15th European Summer School in Financial Mathematics

“Mathematics of FinTech”

Book of Abstracts

DIAM · TU Delft

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Monday

Location: Vakwerkhuis, Professor Snijdersstraat 2, 2628 RA Delft

8:30–9:00	Registration and Opening Address
9:00–10:30	**Martin Kroll** Introduction to Differential Privacy, I
10:30–11:00	Coffee Break
11:00–12:30	**Martin Kroll** Introduction to Differential Privacy, II
12:30–14:00	Lunch Break
14:00–15:30	**Hansjörg Albrecher** Blockchains and Decentralized Insurance, I
15:30–16:00	Coffee Break
16:00–18:00	**Student's presentations, I**

Tuesday

Location: X (Building 37), Mekelweg 8, 2628 CD Delft

9:00–10:30	**Hansjörg Albrecher** Blockchains and Decentralized Insurance, II
10:30–11:00	Coffee Break
11:00–12:30	**Hansjörg Albrecher** Blockchains and Decentralized Insurance, III
12:30–14:00	Lunch Break
14:00–15:30	**Martin Kroll** Introduction to Differential Privacy, III
15:30–16:00	Coffee Break
16:00–18:00	**Poster Session & Borrel** (Location: 7th floor, Building 36, Mekelweg 4, Delft)

Wednesday

Location: X (Building 37), Mekelweg 8, 2628 CD Delft

9:00–10:30	**Jörg Osterrieder** Artificial Intelligence and Deep Reinforcement Learning in Finance, I
10:30–11:00	Coffee Break
11:00–12:30	**Jörg Osterrieder** Artificial Intelligence and Deep Reinforcement Learning in Finance, II
12:30–14:00	Lunch Break
14:00–15:30	**Jörg Osterrieder** Artificial Intelligence and Deep Reinforcement Learning in Finance, III
15:30–16:00	Coffee Break
16:00–17:00	**Student's presentations, II**
17:00–19:00	Free afternoon
19:00–22:00	**Dinner**

Thursday

Location: X (Building 37), Mekelweg 8, 2628 CD Delft

9:00–10:30	**Jörg Osterrieder** Artificial Intelligence and Deep Reinforcement Learning in Finance, IV
10:30–11:00	Coffee Break
11:00–12:30	**Kees Oosterlee:** Machine Learning for Anti-Money Laundering and Deep Portfolio Optimisation in Finance, I
12:30–14:00	Lunch Break
14:00–17:30	**Practitioner's afternoon**

Friday

Location: X (Building 37), Mekelweg 8, 2628 CD Delft

9:00–10:30	**Kees Oosterlee:** Machine Learning for Anti-Money Laundering and Deep Portfolio Optimisation in Finance, II
10:30–11:00	Coffee Break
11:00–12:30	**Kees Oosterlee:** Machine Learning for Anti-Money Laundering and Deep Portfolio Optimisation in Finance, III
12:30–12:40	Closing
12:40–14:00	Lunch

Student’s presentations: schedule

Monday 16:00–18:00

16:00	**Burcu Aydogan** (RWTH Aachen University) Optimal Investment Strategies in Jump-Diffusion Markets for Interacting Agents
16:20	**Nazem Khan** (Dublin City University) Lightning Network Economics: Payment Fees
16:40	**Henk Keffert** (Tilburg University) Robo-Advising: Optimal Investment with Mismeasured and Unstable Risk Preferences
17:00	**Costas Smaragdakis** (National Technical University of Athens) A splitting deep Ritz method for option pricing in Lévy models
17:20	**Lorenc Kapllani** (Bergische Universität Wuppertal) Differential deep learning-based algorithm for solving high-dimensional nonlinear backward stochastic differential equations
17:40	**Chiara Rossato** (ETH Zürich) Golden parachutes under the threat of accidents

Wednesday 16:00–16:40

16:00	**Lorenz Riess** (University of Vienna) The geometry of financial institutions - Wasserstein clustering of financial data
16:20	**Lionel Sopgoui** (Université Paris Cité) Propagation of carbon taxes in credit portfolio through macroeconomic factors

Practitioner's afternoon, Thursday 14:00–17:30

14:00	**Anastasia Melachrinos** (Kaiko) Blockchain & Decentralized Finance (DeFi)
14:30	**Michael W. D. Kurz** (MN) Balancing Wealth & Well-being: Green Portfolio Optimization
15:00	**Behrouz Raftari Tangabi, Xiaoqi Yu, Suvadeep Adhikari, Yuan Li** (ING) Exploring Modelling Approaches for Transaction Monitoring
15:30	Coffee Break
16:00	**Artur Swiech** (Optiver) Selected Topics in Rough Volatility
16:30	**Charles Martinez** (G-Research) Introduction to the G-Research Open Source Software Project
17:00	**Harold de Boer** (TransTrend) Mathematics on the road

Poster session, Tuesday 16:00–18:00

Mikio Hirokane (Osaka University)
A limit theorem for generalized tempered stable processes and their quadratic variations with stable index tending to two

Daniel Krsek (ETH Zürich)
Relaxed principal-agent problem

Yiting Liu (Bern University of Applied Data Science and Finance and University of Twente)
Network-Based Prediction of Loan Default Risk in P2P Lending: A Comparative Analysis of Logistic Regression, Random Forest, and Deep Neural Networks

Gijs Mast (Delft University of Technology)
Replacing the Monte Carlo Simulation with the Cos Method for Potential Future Exposure Calculation

Giulia Pucci (KTH)
Impulse control of conditional McKean-Vlasov jump diffusions

Marco Rodrigues (ETH Zürich)
Reflections on BSDEs

Michael Samet (King Abdullah University of Science and Technology)
Hierarchical Adaptive Quadrature and Quasi-Monte Carlo for Efficient Fourier Pricing of Multi-Asset Options in Lévy Models

Ioannis Tzouanas (Bielefeld University)
Ergodic mean-field games of singular control with regime-switching

Evgenii Vladimirov (University of Amsterdam)
iCOS: Option-Implied COS Method

3 Abstracts

3.1 Mini-courses

Hansjörg Albrecher (University of Lausanne)
Blockchains and Decentralized Insurance

In this mini-course, we give an overview of the concept of blockchains, which are distributed data ledgers based on consensus among different nodes in a peer-to-peer network. We discuss various consensus protocols and evaluation criteria such as efficiency, decentralization and security, and we review mathematical models and tools to assess the performance of blockchain systems. For a resource-consuming proof-of-work based blockchain (as is for instance used for the crypto-currency Bitcoin) we then study the trade-off between profitability and risk for miners in more detail, adapting tools from insurance risk theory, which will also allow to quantify the efficiency of mining pools and selfish mining strategies. Finally, we give an overview of recent developments and the potential of decentralized insurance.

Martin Kroll (University of Bayreuth)
Introduction to Differential Privacy

This mini-course is supposed to provide an introduction to differential privacy. It is divided into four parts. In the first part, we motivate the need for privacy-preserving data analysis. We discuss several notions of privacy circulating in the research literature and discuss the definition and basic properties of differential privacy and its nearby relatives in detail. The second part is mainly algorithmic. We introduce the main methods used to generate differentially private data. The third and the fourth part are then devoted to the analysis of differentially private data. In the third part we discuss the case of global differential privacy, whereas the fourth and final part concerns the more restrictive notion of local differential privacy. In this last part I will also present some results related to my own research.

Kees Oosterlee (Utrecht University)
Machine Learning for Anti-Money Laundering and Deep Portfolio Optimisation in Finance

This 4.5 hours lecture series deals with two separate topics from the financial industry, Anti-Money Laundering and Deep Portfolio Optimisation in Finance. For both topics, in modern machine learning techniques have become imperative, due to the amount of data being processes and due to the problem dimensionality in practice.

Anti-money laundering is a very important topic for the financial industry and falls under the category of fraud detection. Essentially, one searches for outliers in high-dimensional data sets. This part of the day, we start with a light historical overview of the origin of money and the history fraud in finance, after which we dive into anomaly detection to combat fraud in finance. After a brief introduction to rule-based (supervised) anomaly detection, we'll explain the details of unsupervised machine learning. Many unsupervised anomaly detection algorithms rely on the concept of nearest neighbours to compute the anomaly scores, like k-nearest neighbours. Isolation Forest (IF) is a relatively new branch on the tree of anomaly detection algorithms to search for outliers in data sets by means of the concept of isolation. We give an introduction into IF, its advantages and disadvantages as compared to nearest neighbour algorithms. Subsequently, we present the new and parameter-free Analytic Isolation and Distance-based Anomaly (AIDA) detection algorithm, that combines the metrics of distance with isolation. Based on AIDA, we also present the Tempered Isolation-based eXplanation (TIX) algorithm, which identifies the most relevant features characterizing an outlier, even in large multi-dimensional datasets, improving the overall explainability of the detection mechanism.

The second topic of the day is optimal portfolio asset allocation. In this part, we take the perspective of a trader, who is allowed to trade in a risk-free bond, in stocks, and also in options. The trader is allowed to trade at a set of trading dates. In order to evaluate how satisfied the investor is with the return, an objective function is used. A high quality objective function is able to numerically represent the investor's preferences of how much risk is acceptable for a certain level of potential profit. Moreover, we introduce market frictions aspects of incomplete markets and trading constraints. Regarding the market, we add transaction costs as well as a non-bankruptcy constraint and for the trading strategies, we introduce leverage constraints.

The resulting optimization problem admits to closed form strategies only in rare cases and we therefore have to rely on numerical approximations. When it is required, we use a time discretization scheme for the assets and we use empirical distributions as approximations in a Monte–Carlo fashion. The discrete counterpart (in time and/or in probability space) is then approximated by letting deep neural networks represent the trading strategies and optimizing with a gradient decent type algorithm. The neural networks that we use in our implementations are introduced in quite some detail in this presentation.

1. Anomaly detection and fraud (2.25 hours)
1.1. Welcome and overview of the day
1.2. History of money and fraud, Rule-based methods
1.3 Unsupervised learning in fraud detection
1.4. The AIDA algorithm and the TIX explanation method

2. Neural networks for optimal asset allocation in financial portfolios (2.25 hours)
2.1. Optimal asset allocation, objective functions
2.2. Classical approach with Monte Carlo simulation
2.3. Deep neural networks for optimal asset allocation in the general case.
2.4 Numerical example

Jörg Osterrieder (University of Twente · Bern HF)

Artificial Intelligence and Deep Reinforcement Learning in Finance

This lecture offers a comprehensive introduction to Artificial Intelligence (AI) and Deep Reinforcement Learning (DRL) applications in the finance industry. The course covers fundamental AI techniques, their financial applications, and the unique challenges faced in the industry. Participants will gain insights into various AI-driven solutions such as algorithmic trading, credit scoring, fraud detection, and portfolio optimization. The course also delves into the rapidly evolving field of DRL, exploring key algorithms, their underlying principles, and applications in finance, such as algorithmic trading, risk management, and option pricing.

A hands-on workshop will provide participants with practical experience in implementing a DRL model for algorithmic trading. The workshop covers essential steps, including data preprocessing, feature engineering, DRL model implementation, and performance evaluation. Participants will have the opportunity to work with real-world financial data and apply their learnings to develop a trading strategy using DRL.

This lecture is designed for PhD students and early-career researchers interested in the intersection of AI, DRL, and finance. By the end of the course, participants will have a solid understanding of AI applications in finance, DRL techniques, and the practical know-how to implement and evaluate DRL-driven financial strategies.

1. Introduction
1.1. Welcome and overview
1.2. Basics of finance and financial markets
1.3. Introduction to Artificial Intelligence (AI) and Machine Learning (ML)
1.4. Role of AI and ML in finance

2. Artificial Intelligence in Finance
2.1. Overview of AI techniques in finance
2.1.1. Supervised learning
2.1.2. Unsupervised learning
2.1.3. Reinforcement learning
2.2. AI applications in finance
2.2.1. Algorithmic trading
2.2.2. Credit scoring and risk assessment
2.2.3. Fraud detection
2.2.4. Portfolio optimization
2.2.5. Financial forecasting
2.2.6. Chatbots and customer service
2.3. Key considerations and challenges
2.3.1. Data quality and availability
2.3.2. Model interpretability and explainability
2.3.3. Ethical and regulatory issues

3. Deep Reinforcement Learning in Finance
3.1. Introduction to Reinforcement Learning (RL)
3.1.1. RL framework: agents, environments, and interactions
3.1.2. Markov Decision Processes (MDPs)
3.1.3. Exploration vs. exploitation
3.1.4. Policy and value functions
3.2. Deep Reinforcement Learning (DRL) algorithms
3.2.1. Value-based methods: Q-learning, Deep Q-Networks (DQN)
3.2.2. Policy-based methods: REINFORCE, Proximal Policy Optimization (PPO)
3.2.3. Actor-critic methods: Advantage Actor-Critic (A2C), Deep Deterministic Policy Gradients (DDPG)
3.3. DRL applications in finance
3.3.1. Algorithmic trading and market making
3.3.2. Portfolio optimization and asset allocation
3.3.3. Risk management
3.3.4. Option pricing and hedging
3.4. Practical aspects of DRL in finance
3.4.1. Data preprocessing and feature engineering
3.4.2. Training and evaluation of DRL models
3.4.3. Hyperparameter tuning and model selection
3.4.4. Overfitting and generalization

4. Hands-on Workshop: Deep Reinforcement Learning for Algorithmic Trading
4.1. Introduction to the workshop
4.1.1. Overview of the problem and objectives
4.1.2. Dataset and tools
4.2. Preprocessing and feature engineering

4.2.1. Data cleaning and normalization
4.2.2. Feature selection and extraction
4.2.3. Data splitting: training, validation, and testing
4.3. Implementing a DRL algorithm
4.3.1. Selecting a suitable DRL algorithm
4.3.2. Defining the environment, agent, and reward function
4.3.3. Implementing the DRL model using a suitable framework (e.g., TensorFlow, PyTorch)
4.4. Training and evaluation
4.4.1. Training the DRL model
4.4.2. Evaluating the model on validation and test data
4.4.3. Assessing the performance of the trading strategy
4.5. Wrap-up and discussion
4.5.1. Sharing results and insights
4.5.2. Challenges faced and lessons learned
4.5.3. Potential improvements and future work

5. Conclusion
5.1. Recap of key takeaways
5.2. Future trends and research directions
5.3. Closing remarks and end of the session

3.2 Talks

Burcu Aydogan (RWTH Aachen University)

Optimal Investment Strategies in Jump-Diffusion Markets for Interacting Agents

We work on a portfolio management problem in a continuous-time setting for one agent and a large group of agents where the agents interact with each other strategically and determine their investment strategies depending on the others' performances. Herein, we define two wealth dynamics: the agent's and the group's wealth. The wealth dynamics appear in jump-diffusion markets. We measure the performance of the representative agent with preferences linked to the group performance. Therefore, we have a classical Merton problem to determine the agent's optimal strategy relative to the group performance. Furthermore, our framework assumes that the agent's utility performance does not affect the group, while the group affects the agent's utility. Moreover, we investigate the case when all agents are homogeneous in their risk aversion and relative performances. As a conclusion, we explore the optimal investment strategies of the representative agent under the relative performance concerns. This is a joint work with Mogens Steffensen in the University of Copenhagen.

Kristian Boroz (TU Berlin)

The Good, the Bad and the Ugly: Time Series with Discrete, Continuous and Neural Network Models

I review and motivate the usage of ARMA-GARCH-type time-series models and Generative Adversial Networks to forecast crypto-assets like the CRIX or Bitcoin and the major German stock index (DAX)

Nazem Khan (Dublin City University)

Lightning Network Economics: Payment Fees

In this work, we find what the optimal channel allocations are for two parties opening a payment channel in the lightning network. We find a corresponding optimal policy, and apply our results to several examples. This is joint work with Paolo Guasoni.

Lorenc Kapllani (Bergische Universität Wuppertal)

Differential deep learning-based algorithm for solving high-dimensional nonlinear backward stochastic differential equations

In this work we propose a novel differential deep learning-based algorithm for solving high-dimensional nonlinear backward stochastic differential equations (BSDEs) with differentiable coefficients, where the deep neural network (DNN) models are trained not only on the inputs and labels, but also the differentials of the corresponding labels. This is motivated by the fact that differential deep learning can provide an efficient approximation of the derivatives of the labels. The BSDEs are reformulated as a differential deep learning problem by using Malliavin calculus, which can be presented by a BSDE system. All the integrals in that system are discretized by using the Euler-Maruyama method. Then the DNNs are employed to approximate the unknown solution of the discretized BSDE system by estimating the solution, its gradient, and the Hessian matrix. The parameters of the DNNs are backwardly optimized at each time step by minimizing the loss function defined as a weighted sum of the dynamics of the discretized BSDE system. Various numerical experiments are carried out to demonstrate a high efficiency of the proposed algorithm not only on the solution but also its gradient and the Hessian matrix. The proposed algorithm can play an important role in pricing and hedging financial derivatives in high dimensions.

Henk Keffert (Tilburg University)

Robo-Advising: Optimal Investment with Mismeasured and Unstable Risk Preferences

We study a robo-advising framework that allows for interactions with a client who has time-varying risk preferences that can be mismeasured. A client's willingness to interact is incorporated using a budget constraint. We find that when measurements are more volatile interacting frequently can lead to losses in a client's welfare. When incorporating a constraint for the client's resources, a trade-off arises between interacting frequently to obtain up-to-date information with more volatile measurements versus less up-to-date information with more accuracy. Using an alternative investment strategy rather than a time-consistent strategy can lead to improved welfare for the client. Allowing client-initiated interactions and using an average of measured risk aversions both lead to more personalised investment advice.

Lorenz Riess (University of Vienna)

The geometry of financial institutions - Wasserstein clustering of financial data

The increasing availability of granular and big data on various objects of interest has made it necessary to develop methods for condensing this information into a representative and intelligible map. Financial regulation is a field that exemplifies this need, as regulators require diverse and often highly granular data from financial institutions to monitor and assess their activities. However, processing and analyzing such data can be a daunting task, especially given the challenges of dealing with missing values and identifying clusters based on specific features. To address these challenges, we propose a variant of Lloyd's algorithm that applies to probability distributions and uses generalized Wasserstein barycenters to construct a metric space which represents given data on various objects in condensed form. By applying our method to the financial regulation context, we demonstrate its usefulness in dealing with the specific challenges faced by regulators in this domain.

This is based on joint work with Julio Backhoff, Mathias Beiglböck, Johannes Temme and Andreas Wolf. See also https://arxiv.org/abs/2305.03565.

Chiara Rossato (ETH Zürich)

Golden parachutes under the threat of accidents

Based on recent work by Possamaï and Touzi, we consider an extension of Sannikov's principal-agent problem by letting the agent control the drift and the jump intensity of the output process. We investigate whether the problem exhibits a golden parachute, that is, whether there is a scenario in which the agent retires and receives a continuous stream of payments or the agent receives a lump-sum payment as compensation for the termination of the contract by the principal. With the introduction of the face-lifted utility, we can study the two cases simultaneously in a different principal-agent problem that we reduce to a standard mixed control-stopping problem. This is based on joint work with Dylan Possamaï.

Lionel Sopgoui (Université Paris Cité)

Propagation of carbon taxes in credit portfolio through macroeconomic factors

We study how the introduction of carbon taxes in a closed economy propagate in a credit portfolio and precisely describe how carbon taxes dynamics affect the firm value and credit risk measures such as probability of default, expected and unexpected losses. We adapt a stochastic multisectoral model to take into account carbon taxes on both sectoral firms' production and sectoral household's consumption. Carbon taxes are calibrated on carbon prices, provided by the NGFS transition scenarios, as well as on sectoral households' consumption and firms' production, together with their related greenhouse gases emissions. For each sector, this yields the sensitivity of firms' production and households' consumption to carbon taxes and the relationships between sectors. Our model allows us to analyze the short-term effects of carbon taxes as opposed to standard Integrated Assessment Models (such as REMIND), which are not only deterministic but also only capture long-term trends of climate transition policy. Finally, we use a Discounted Cash Flow methodology to compute firms' values which we then use in the Merton model to describe how the introduction of carbon taxes impacts credit risk measures. We obtain that the introduction of carbon taxes distorts the distribution of the firm's value, increases banking fees charged to clients (materialized by the level of provisions computed from the expected loss), and reduces banks' profitability (translated by the value of the economic capital calculated from the unexpected loss). In addition, the randomness introduced in our model provides extra flexibility to take into account uncertainties on productivity and on the different transition scenarios by sector. We also compute the sensitivities of the credit risk measures with respect to changes in the carbon taxes, yielding further criteria for a more accurate assessment of climate transition risk in a credit portfolio. This work provides a preliminary methodology to calculate the evolution of credit risk measures of a multisectoral credit portfolio, starting from a given climate transition scenario described by a carbon price.

Costas Smaragdakis (National Technical University of Athens)

A splitting deep Ritz method for option pricing in Lévy models

Solving high-dimensional differential equations is still a challenging field for researchers. In recent years, many works have been presented that provide approximation by training neural networks using loss functions based on the differential operator of the equation at hand, as well as its initial/terminal and boundary conditions. In this work, we use a machine learning approach for pricing European (basket) options written with respect to a set of correlated underlyings whose dynamics undertake discontinuities. We approximate the solution of the corresponding partial integro-differential equation using a variant of the deep Ritz method that splits the differential operator into symmetric and asymmetric parts. The method is driven by a modified version of the neural network introduced in the deep Galerkin method. The structure of the proposed neural network ensures the asymptotic behaviour of the solution for large values of the underlyings. Moreover, it leads the outputs of the network to be consistent with the prior known qualitative properties of the solution. We present the formulation of the Merton jump-diffusion and Variance Gamma (VG) models. The results demonstrate the efficiency of our method in pricing European basket options within the framework of Lévy models.

3.3 Posters

Mikio Hirokane (Graduate School of Engineering Science, Osaka University)

A limit theorem for generalized tempered stable processes and their quadratic variations with stable index tending to two

Motivated by Yoshida's martingale expansion theory, we study the limit of the joint distribution of a multidimensional Generalized Tempered Stable (GTS) process and its quadratic covariation process when the stable index tends to two. Under a proper scaling, the GTS processes converge to a Brownian motion that is a stable process with stable index two. We renormalize their quadratic covariation processes so that they have a nondegenerate limit distribution. We show that the limit is a stable process with stable index one and is independent of the limit Brownian motion of the GTS processes. According to Yoshida's martingale expansion theory, when a sequence of martingales converges to a Brownian motion, we can derive an asymptotic expansion of the density of the martingale marginal by specifying the limit distribution of suitably normalized quadratic variations of the martingales. For an application to finance, where an asset price process is modeled by a martingale, an asymptotic expansion of the marginal distribution derives that of the implied volatility under the model. Therefore, calculating the limit of normalized quadratic variations plays an important role in such application.

Daniel Krsek (ETH Zürich)

Relaxed principal-agent problem

We study a principal-agent problem with a lump-sum payment on a finite-time horizon. Extending the dynamic programming approach in Cvitanić, Possamaï and Touzi (2017), which reduces the principal's problem to a standard optimal control problem, we consider problems involving constraints on the optimal contract. Since such an optimal control problem ceases to be tractable with the standard PDE approach, we introduce a framework, in which the agent is allowed to choose measure-valued controls. This in turn gives more freedom to the principal, when she chooses the contract, and allows us to show existence of an optimal contract in problems with fairly general constraints.

Yiting Liu (Bern University of Applied Data Science and Finance and University of Twente)

Network-Based Prediction of Loan Default Risk in P2P Lending: A Comparative Analysis of Logistic Regression, Random Forest, and Deep Neural Networks

This research presents a novel two-step model leveraging machine learning techniques to predict loan defaults in peer-to-peer (P2P) lending, utilizing data from the Bondora P2P lending platform. The first step involves constructing a graph of loans to extract graph features: pagerank, betweeness, closeness, eigenvector, katz, authority, and hub—thus expanding the pool of information beyond traditional credit risk factors. In the second step, we employ three distinct machine learning models: elastic net regression, random forest, and a deep neural network, to exploit these features. Subsequently, a feature importance analysis is conducted to assess the contribution of the seven centrality measures to the model performance. This study not only offers significant contributions to the literature on P2P lending default prediction but also provides practical insights for industry stakeholders. We suggest further research into other network-based features, alternative machine learning models, and possible applications of our method to other financial industry domains.

Gijs Mast (Delft University of Technology)

Replacing the Monte Carlo Simulation with the Cos Method for Potential Future Exposure Calculation

To fulfill the need in the industry for fast and accurate quantification of counterparty credit risk (CCR), in this paper a new Fourier method of calculating the potential future exposure (PFE) for CCR is developed, tested and analyzed. The key insight is that the cumulative distribution function can be recovered semi-analytically using Fourier-cosine expansion, whereby the series coefficients are readily available from the characteristic function (ch.f.) of the total exposure. The ch.f. itself can be solved numerically via advanced quadrature rules. Herewith we focus on liquid IR and FX portfolios involving up to three correlated risk factors: a domestic and foreign short rate and the exchange rate of this currency pair. Both netting-set level and counterparty-level PFEs are covered in our research. The short rates are modelled under the one-factor Hull-White model and for the exchange rate, we assume they follow geometric Brownian motion. Our theoretical analysis predicts stable convergence of this method and observed exponential convergence. It was observed that this method is at least twice as accurate as the Monte Carlo (MC) simulation method and takes only one-tenth of the CPU time. The advantage of this method becomes even more prominent when the number of derivatives in a portfolio increases. Extending the method to involve more risk factors is ongoing, but we already foresee that it can be a much more efficient alternative to the MC method for liquid portfolios.

Giulia Pucci (KTH Royal Institute of Technology, Stockholm SE)

Impulse control of conditional McKean-Vlasov jump diffusions

This talk is about impulse control problems involving conditional McKean-Vlasov jump diffusions, in particular, the existence of an optimal solution through a verification theorem approach is established. The lack of Markov property due to the mean-field term can be overcome by combining the state equation of the problem with the stochastic Fokker-Planck equation for the conditional probability law of the state. Afterwards, it is possible to derive sufficient variational inequalities for a function to be the value function of the impulse control problem, and for an impulse control to be the optimal control. This result could be illustrated by applying it to the study of an optimal stream of dividends under transaction costs, by finding explicitly the solution as a function and associated impulse control which satisfy the verification theorem.

Marco Rodrigues (ETH Zürich)

Reflections on BSDEs

We consider backward stochastic differential equations (BSDEs) and reflected BSDEs in the genereality that will allow a unified study of certain discrete-time and continuous-time control problems on random time horizons. We provide well-posedness results for the BSDEs and reflected BSDEs with optional obstacle process in case of appropriately weighted square-integrable data. This is based on joint work with Dylan Possamaï.

Michael Samet (King Abdullah University of Science and Technology)

Hierarchical Adaptive Quadrature and Quasi-Monte Carlo for Efficient Fourier Pricing of Multi-Asset Options in Lévy Models

Fourier methods are significantly fast in pricing single-asset options, however, extending their tractability for multi-asset option pricing is challenging. The high smoothness of the integrand in the Fourier space motivates the exploration of deterministic quadrature methods that are highly efficient under regularity assumptions that are not typically satisfied by the integrand in the physical space, such as, adaptive sparse grids quadrature (ASGQ), and randomized Quasi-Monte Carlo (rQMC). When designing a numerical quadrature method for most of the existing Fourier pricing approaches, two key factors affecting the time-complexity should be carefully controlled, (i) the choice of the vector of damping parameters that ensure the Fourier-integrability (ii) the high-dimensionality of the integration problem. To address these challenges, we propose a heuristic rule for choosing the damping parameters, resulting in smoother integrands. Moreover, we explore the effect of sparsification and dimension-adaptivity in alleviating the curse of dimensionality. In addition, for applications where error estimation is a priority, we design an rQMC-based method for the Fourier integral computation. Since the integral we are addressing is on an unbounded domain, employing RQMC requires a domain transformation to the hypercube. A standard way to map the integrand from is by composition of the integrand with an inverse cumulative distribution function (icdf), however, the transformed integrand oftentimes singular or has large derivatives near boundary of the hypercube. Consequently, the integrand no longer satisfies the assumptions of the Koksma-Hlawka inequality, and the rate of convergence of RQMC is deteriorated. To circumvent this problem, we propose model-specific transformations and we derive appropriate conditions on the parameters of the icdf mapping to preserve the regularity of the transformed integrand and retain fast convergence of RQMC. Numerical experiments are conducted on basket put and call on min options for Geometric Brownian Motion, Variance Gamma, and Normal Inverse Gaussian. The performance of the proposed approaches is benchmarked with the crude Monte Carlo method.

Ioannis Tzouanas (Bielefeld University)

Ergodic mean-field games of singular control with regime-switching

This paper studies the stationary mean-field games of singular control with regime-switching. The representative agent adopts an ergodic criterion and interacts through a long-time (stationary) mean-field parameter. The solution strategy is divided into two steps. Firstly, for fixed mean-field parameter, we prove the existence of optimal control for the representative agent. To the best of our knowledge this is the first result for ergodic singular stochastic control problems with regime-switching. Secondly, we prove the existence and uniqueness of mean-field equilibria. By using the mean-field equilibria, an approximate result for the Nash equilibrium of (symmetric) N-player game is provided. Finally, we solve a mean-field game of (sustainable) productivity expansion and using sensitivity analysis we study the dependence of mean-field equilibrium from the parameters of the model. The presentation based on the joint work with

Jodi Dianetti and Giorgio Ferrari.

Evgenii Vladimirov (University of Amsterdam)
iCOS: Option-Implied COS Method

This paper proposes the option-implied Fourier-cosine method, iCOS, for non-parametric estimation of risk-neutral density, option prices, and option sensitivities. The iCOS method leverages the Fourier-based COS technique, proposed by Fang and Oosterlee (2008), by utilizing the option-implied cosine series coefficients. This procedure does not require any model assumptions about the underlying asset price dynamics, it is fully non-parametric, and it does not involve any numerical optimization. All this makes it rather general and computationally very appealing. Furthermore, we derive the asymptotic properties of the proposed non-parametric estimators and study their finite-sample behavior in Monte Carlo simulations. Our empirical analysis using S&P 500 index options and Amazon equity options illustrates the effectiveness of the iCOS method in extracting valuable information from option prices in different market conditions.

3.4 Practitioner's presentations

Charles Martinez (G-Research)
Introduction to the G-Research Open Source Software Project

In support of G-Research's activities in quantitative research, the GR Open Source Software team contributes to a variety of projects in the open source ecosystem, with a focus on three fundamental and overlapping areas of research:

- Data science and machine learning tools
- The infrastructure to support those tools
- Security across those tools and infrastructure.

Behrouz Raftari Tangabi, Xiaoqi Yu, Suvadeep Adhikari, Yuan Li (ING)
Exploring Modelling Approaches for Transaction Monitoring

In this talk, we dive into the word of transaction monitoring and how different modelling approaches can help to make financial system safer. We will explore various ways to understand and detect unusual / suspicious transaction activities. If you are curious about how data, expert knowledge and models can team up to protect our transactions, join us for a journey into this important topic.

Anastasia Melachrinos (Kaiko)
Blockchain & Decentralized Finance (DeFi)

In this session, we will concentrate on the fundamental concepts of Bitcoin and Ethereum blockchains, and explain the role of smart contracts in financial innovation, specifically in the context of the price determination mechanisms applied to so-called decentralized exchanges. Using data as our guide, we will delve into the opportunities these innovations offer to traders and market makers, while also considering the challenges and costs they face due to their roles in these markets.

Michael W. D. Kurz (MN)

Balancing Wealth & Well-being: Green Portfolio Optimization

The traditional mean-variance portfolio optimization is expanding to integrate sustainability, leading to the concept of 3D investing. This presentation underscores the complexities associated with integrating non-financial data into portfolio optimization. We will explore the methodologies used in this integration, discussing data challenges and how sustainability can be incorporated either through modifying objective functions or introducing specific constraints. As sustainability brings with it a myriad of facets, understanding how each can be incorporated is crucial for optimized portfolio construction. By highlighting these techniques and challenges, attendees will gain insights into approaches to portfolio optimization that balances both wealth and sustainability considerations from a practical perspective.

Artur Swiech (Optiver)

Selected Topics in Rough Volatility

We give a quick introduction to the topic of rough volatility and why models based on fractional Brownian motion are useful in trading. We present both a forecasting model for realized volatility based on historical estimation of Hurst exponent, as well as an example of a forward looking pricing model - the Rough Heston Model. We focus on the practical aspect of using those when addressing the trading problems faced by a market maker.