods for the aim of encouraging the long term investment. In the meanwhile, the regime switching of market state is firstly considered in fuzzy portfolio selection, where fuzzy random variables are employed to denote the uncertain returns of risky assets in regime switching markets. An adjusted L-R fuzzy number is proposed and its mathematical properties are studied for the convenience of computing the expected value and variance of the final return. In addition, a multiobjective mean-variance portfolio selection model is formulated by jointly maximizing the return and minimizing the risk. A numerical integral simulation based particle swarm optimization algorithm (NISPSOA) is designed to derive the efficient front of the portfolio. Finally, some numerical experiments are proposed to validate the effectiveness of the model and NISPSOA.

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PP1

Hierarchical Adaptive Sparse Grids for Option

Pricing under the Rough Bergomi Model

The rough Bergomi (rBergomi) model, introduced recently, is a promising rough volatility model in quantitative finance. This new model exhibits consistent results with the empirical fact of implied volatility surfaces being essentially time-invariant. This model also has the ability to capture the term structure of skew observed in equity markets. In the absence of analytical European option pricing methods for the model, and due to the non-Markovian nature of the fractional driver, the prevalent option is to use Monte Carlo (MC) simulation for pricing. Despite recent advances in the MC method in this context, pricing under the rBergomi model is still a time-consuming task. To overcome this issue, we design a novel, alternative, hierarchical approach, based on adaptive sparse grids quadrature, specifically using the same construction as multi-index stochastic collocation (MISC), coupled with Brownian bridge construction and Richardson extrapolation. By uncovering the available regularity, our hierarchical method demonstrates substantial computational gains with respect to the standard MC method, when reaching a sufficiently small error tolerance in the price estimates across different parameter constellations, even for very small values of the Hurst parameter. Our work opens a new research direction in this field, i.e. to investigate the performance of methods other than Monte Carlo for pricing and calibrating under the rBergomi model.

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PP1

Extending (s,S) Policy for Concave Piecewise Linear Ordering Cost

We are considering stochastic inventory control system for an infinite horizon in which the ordering/production cost is piece-wise linear. In our study we replaced the fixed cost(K) with two variable costs and therefore, we are setting two sets of assumptions. For the first set of assumption we will have the well known (s_ϵ, S_ϵ) policy but for the second set of assumption we explore an interesting situation, which we are calling $(\sigma_\epsilon, s_\epsilon, S_\epsilon)$ policy. And in the course of the paper, we will prove that the new outlined policy is optimal.

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PP1

Pricing Real Options with a Finite Time Horizon under Regime-Switching Jump-Diffusion Models

A real option, which is irreversible investment, under a regime-switching jump-diffusion model is considered. When the stochastic process of an underlying cash flow follows the regime-switching jump-diffusion model, the objective of the investor is to find an optimal investment time to maximize the discounted expectation of a payoff function. First of all, the project value which is the discounted expectation of the cash flow stream can be evaluated by solving a partial integro-differential equation (PIDE). Then the objective function and the optimal investment time are concerned with a Hamilton-Jacobi-Bellman (HJB) equation. Numerical experiments are carried out to show that the proposed method has the second-order convergence rate in the time and spatial variables and then the various phenomena of the real option are described with the regime-switching process.

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PP1

Momentum and Volatility Timing

The growing adoption of factor investing simultaneously prompted the active topic of factor timing approaches for the dynamic allocation of multi-factor portfolios. The trend represents a natural development of filling the gap between passive and active management aiming to provide a flexible, transparent, cost-efficient investment for improving returns, lowering risk and increasing diversification. The proposed approach addresses this direction by introducing the volatility-timed winners strategy for mitigating the momentum factors intervals of underperformance relative to the market. The strategy was derived as a generalization of the volatility scaling approach and subsequently extended its scope from the market downturn (2008-2009) to the post-crisis period (2010-2018). In addition, the volatility-timed winners strategy brings together the two branches of the smart-beta domain: factor investing and risk-based allocation. The corresponding analysis was conducted on the Quantopian research platform and demonstrated the proposed strategys performance in relation to alternative solutions such as risk-parity allocation, cross-sectional and time series momentum scaling.

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PP1

Artificial Intelligence Guided Algorithmic Trading for Optimal Price Discovery: a Bayesian Approach

Algorithmic trading is a field which stands to benefit from guidance by intelligent, autonomous systems. We consider the problem of teaching a high-speed market making algorithm to discover and track optimal market prices over time. Most of the existing methods used to guide such algorithms do not consider both the tasks of discovering optimal prices, as well as tracking them over time. Other

existing methods require lots of input data, which reduces the speed of the algorithm. The remaining methods in use are unsuitable because they require a long training period before they are effective. This paper proposes a solution which models the problem as a variant of Sequential Bayesian Optimization. The solution attempts to discover the optimal price using Bayesian Optimization, and then to track it using kinematic motion models. Additionally, the solution considers a novel way of optimizing the search by using unsuccessful searches. The results show that the proposed solution is more efficient at finding and tracking a target than existing methods. The implications are rapid price discovery, which is a prerequisite to efficient financial markets.

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PP1

Investment Strategies with Long Memory Processes: Log-Optimal and Approximative Solutions

One major question in portfolio optimization is how to construct an optimal investment strategy when the stock price has long memory. In my presentation, I will present a family of models in discrete time, called *Conditionally Gaussian* model family, which can incorporate long memory such that log-optimal solution exists (existence is guaranteed by a theorem), and it can be calculated numerically. Next, I will introduce two approximative solutions which are computationally more feasible. These approximations also allow us to use learning methods (stochastic gradient) to find the optimal strategy without knowing the true parameters of the model. For numerical results, I will use a stochastic volatility model constructed in the spirit of the Fractional Stochastic Volatility model. This model has long memory and belongs to the Conditionally Gaussian family, and it has several statistical advantages. This presentation substantially relies on the following paper: Zs. Nika, M. Rásonyi, Log-optimal portfolios with memory effect, 2018.

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PP1

Time-Inconsistent Mean-Field Optimal Control Problems and the Equilibrium HJB Equation

The appearance of conditional expectations in a nonlinear form is one of the source of time inconsistency. We investigated the problem by applying the method of differential game. The whole problem is based on the dynamic programming principle for mean-filed optimal control problem and calculus for functions of distributions. It also reflects the relationships between open-loop control and closed-loop strategy in the mean-field framework.

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PP1

Generalized MarčenkoPastur for Datasets with Fixed Time Horizons

We consider the use of random matrix theory in modeling and studying large financial datasets, particularly when estimating out-of-sample risk in Mean-Variance portfolio allocation. This type of modeling has been considered especially attractive due to the universality of the underlying mathematical results: if the returns of assets to be held in the portfolio are assumed independent and stationary, then these results do not depend on the precise distribution of returns. We contest that this universality has been somewhat misrepresented in the literature, as asymptotic results require that an arbitrarily long time horizon be before becoming useful. In order to reconcile these models with the highly leptokurtic returns that are observed in real financial data, we introduce a new type of random matrix model, driven by an underlying assumption that the data is collected based on the observations of Lévy processes over a fixed time horizon.

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SIAM Conference on Financial Mathematics & Engineering

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Conference Budget

Conference Budget
SIAM Conference on Financial Mathematics and Engineering
June 4-7, 2019
Toronto, Canada

Expected Paid Attendance		245	
Revenue			
Registration Income			$112,945
	Total		$112,945
Expenses			
Printing			$1,400.00
Organizing Committee			$3,100.00
Invited Speakers			$9,600.00
Food and Beverage			$19,900.00
Equipment Rental			$19,400.00
Room Rental			$0.00
Advertising			$4,000.00
Conference Labor (including benefits)			$40,523.00
Other (supplies, staff travel, freight, misc.)			$6,325.00
Administrative			$12,442.00
Accounting/Distribution & Shipping			$7,068.00
Information Systems			$12,200.00
Customer Service			$4,287.00
Marketing			$8,137.00
Office Space (Building)			$4,909.00
Other SIAM Services			$4,615.00
	Total		$157,906.00
Net Conference Expense			($44,961)
Support Provided by SIAM			$44,961
			$0
Estimated Support for Travel Awards not included above:			
Early Career and Students		19	$17,095

Maps

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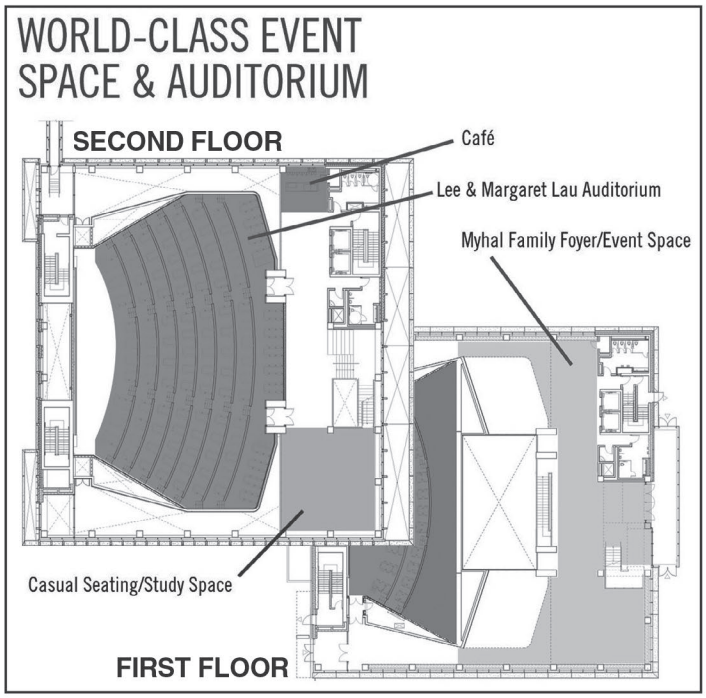
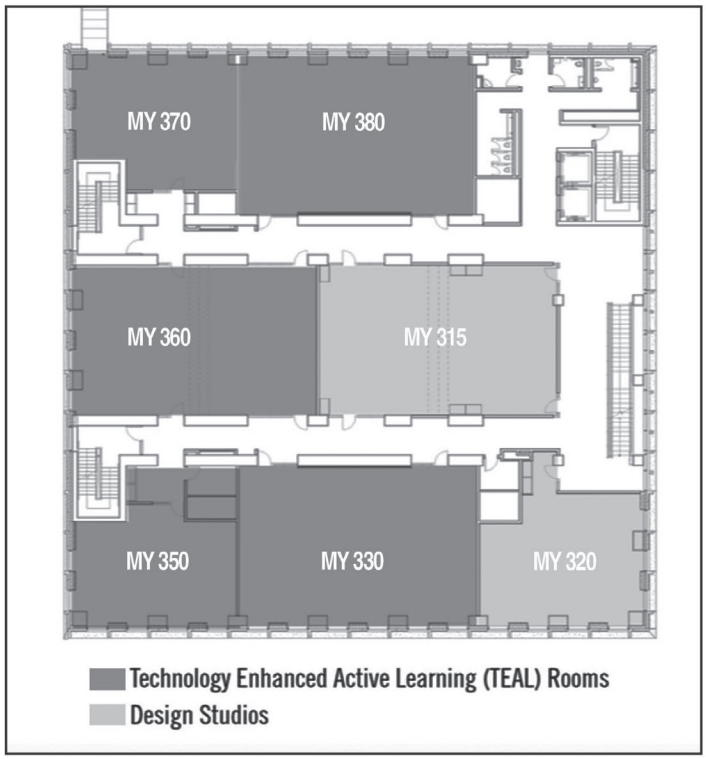


First and Second Floors



Third Floor

Campus Map