Book of Abstracts

BFS World Congress 2026 (Bologna)

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Poster Abstracts

June 29 - Plenary speakers

T.B.D.

Nicole El Karoui (*Professor Emeritus of Applied Mathematics, Sorbonne University, France*)

Abstract: *TBD*

Beyond Model Selection: Combining, Projecting, and Clustering Stochastic Models

Sebastian Jaimungal (*University of Toronto, Canada*)

Abstract: *Financial decisions are increasingly informed by collections of plausible models rather than a single trusted one. This talk develops a framework for combining, projecting, and clustering probability measures on path space. The framework is based on projected Kullback-Leibler barycenters coupled with clustering to construct representative stochastic models to support decision-making under ambiguity.*

June 30 - Plenary speakers

Modelling contagious bank runs

Luitgard Veraart (*LSE, London, United Kingdom*)

Abstract: *We develop a modelling framework for contagion in financial networks arising from bank runs. We show how interacting channels of contagion, namely funding withdrawals in the interbank network and price-mediated contagion arising from fire sales can turn a bank run on one institution into a systemic crisis. Furthermore, we also model how contagion effects can lead to additional bank runs. Our model allows for a wide range of withdrawal mechanisms both by banks and by external depositors. It can be used for financial stress testing and particularly for analysing implications of different withdrawal mechanisms for systemic risk. We illustrate this in stylised examples and an empirical case study. We find that the extent of systemic risk is highly sensitive to the choices of withdrawal strategies used by the market participants. We also discuss policy implications.*

Processing risk and ambiguity in decision making and risk management

Ruodu Wang (*University of Waterloo, Canada*)

Abstract: *Risk and ambiguity are two different sources of uncertainty that widely exist in a large range of decision and risk management problems. The traditional approach to address both, as in distributionally robust optimization, is to evaluate risk under a set of probability measures and then aggregate the risk evaluations to make a consolidated financial decision. We argue that this popular approach creates conceptual and practical issues when risk evaluation is made with risk measures. We present, with simplistic examples and an axiomatic theory, an alternative framework of decision making under risk and ambiguity: processing ambiguity before risk. The alternative framework gives rise to new risk management methodologies, including the model aggregation approach for robust optimization, partially law-invariant risk measures, and a Bayesian approach for risk measures.*

July 1 - Plenary speakers

Belief Dynamics and the Fragility of Algorithmic Collusion: A Two-Timescale Evolutionary Game Approach for Multi-agent Reinforcement Learning (MARL)

Nan Chen (*Chinese University of Hong Kong, China*)

Abstract: *Wide adoption of pricing algorithms in the market raises a pressing concern: can autonomous learning agents tacitly collude without any explicit agreement? We address this question by developing a novel two-timescale evolutionary game approach for solving general-sum MARL problems, designed to capture a feature that empirical evidence shows is central to AI decision-making—the evolution of an agent's beliefs about its rivals. Our approach integrates three key components: a perturbed best-response protocol for policy updates, fictitious play for belief updates, and a two-timescale scheme that resolves the non-stationarity inherent in learning. We prove that the dynamics converge toϵ-Nash equilibria without the restrictive assumptions typically required in the existing literature. Numerical experiments show that collusion hinges on algorithmic sophistication: naive agents' collusion is fragile and collapses under exploration, while sophisticated agents sustain robust, punishment-supported collusion. These findings offer insights for competition policy in algorithmically mediated markets.*

AI and Portfolio Management

Roberto Violi (*Banca d'Italia, Italy*); **Mark Burnett** (*G-Research, United Kingdom*); **Xunyu Zhou** (*Columbia University, United States of America*); **Chris Russell** (*Susquehanna, United States of America*); **Giovanni Beliossi** (*Axyon AI, Italy*)

Abstract: *TBD*

Power System Decarbonization: Resilience and Flexibility

Clémence Alasseur (*EDF, Paris, France*)

Abstract: *The decarbonization of our economies critically depends on the transformation of power systems. Electrification, coupled with the deployment of low-carbon electricity, is at the core of emissions reduction strategies. However, electricity is a unique good: essential, non-storable at scale, and requiring a continuous balance between supply and demand. This creates both short-term operational challenges and long-term investment needs. The increasing penetration of renewable energy sources and impacts of climate change introduce significant variability, raising new questions about system resilience and adequacy. Ensuring real-time balance while planning sufficient capacity in the long term requires a systemic approach that integrates multiple actors, infrastructures, and uncertainties. In this context, adaptation to climate change becomes a key dimension of power system planning. Meeting these challenges requires massive investments. This raises critical questions regarding the effectiveness of existing financial instruments and the role of green finance. The talk will provide an overview of the green finance landscape, including evolving regulatory frameworks. Beyond financing, achieving a resilient and efficient power system also depends on mobilizing flexibility sources and designing appropriate market and regulatory incentives. Mathematical and quantitative tools play a crucial role in addressing these issues. The presentation will illustrate how advanced modeling approaches can support decision-making, through selected examples drawn from research.*

July 2 - Plenary speakers

Dealer intermediation with private information (joint work with Darius Nik Nejad, EPFL)

Julien Hugonnier (*EPFL, Lausanne, Switzerland*)

Abstract: *We study an auction in which bidders submit quotes to a privately informed requester. We establish the existence of a unique symmetric mixed-strategy equilibrium and characterize the endogenous quote distribution in closed form. In equilibrium, requesters are endogenously partitioned into three groups: those who always trade, those who trade with positive probability, and those who never trade. We then embed this static Request-For-Quotes (RFQ) pricing mechanism in a dynamic dealer-intermediated OTC market with search frictions. We prove the existence and uniqueness of an equilibrium in which asset allocations, reservation values, the interdealer price, and the quote distributions are jointly determined.*

Learning with Limited Data in Finance

Ian Jubb (*Susquehanna*)

Abstract: *Financial markets generate enormous amounts of data — every order, cancellation, and trade across thousands of order books worldwide. Yet from a statistical point of view, far less of it is usable than it appears: observations are heavily correlated, the system changes as its participants adapt, and the signal-to-noise ratio is very low. This talk is an account from inside one quantitative trading firm — shaped by a handful of its researchers over the years — of what that constraint does to the day-to-day work of high-frequency trading research. I'll cover why the data is smaller than it looks, some things that have helped in making the most of what's left, and how much of our progress has come from rethinking the architecture of our models, the pipeline around them, and exactly how we trade with them.*

Generative Diffusion Models in Finance

Renyuan Xu (*Stanford University, United States of America*)

Abstract: *Generative modeling for financial data lies at the intersection of stochastic processes, statistical learning, and mathematical finance. Unlike image or text data, financial data exhibit temporal dependence, stochastic volatility, heavy tails, cross-sectional dependence, rare events, and structural restrictions from market mechanisms and no-arbitrage considerations. In this talk, I will first consider the generation of high-dimensional asset returns, where low-dimensional factor structure can be incorporated to reduce sample complexity and improve statistical guarantees. I will then discuss sequential financial time series generation, where the generative model must respect the underlying filtration and non-anticipative structure of the data. Finally, I will describe how hard constraints can be incorporated into the sampling procedure through tools from stochastic analysis, including Doob's h-transform and Malliavin calculus, with potential applications to stress testing and risk analysis.*

July 3 - Plenary speakers

Quantum For Quants (Quantum Computing Quantum Computing, a new toolbox for Stochastic Analysis & Machine Learning?)

Antoine Jacquier (*Imperial College London, United Kingdom*)

Abstract: *The goal of this talk is to highlight how (Applied / Financial / ....) mathematicians can contribute to the development of Quantum Computing and how the latter may contribute to the growth and advancement of Quantitative Finance. We shall focus on recent developments in Quantum Computing from an algorithmic standpoint, with a view towards applications (with an emphasis on Mathematical Finance and Stochastic Analysis), in particular emphasising the close connections with SDEs, neural networks and PDEs.*

Optimal Control, Entropy, and Market Making (To Say Nothing of the Quantum Harmonic Oscillator)

Olivier Guéant (*Université Paris Cité, France*)

Abstract: *Travelling through several years of academic research on market making models à la Ho-Stoll and Avellaneda-Stoikov, this talk revisits a decade and a half of literature through the lens of optimal control on graphs. We shed light on the crucial role of entropy and its associated duality in unlocking closed-form results. Moving from theory to practice, we then present recent extensions and real-world applications to FX and commodities markets.*

Recent developments in interest rate modeling - Part 1 - Aula A

Organized by: **Claudio Fontana** and **Alessandro Gnoatto**

MINI-SYMPOSIUM (ID 65): ID 701 (01)

Implications of Scheduled Jumps in Interest Rate Term Structure Dynamics

Erik Schlögl (*University of Technology Sydney, Australia*)

Abstract: *It is widely recognised that the move to new interest rate benchmarks based on overnight rates requires jumps at known dates to be incorporated into model of interest rate dynamics. This talk further explores the implications of the approach taken in Brace, Gellert and Schlögl (2024), revealing further insights into how "term rates" and their volatilities behave during accrual periods, and showing how this modelling approach naturally connects monetary policy with mean-reverting interest rate dynamics.*

MINI-SYMPOSIUM (ID 65): ID 593 (02)

Short-rate models with stochastic discontinuities: a PDE approach

Simona Sanfelici (*Università degli Studi di Parma, Italy*); **Alessandro Calvia** (*Politecnico di Milano, Italy*); **Marzia De Donno** (*Università Cattolica del Sacro Cuore, Italy*); **Chiara Guardasoni** (*University of Parma, Italy*)

Abstract: *With the reform of interest rate benchmarks, interbank offered rates like LIBOR have been replaced by risk-free rates, such as SOFR in the U.S. and eSTR in Europe. These rates exhibit jumps and spikes linked to specific market events, driven by regulatory and liquidity constraints. We consider a general short-rate model incorporating discontinuities at fixed times with random sizes and introduce a PDE-based approach for pricing interest rate derivatives, establishing under suitable assumptions a Feynman-Kač representation formula. For affine models, we derive (quasi) closed-form solutions, while in the general case we develop numerical methods to solve the resulting PDEs.*

MINI-SYMPOSIUM (ID 65): ID 300 (03)

An extended CIR process with stochastic discontinuities

Simone Pavarana (*University of Freiburg, Germany*); **Claudio Fontana** (*University of Padova, Italy*); **Thorsten Schmidt** (*University of Freiburg, Germany*)

Abstract: *We study an extension of the Cox–Ingersoll–Ross (CIR) process with jumps at deterministic dates. The model is motivated by short-rate dynamics for overnight rates, which often exhibit spikes at scheduled central bank meetings. We define a CIR process with state-dependent jumps, allowing for both upward and downward movements. Under mild assumptions, we establish existence and characterize conditions for preservation of the affine property and non-negativity. We provide constructive examples, including a representation via deterministic càdlàg time changes of a standard CIR process. We discuss implications for interest-rate pricing and hedging.* Joint work with Claudio Fontana and Thorsten Schmidt.

MINI-SYMPOSIUM (ID 65): ID 734 (04)

Affine and polynomial modeling of overnight rates

Thorsten Schmidt (*University of Freiburg, Germany*)

Abstract: *In this talk we present new results on the general structure and the modeling of interest rate markets with overnight rates. The characteristic dynamics of overnight rates with low volatility and jumps at scheduled dates is a challenge for most existing models. We show how existing models can be modified via a time-change to capture these stylized facts, but also how more general approaches allow for higher flexibility.*

Deep learning methods for stochastic control and BSDEs - Aula G

Organized by: **Kristoffer Andersson**

MINI-SYMPOSIUM (ID 215): ID 562 (01)

Deep Learning Algorithm for Solving High-dimensional Nonlinear PIDEs in Finance

Ariel Neufeld (*Nanyang Technological University, Singapore*); **Philipp Schmocker** (*ETH Zurich, Switzerland*); **Sizhou Wu** (*Shanghai University of Finance and Economics, China*)

Abstract: *We present a (random) neural networks based algorithm which can efficiently solve high dimensional nonlinear partial integro-differential equations (PIDEs) and apply this algorithm to price high-dimensional financial derivatives under default risk. We provide a full error analysis of our algorithm as well as empirically demonstrate that our algorithm can approximately solve nonlinear PIDEs in 10'000 dimensions within seconds. This talk is based on joint work with Philipp Schmocker and Sizhou Wu*

MINI-SYMPOSIUM (ID 215): ID 565 (02)

A deep solver for backward stochastic Volterra integral equations

Kristoffer Andersson (*Università degli studi di Verona, Italy*); **Alessandro Gnoatto** (*Università degli studi di Verona, Italy*); **Camilo Andrés García Trillos** (*Department of Mathematics, University College London, United Kingdom*)

Abstract: *We present the first deep-learning solver for backward stochastic Volterra integral equations and fully coupled forward–backward variants. A single-stage neural network approximates both solution fields, avoiding nested time-stepping schemes used in classical methods. For decoupled equations, we establish a non-asymptotic error bound combining an a posteriori residual with the standard square-root time-step rate. Numerical experiments confirm this behavior and demonstrate scalability up to 500 dimensions with nearly constant wall-clock time under GPU batching. The approach also handles fully coupled systems, enabling practical solutions to high-dimensional, time-inconsistent problems in stochastic control and quantitative finance.*

MINI-SYMPOSIUM (ID 215): ID 573 (03)

The Compound BSDE Method: A Fully Forward Method for Option Pricing and Optimal Stopping Problems in Finance

Zhipeng Huang (*University of Utrecht, Mathematical Institute, Mathematical Modelling, Netherlands*); **Cornelis Oosterlee** (*University of Utrecht, Mathematical Institute, Mathematical Modelling, Netherlands*)

Abstract: *We propose the Compound BSDE method, a fully forward, deep-learning-based approach for solving a broad class of problems in financial mathematics, including optimal stopping. The method reformulates option pricing as a system of backward stochastic differential equations (BSDEs), offering a new perspective on the numerical treatment of compound options and financial optimal stopping problems. Building on the classical deep BSDE method for a single BSDE, we develop an algorithm for compound BSDEs and establish convergence properties. We derive an a posteriori error estimate. Numerical experiments demonstrate accuracy and computational efficiency for high-dimensional option pricing and optimal stopping problems.*

MINI-SYMPOSIUM (ID 215): ID 737 (04)

The Deep Multi-FBSDE Method: A Robust Deep Learning Method for Coupled FBSDEs

Cornelis Oosterlee (*University of Utrecht, Mathematical Institute, Mathematical Modelling, Netherlands*)

Abstract: *We introduce the deep multi-FBSDE method for coupled forward-backward stochastic differential equations (FBSDEs). To overcome any convergence issues, we consider a family of FBSDEs, equivalent to the original problem in the sense that they satisfy the same associated partial differential equation (PDE) and initial value. Our algorithm proceeds in two phases: first, we approximate the initial condition jointly for a small number of FBSDEs from the FBSDE family, and second, we approximate the original FBSDE using the initial condition approximated in the first phase. Numerical experiments show that our method converges even when the standard deep FBSDE method does not.*

Contemporary Stochastic Control of Interacting Particle Systems - Aula B

Organized by: **Idris Kharroubi**

MINI-SYMPOSIUM (ID 247): ID 556 (01)

Contracting a crowd of heterogeneous agents

Guillermo Alonso Alvarez (*University of Michigan, United States*); **Ibrahim Ekren** (*University of Michigan, United States*); **Erhan Bayraktar** (*University of Michigan, United States*)

Abstract: *We study a principal–agent model with a large population of heterogeneously interacting agents under a linear–quadratic structure. Using a continuum-agent framework, we derive scalable optimal contracts and show that they remain near-optimal for large finite populations. Through comparative statics and numerical simulations, we illustrate how agents' network connectivity affects the principal's value, agents' effort levels, and the structure of optimal contracts.*

MINI-SYMPOSIUM (ID 247): ID 567 (02)

Graphon Mean-Field Games with Jumps and approximate Nash equilibria of large network games

Agnes Sulem (*INRIA Paris, France*); **Hamed Amini** (*University of Florida, United States*); **Zhongyuan Cao** (*NYU Shanghai, China*)

Abstract: *We study continuous-time n-player games on large networks and their limiting graphon game. Interactions between players are heterogeneous and of mean field type, governed by an underlying graph converging to a limiting graphon. Each player's dynamics is driven by controlled stochastic differential equations with jumps, and drifts and diffusions with mean field interactions weighted by heterogeneous graphs. The objective function is of cooperative form. We first analyse stochastic graphon games and associated equilibria via a relaxed formulation approach and the study of the associated controlled martingale problem. We then study limiting characteristics of large finite network games with heterogeneous interactions.*

MINI-SYMPOSIUM (ID 247): ID 697 (03)

Probabilistic Analysis of Heterogeneous Mean Field Control with Graphon Interactions

Zhongyuan Cao (*NYU Shanghai, China*); **Mathieu Laurière** (*NYU Shanghai, China*)

Abstract: *In this talk, we discuss heterogeneous mean field control problems with graphon interactions from a probabilistic point of view. The controlled dynamics are governed by a continuum of heterogeneous mean field stochastic differential equations. We establish the existence and uniqueness of the associated graphon mean field forward-backward stochastic differential equations. We then derive a version of the Pontryagin stochastic maximum principle tailored to heterogeneous mean field control problems. Furthermore, we show that the solution to the heterogeneous mean field control problem provides an approximately optimal control for large heterogeneous systems with networked interactions, based on a propagation of chaos result.*

MINI-SYMPOSIUM (ID 247): ID 743 (04)

A non-exchangeable mean field control problem with controlled interactions

Fabrice Djete (*Ecole Polytechnique, France*)

Abstract: *In this work, we study a new class of mean–field control problems with controlled interactions. Unlike the classical mean–field framework, where agents are exchangeable and interact only through the population law, we allow for heterogeneous and possibly asymmetric interactions encoded by a structural kernel, typically of graphon type. The main novelty is that the interaction structure itself becomes a control variable. In other words, the planner optimizes not only a standard control acting on the local dynamics, but also an interaction control which shapes how agents influence one another through the network.*

Memory in Quantitative Finance - Part 1 - Aula C

Organized by: **Eduardo Abi Jaber**

MINI-SYMPOSIUM (ID 40): ID 726 (01)

Multivariate Self-Exciting Processes with Dependencies

Caroline Hillairet (*ENSAE, France*); **Anthony Reveillac** (*Institut Mathématique de Toulouse, France*); **Thomas Peyrat** (*ENSAE, France*)

Abstract: *We introduce the class of multidimensional self-exciting processes with dependencies (MSPD), which is a unifying writing for a large class of processes: counting, loss, intensity, and also shifted processes. The framework takes into account dynamic dependencies between the frequency and the severity components of the risk, and therefore induces theoretical challenges in the computations of risk valuations. We present a general method for calculating different quantities related to these MSPDs, which combines the Poisson imbedding, the pseudo-chaotic expansion and Malliavin calculus. The methodology is illustrated for the computation of explicit general correlation formula.*

MINI-SYMPOSIUM (ID 40): ID 571 (02)

Global and local regression: a signature approach with applications

Christian Bayer (*WIAS Berlin, Germany*); **Davit Gogolashvili** (*Weierstrass Institute for Applied Analysis and Stochastics, Germany*); **Luca Pelizzari** (*University of Vienna, Austria*)

Abstract: *The path signature is a powerful tool for solving regression problems on path space, i.e., for computing conditional expectations$\mathbb{E}[Y \mid X]$when the random variable X is a stochastic process - or a time-series. We provide new theoretical convergence guarantees for two different, complementary approaches to regression using signature methods. In the context of global regression, we show that linear functionals of the robust signature are universal in the L sense in a wide class of examples. In addition, we present a local regression method based on signature semi-metrics, and show universality as well as rates of convergence.*

MINI-SYMPOSIUM (ID 40): ID 597 (03)

Signature volatility model: Martingale property and Laplace transform

Eduardo Abi Jaber (*Ecole Polytechnique, France*); **Paul Gassiat** (*Université Paris Dauphine, France*); **Dimitri Sotnikov** (*Ecole Polytechnique, France*)

Abstract: *We study a signature stochastic volatility model with volatility given by a linear functional of the signature of a time-extended Brownian motion. Motivated by pricing applications, we address two questions: conditions for the martingale property of the price and computation of the Laplace transform. We prove that martingality holds if and only if the order of the volatility coefficient is odd and the correlation parameter is negative. We then characterize the Laplace transform via an infinite-dimensional Riccati equation and establish existence of solutions under conditions ensuring martingality. Based on joint work with Eduardo Abi Jaber and Paul Gassiat.*

MINI-SYMPOSIUM (ID 40): ID 541 (04)

Signature approach for pricing and hedging path-dependent options with frictions

Eduardo Abi Jaber (*Ecole Polytechnique, France*); **Donatien Hainaut** (*Université catholique de Louvain, Belgium*); **Edouard Motte** (*Université catholique de Louvain, Belgium*)

Abstract: *We introduce a novel signature approach for pricing and hedging path-dependent options with instantaneous and permanent market impact under a mean-quadratic variation criterion. Leveraging the expressive power of signatures, we recast an inherently nonlinear and non-Markovian stochastic control problem into a tractable form, yielding hedging strategies in linear feedback form in the time-augmented signature of the control variables, with coefficients characterized by non-standard infinite-dimensional Riccati equations on the extended tensor algebra. Numerical experiments demonstrate the effectiveness of these signature-based strategies for pricing and hedging general path-dependent payoffs in the presence of frictions.*

Optimal Control and Incentive Design in Automated Market Makers - Aula D

Organized by: **Philippe Bergault** and **Leandro Sánchez Betancourt**

MINI-SYMPOSIUM (ID 80): ID 692 (01)

Fixed For Floating Swap in AMM Liquidity Provision

Marina Georgiou (*Stevens Institute, United States*); **Zachary Feinstein** (*Stevens Institute of Technology, United States*); **Faycal Drissi** (*University of Oxford, United Kingdom*); **Alvaro Cartea** (*University of Oxford, United Kingdom*)

Abstract: *Decentralized finance has reshaped digital asset trading through Automated Market Makers, making liquidity provision a central economic activity. Although extended literature has been developed around the concept of pricing liquidity provision and optimal investing in AMMs, transferring risk within the DeFi scheme still remains underdeveloped. In this study, we aim to price the fixed-for-floating swap by proposing a market design that fully captures the dynamics of a LP position. The existence of such a product would enable investors to transfer risks they are unwilling to bear and simultaneously contribute to a deeper understanding of implied volatilities and fee stream valuations.*

MINI-SYMPOSIUM (ID 80): ID 705 (02)

Optimal Funding Rate Mechanisms in Cryptocurrency Perpetual Futures

Sébastien Bieber (*Université Paris Dauphine, France*); **Philippe Bergault** (*Université Paris Dauphine, France*); **Olivier Guéant** (*Université Paris Cité - LPSM, France*)

Abstract: *This paper derives optimal funding rates for cryptocurrency perpetual futures to ensure price convergence with the underlying spot market. Utilizing a Stackelberg differential game, we model the strategic interaction between the exchange as the leader and traders as followers. By applying a stochastic maximum principle, we characterize equilibrium dynamics, yielding tractable Riccati equations that provide a closed-form solution. Our findings establish a rigorous mathematical foundation for funding rate design, balancing price-tethering objectives with trader risk-management constraints. This framework minimizes tracking error and optimizes liquidity across both centralized and decentralized trading environments.*

MINI-SYMPOSIUM (ID 80): ID 735 (03)

A Grid-Based Approach to Optimal Liquidity Provision in Automated Market Makers

Steve Zambou Woukeng (*University of Oxford, United Kingdom*); **Leandro Sánchez Betancourt** (*University of Oxford, United Kingdom*); **Faycal Drissi** (*University of Oxford, United Kingdom*)

Abstract: *Automated market makers (AMMs), particularly Uniswap v3, allow liquidity providers (LPs) to allocate capital across price intervals, turning liquidity provision into an active allocation problem. Prior literature shows that volatility widens liquidity ranges, price trends induce asymmetry, and aggregate liquidity depends on capital and competition, but lacks a unified microstructural foundation. We develop a tractable model with arbitrageurs and noise traders where price movements arise endogenously. A representative LP optimally allocates liquidity under a budget constraint. By discretizing prices, we obtain closed-form solutions that microfound existing insights and deliver transparent comparative statics on range width, skewness, and liquidity scale.*

MINI-SYMPOSIUM (ID 80): ID 712 (04)

Arbitrage on Decentralized Exchanges

Xuedong He (*The Chinese University of Hong Kong, Hong Kong*); **Chen Yang** (*The Chinese University of Hong Kong, Hong Kong*); **Yutian Zhou** (*The Chinese University of Hong Kong, Hong Kong*)

Abstract: *Decentralized exchanges with automated market makers generate arbitrage opportunities against centralized exchanges, where gas fees and transaction ordering are pivotal. Existing models neglect competition among arbitrageurs despite public price discrepancies. We present the first equilibrium model of gas fee competition between two arbitrageurs under no-revert, auto-revert, and selectable-revert settings. Pure symmetric equilibria are absent, but unique mixed equilibria emerge. Comparative analysis shows no-revert favors profits under low inventory risk, while auto- and selectable-revert enhance efficiency. With high risk, no-revert and selectable-revert dominate. Empirical evidence from Binance and Uniswap V2 validates our model's predictions on gas fees and trading behavior.*

Recent advances in Stackelberg games and applications - Aula E

Organized by: **Nicolás Hernández-Santibáñez , Emma Hubert, Thibaut Mastrolia** and **Matìas Vera**

MINI-SYMPOSIUM (ID 57): ID 574 (01)

Revisiting contract theory with volatility control

Alessandro Chiusolo (*Princeton University, United States*); **Emma Hubert** (*Université Paris Dauphine, France*); **Dylan Possamaï** (*ETH Zurich, Switzerland*); **Nizar Touzi** (*New York University, United States*)

Abstract: *We revisit continuous-time principal–agent problems with volatility control by introducing an alternative formulation in which the principal directly controls the quadratic variation of the output process. First, the resolution of this contractible-volatility problem follows the classical methodology of Sannikov (2008), relying on first-order BSDEs only. Second, we introduce a new contract form allowing the principal to achieve her contractible-volatility value, thereby ensuring both the optimality of this contract form and the equivalence between the original and the alternative problems. By simplifying the existing theory of principal–agent problems with volatility control, this work opens new directions for further extensions and applications.*

MINI-SYMPOSIUM (ID 57): ID 585 (02)

Closed-loop Equilibria for Stackelberg Games: A Story About Stochastic Targets

Nicolas Hernandez (*Universidad Técnica Federico Santa María, Chile*); **Camilo Hernández** (*University of Southern California, United States*); **Emma Hubert** (*Université Paris Dauphine, France*); **Dylan Possamaï** (*ETH Zurich, Switzerland*)

Abstract: *We develop a general method to reformulate continuous-time stochastic Stackelberg differential games with closed-loop strategies as a single-level optimisation problem with target constraints. Both leader and follower control the drift and volatility of a stochastic output process to maximise expected utilities. Focusing on closed-loop strategies based only on the output history, we characterise the Stackelberg equilibrium. By treating the follower's continuation utility, described by a second-order backward stochastic differential equation, as a controlled state variable, the leader's problem becomes a standard stochastic control problem with target constraints. Using dynamic programming, we derive the equilibrium via Hamilton–Jacobi–Bellman equations.*

MINI-SYMPOSIUM (ID 57): ID 706 (03)

Revisiting deterministic Stackelberg games with closed-loop strategies

Matías Vera Villalobos (*ETH Zurich, Switzerland*); **Nicolas Hernandez** (*Universidad Técnica Federico Santa María, Chile*); **Dylan Possamaï** (*ETH Zurich, Switzerland*)

Abstract: *In this talk, we study the closed-loop formulation of deterministic Stackelberg games and adapt the arguments used in the stochastic case using the theory of path-dependent PDEs. We show that, similarly to the stochastic case, the problem can be reformulated as the supremum of deterministic control problems with target constraints. We then introduce a stochastic perturbation and obtain a problem that admits a similar characterization. We further address the discontinuity issue that arises as the perturbation vanishes. Finally, we discuss how these results relate to extensions of the closed-loop formulation in the stochastic setting.*

MINI-SYMPOSIUM (ID 57): ID 708 (04)

Incentives, Competition and Efficiency in Auction Markets

Thibaut Mastrolia (*UC Berkeley, United States*); **Tianrui Xu** (*UC Berkeley, United States*)

Abstract: *This study explores the design of an efficient rebate policy in auction markets, focusing on a continuous-time setting with competition among market participants. A stock exchange collects transaction fees from auction investors executing block trades to buy or sell a risky asset, then redistributes these fees as rebates to competing market makers submitting limit orders. Market makers influence both the price at which the asset trades and their arrival intensity in the auction. Our results show that optimal transaction fees and rebate structures improve market efficiency by narrowing the spread between the auction clearing price and the asset's fundamental value.*

Risk Management - Aula F

ORAL ID 594 (01)

Measuring and Mapping Public Investment for Hydrologic Risk Management in Italy

Antonella Fabrizio (*Prometeia, Italy*); **Francesco Giovanardi** (*Prometeia, Italy*); **Michele Penza** (*Prometeia, Italy*); **Lea Zicchino** (*Prometeia, Italy*); **Sedric Zucchiatti** (*Prometeia, Italy*)

Abstract: *We construct a novel dataset of hydro-related public investments for Italian municipalities (2003-2024), identifying projects aimed at reducing flood vulnerability and distinguishing between ex ante and ex post interventions using a hybrid TF-IDF and LLM-based classification algorithm. Combining investment data with hydrologic risk exposures, we develop an Adaptation Investment Gap Index (AIGI) to detect municipalities with potential adaptation deficits. We further build a municipality-river panel mapping investments, extreme rainfall, and flood events to the Italian hydrography. Using local projections, we document a post-disaster investment cycle, with sharp but short-lived ex-post responses and more persistent ex-ante dynamics after extreme rainfall events.*

ORAL ID 459 (02)

Ranking Metrics: Extending Acceptability and Performance Indexes

Elisa Mastrogiacomo (*Università dell'Insubria, Italy*); **Asmerilda Hitaj** (*Università dell'Insubria, Italy*); **Ilaria Peri** (*Birkbeck University of London, United Kingdom*); **Marcelo Righi** (*Universidade Federal do Rio Grande do Sul, Brazil*)

Abstract: *The talk develops an axiomatic framework for ranking metrics, a general class of functionals for evaluating and ordering financial or insurance positions. Unlike traditional risk-adjusted performance measures, ranking metrics assign each position a performance level rather than a normalized return. Relying on monotonicity and a new property called cash-quasiconcavity property, we derive representation results linking ranking metrics to families of acceptance sets and risk measures, extending the theory of acceptability indices. Classical ratios arise as special cases; new examples—based on expected-loss,Λ-quantile, and bibliometric indices—illustrate the framework's flexibility. Empirical applications to portfolio ranking and climate-risk insurance demonstrate its practical relevance.*

ORAL ID 471 (03)

How to reduce risk by increasing risk

Cosimo Munari (*Università degli studi di Verona, Italy*); **Martin Herdegen** (*Universität Stuttgart, Germany*); **Nazem Khan** (*University of Oxford, United Kingdom*)

Abstract: *We show that it is possible to reduce the risk of an outstanding portfolio, as measured by Expected Shortfall, by adding to it a fully-leveraged portfolio of traded assets, thereby increasing the overall portfolio's loss potential. We first provide necessary and sufficient conditions for the financial market to admit such "'costless risk reducers" in terms of some weak pricing measure exceeding a certain threshold. We then present examples from bond and equity markets showing that it is possible for costless risk reducers to exist in practice. These findings are relevant for risk managers and financial regulators alike.*

ORAL ID 45 (04)

Tail Dispersion Measures: From Inequality Indices to Relative Risk Measures

Steven Kou (*Boston University, United States*)

Abstract: *This paper introduces an axiomatic framework that characterizes a general class of tail dispersion measures, which use the information from the lower tails. The proposed class encompasses numerous well-established measures. Applying these measures, we investigate income inequality and the prediction of financial asset returns. Our analysis reveals that despite stable overall Gini coefficients from 1980 to 2020, Gini curves indicate that lower- and middle-income individuals in the U.S. have become more equally relatively poorer, not just relatively poorer. In the context of stock returns, our relative tail risk measure exhibits significant predictive power.*

Credit Risk - Aula P

ORAL ID 616 (01)

Bridging Credit Transitions and Spread Dynamics

Selene Comolli (*Prometeia, Italy*); **Fabio Menozzi** (*Prometeia, Italy*); **Pietro Rossi** (*University of Bologna, Italy*); **Riccardo Tedeschi** (*Prometeia, Italy*)

Abstract: *This paper presents a model for a coherent simulation of rating transitions and credit-spread term structures based on a generator framework, building on and refining the work of Lando, Arvanitis et al and Dubrana. The paper provides a clear formulation of the transition matrix evolution process, which allows for cumulative matrices, and a pragmatic calibration procedure based on a time-dependent Cox-Ingersoll-Ross specification yielding market-consistent bond pricing. It also presents two possible applications. In the first, the actualised distribution of the future value of a coupon bond portfolio is provided, considering both defaults and rating migration; the second focuses on the future portfolio composition in terms of rating classes.*

ORAL ID 10 (02)

Joint Learning of Credit Ratings and Term Structures

Joshua Hayes (*EPFL, Switzerland*); **Damir Filipović** (*EPFL, Switzerland*)

Abstract: *We present a data-driven framework that jointly infers market-implied credit ratings and representative term structures of credit risk from sparse and noisy market prices. The method combines probabilistic classification into ordered classes and class-level term-structure estimation in a reproducing kernel Hilbert space setting. Class-membership probabilities and term structures are mutually dependent, and an alternating optimisation algorithm links classification and estimation steps, both driven by pricing errors and optional additional firm/instrument characteristics. Economically motivated regularisation encourages smoothness across the maturity domain and transfer learning across classes. The approach extends naturally to alternative features and valuation assumptions.*

ORAL ID 386 (03)

Assessing the presence of the physical risk with a structural credit risk model

Elia Smaniotto (*Università Cattolica del Sacro Cuore, Italy*); **Alessandro Sbuelz** (*Università Cattolica del Sacro Cuore, Italy*); **Davide Radi** (*Università Cattolica del Sacro Cuore, Italy*); **Andrea Tarelli** (*Università Cattolica del Sacro Cuore, Italy*)

Abstract: *The rising frequency of climate-related disasters has fostered the need for pricing models that incorporate factors explicitly aimed at modeling physical risk. We develop a structural credit-risk model to price Credit Default Swaps (CDS), in which both firm asset value and the arrival rate of climate-event-related jumps are stochastic. The pricing approach relies on Laplace transforms and an approximation of the two-dimensional problem to derive semi-closed-form CDS pricing formulas. To study cross-sectional implications, we estimate the model using sequential Monte Carlo methods applied to CDS time series data for a panel of U.S. firms.*

ORAL ID 387 (04)

Filtering Credit Risk with Stochastic Discontinuities

Felix Barrez Tambe Ndonfack (*University of Freiburg, Germany*)

Abstract: *We develop a structural credit risk model where firm value experiences predictable jump times (scheduled events) under incomplete information. A novel Kushner-Stratonovich filtering equation with atomic updates yields Bayesian beliefs and a hybrid default intensity. This framework also delivers local risk-minimizing hedging strategies for corporate claims, accounting for discontinuous information flows. Numerical implementation via particle filtering generates signature empirical patterns: sawtooth-shaped credit spreads and default-risk clustering at announcements. The model structurally explains event-driven short-term spread dynamics and provides a unified approach for pricing and hedging under informed, predictable jumps.*

Term Structures, Forecasting and Financial Dynamics - Aula Q

ORAL ID 380 (01)

Dynamically Consistent Analysis of Realized Covariations in Term Structure Models

Dennis Schroers (*University of Bonn, Germany*)

Abstract: *We show how to analyze the covariation of bond prices nonparametrically and robustly, staying consistent with a general no-arbitrage setting. This is, in particular, motivated by the problem of identifying the number of statistically relevant factors in the bond market under minimal conditions. We apply our method in an empirical study, which suggests that a high number of factors is needed to describe the term structure evolution and that the term structure of volatility varies over time.*

ORAL ID 508 (02)

Re(Visiting) Time Series Foundation Models in Finance

Eghbal Rahimikia (*Manchester University, United Kingdom*); **Hao Ni** (*University College London, United Kingdom*); **Weiguan Wang** (*Shanghai University of Finance and Economics, China*)

Abstract: *Financial time series forecasting is central to trading, portfolio optimization, and risk management, yet it remains challenging due to noisy, non-stationary, and heterogeneous data. Advances in time series foundation models (TSFMs), inspired by large language models, offer a new paradigm for learning temporal representations from datasets. Using a large-scale dataset of daily excess returns, we evaluate zero-shot inference, fine-tuning, and pre-training from scratch against benchmark models. We find that off-the-shelf pre-trained TSFMs perform poorly, whereas models pre-trained from scratch on financial data achieve forecasting improvements. Increasing the dataset size, incorporating synthetic data augmentation, and applying hyperparameter tuning enhance performance.*

ORAL ID 115 (03)

A PDV Extension of the FMM for Long-Term Simulations

Laura Bonisoli (*Università degli studi di Verona, Italy*); **Alessandro Gnoatto** (*Università degli studi di Verona, Italy*); **Cosimo Munari** (*Università degli studi di Verona, Italy*)

Abstract: *Standard specifications of the Forward Market Model (FMM) may lead to unreasonable behavior when we simulate over horizons extending several decades as typically used for the evaluation of long-term insurance liabilities. We propose an extension of the FMM in which the volatility of the forward rates is defined as the product of a local volatility component and a path-dependent factor evolving according to the 4-Factor Markovian Path-Dependent Volatility (PDV) model introduced by Guyon and Lekeufack (2023). The resulting PDV-FMM preserves the arbitrage-free structure of the FMM while leading to more realistic long-term dynamics.*

ORAL ID 272 (04)

Options Implied Pricing Measure Extraction via Optimal Transport

Mauricio Junca (*Universidad de los Andes, Colombia*); **Sergio Arango** (*Carnegie Mellon University, United States*)

Abstract: *We propose a novel model-free method for risk-neutral measure extraction from observed option prices. The method finds the optimal transport map between the pricing measure and an arbitrary reference measure through the semidual formulation of their Wasserstein Distance. The final formulation of the problem that allows the extraction of the measure is a convex quadratic minimization problem on the simplex. Simulations results show stronger results than the Breeden–Litzenberger method.*

Stochastic Analysis - Aula H

ORAL ID 193 (01)

Cutoff phenomena for stochastic Volterra processes in the large initial condition regime

Mohamed Ben Alaya (*University of Rouen Normandy, France*); **Ole Cañadas** (*Dublin City University, Ireland*); **Martin Friesen** (*Dublin City University, Ireland*)

Abstract: *Understanding convergence to equilibrium is central to stochastic modelling in finance and to the efficiency of simulation methods. While existing results typically provide only coarse convergence rates, many models exhibit a sharp transition to equilibrium at a specific time scale, known as the cutoff phenomenon. This talk presents a general framework for studying cutoff behaviour in affine Volterra processes, a class of path-dependent models that gained recent attention in the modelling of rough volatility. The results extend previous work beyond Markovian dynamics and have implications for Markov chain Monte Carlo methods by providing sharp insight into mixing times.*

ORAL ID 663 (02)

Stratified Regime-Switching Copula Diffusions

Leonardo Marconi (*University of Bologna, Italy*)

Abstract: *We introduce a stratified non-planar tree state space representation for one parameter Archimedean copulas and, in this novel ambient space, devise a stochastic process framework for hierarchical dependence models in which the dependence structure evolves jointly with continuous copula parameters. As a running example, we focus on nested Clayton copulas, but the construction is formulated at a level that isolates the geometric and probabilistic mechanisms from the specific copula family. The resulting processes are called regime-switching copula diffusions.*

ORAL ID 461 (03)

From Particles to Mean-Field to Quantum Systems: Operator-Valued Non-Commutative Probability Methods for the Propagation of Chaos

Joshué Helí Ricalde Guerrero (*ETH Zürich, Department of Mathematics, Switzerland*); **Dylan Possamaï** (*ETH Zurich, Switzerland*)

Abstract: *On one hand, the theory of Mean-Field Games studies the behavior of large interacting particle systems in which individual influences weaken as the population grows. On the other, Operator-valued Free Probability investigates the asymptotic behavior of ensembles of random block-matrix models in the large-dimension limit. Both frameworks are motivated by physics and both share a common goal: understanding emergent collective phenomena from complex microscopic interactions. In this talk, we propose a framework that combines these perspectives, using non-commutative operator-valued stochastic analysis to study particle systems with many participants. This is joint work with Prof. Dr. Dylan Possamaï.*

Hedging - Aula I

ORAL ID 47 (01)

Deep Hedging with Options Using the Implied Volatility Surface

Pascal François (*HEC Montréal, Canada*); **Geneviève Gauthier** (*HEC Montréal, Canada*); **Frédéric Godin** (*Concordia University, Canada*); **Carlos Octavio Perez Mendoza** (*Concordia University, Canada*)

Abstract: *We propose a deep hedging framework for index option portfolios, grounded in a realistic market simulator that captures the joint dynamics of S&P 500 returns and the full implied volatility surface. Our approach integrates surface-informed decisions with multiple hedging instruments and explicitly accounts for transaction costs. The hedging strategy also considers the variance risk premium embedded in the hedging instruments, enabling more informed and adaptive risk management. Tested on a historical out-of-sample set of straddles from 2020 to 2023, our method consistently outperforms traditional delta-gamma hedging strategies across a range of market conditions.*

ORAL ID 398 (02)

Robust Static Hedging of path-dependent options using Martingale Optimal Transport

Purba Banerjee (*Indian Institute of Science, India*); **Srikanth Iyer** (*Indian Institute of Science, India*); **Shashi Jain** (*Indian Institute of Science, India*)

Abstract: *We consider an investor who wishes to hedge a path-dependent option with maturity$T$using a static hedging portfolio comprising cash, the underlying, and vanilla put/call options with a shorter maturityt_1. We propose a model-free approach to construct such a portfolio, which is inspired by theprimal-dualMartingale Optimal Transport (MOT) problem, pioneered by Beiglböck (2013). Contrary to the approach in Beiglböck (2013), our robust hedging problem is an optimization problem that determines a portfolio minimizing the expected worst-case hedging error att$_1$. We present numerical results on hedging performance and provide theoretical bounds on the hedging error at$T$.*

ORAL ID 220 (03)

Semi-static variance optimal hedging of multi-asset derivatives under affine stochastic covariance models

Konstantinos Chatziandreou (*University of Amsterdam, Netherlands*); **Sven Karbach** (*University of Amsterdam, Netherlands*)

Abstract: *We develop semi-static variance-optimal hedging strategies for multi-asset contingent claims in multivariate stochastic covariance models. These strategies combine continuous trading in the underlying assets with static positions in a set of auxiliary instruments. Using a multivariate Galtchouk-Kunita–Watanabe (GKW) decomposition, we demonstrate that the semi-static variance-optimal hedging problem naturally decouples into an inner dynamic quadratic hedging problem and an outer optimization. For affine and linear–quadratic stochastic covariance models, we obtain semi-closed-form expressions for optimal hedge ratios and prices. Applications to a range of exotic multi-asset derivatives illustrate the tractability and interpretability of the proposed framework.*

ORAL ID 129 (04)

Optimal strategy and deep hedging for share repurchase programs

Stefano Corti (*Politecnico di Milano, Italy*); **Roberto Daluiso** (*Intesa Sanpaolo, Italy*); **Andrea Pallavicini** (*Intesa Sanpaolo, Italy*)

Abstract: *Companies often use investment banks to execute rapid share buybacks. However, hedging these programs is challenging due to product complexity and regulatory constraints that render traditional Greek-based hedging infeasible. We propose a machine-learning framework that optimizes buyback execution by accounting for the bank's actual trading capabilities. By unifying execution and hedging, this approach yields realistic, high-performance policies. Furthermore, we apply indifference pricing to determine the discount offered to clients, using risk measures as objective functions. This framework provides a feasible pricing and hedging strategy that accurately captures the bank's operational performance.*

Empirical Asset Pricing and Market Sentiment - Aula L

ORAL ID 223 (01)

Understanding climate risk in Europe: Are transition and physical risk priced in equity and fixed-income markets?

Nicola Bartolini (*University of Bologna, Italy*); **Silvia Romagnoli** (*Università di Bologna, Italy*); **Amia Santini** (*Università di Bologna, Italy*)

Abstract: *This study analyzes how climate-related physical and transition risks affect European equity and fixed-income markets. While stock returns are largely unaffected, bond z-spreads show significant sensitivity to both risk types. Physical risk tends to favor green bonds and penalize traditional ones. Transition risk proxies capture different information, indicating that credit default spreads price broader transition risks beyond carbon emissions.*

ORAL ID 61 (02)

Memory Shapes Reaction to Extreme Returns in Stock Sale Decisions

Vicky Henderson (*University of Warwick, United Kingdom*); **Giovanni Burro** (*Binghamton University, United States*); **Julia Brettschneider** (*University of Warwick, United Kingdom*)

Abstract: *We provide empirical evidence on how memory shapes the propensity for an investor to realize the sale of stocks in their portfolio after observing extreme stock and market returns. Investors are more likely to sell stocks with a large return on the previous day. We observe that investor reactions to such extreme events, or cues, are significantly affected by their own past realized returns. Eg. Those with lower worst past realized returns tend to react more to extreme negative stock (or market) returns. Memory effects are stronger for more attentive and sophisticated investors and demonstrate a positive memory bias.*

ORAL ID 105 (03)

Predicting Cryptocurrency Returns with Multi-Agent LLM Stress Scores

Seungju Lee (*Seoul National University, Korea, Republic of*); **Jaewook Lee** (*Seoul National University, Korea, Republic of*)

Abstract: *We propose a multi-agent framework based on large language models (LLMs) to predict cryptocurrency returns. Five specialized agents process technical indicators, investor attention, news sentiment, on-chain activity, and market risk to produce daily stress scores, calibrated using walk-forward feedback. Aggregating agent outputs via the maximum stress score captures episodes of extreme pessimism. In predictive regressions, elevated stress is significantly associated with higher next-day returns, consistent with a contrarian reversal mechanism. Out-of-sample tests show that LLM-based stress scores outperform standard benchmarks. Predictive strength varies across assets, with stronger effects for less efficient cryptocurrencies.*

ORAL ID 39 (04)

From risk-on to risk-off: The role of risk and uncertainty in shaping market sentiment

Cathy Goldberg (*University of San Francisco, United States*); **Robert Mefford** (*University of San Francisco, United States*)

Abstract: *Recent observations in asset market pricing reveal anomalies in the relationship between return and risk. This paper explores the potential role of uncertainty as a missing factor that could clarify this relationship. Unlike risk, which is quantifiable, uncertainty is often perceived as unmeasurable, making its effects on market behavior challenging to identify. To address this, we use the VVIX index as a proxy for uncertainty to analyze U.S. equity returns from 2007 to 2022. Our findings indicate that both risk and uncertainty jointly influence market sentiment and equity returns.*

Affine Models, Volatility and Asset Valuation - Aula M

ORAL ID 316 (01)

Joint Calibration of Affine Jump-Diffusion Models to S&P 500 and VIX Option Data

Andrea Mazzoran (*University of Freiburg, Germany*); **Eva Lütkebohmert** (*University of Freiburg, Germany*); **Riccardo Brignone** (*University of Pavia, Italy*)

Abstract: *We develop a joint calibration framework for affine jump-diffusion models to options' data on both the S&P 500 and the VIX index. Building on recent results for time-changed Lévy processes, we revisit the representation of the VIX in terms of higher-order risk-neutral cumulants and extend these results to affine diffusion and jump-diffusion models, including the Heston and Bates specifications. Using joint characteristic functions and associated Riccati equations, we derive tractable expressions for the forward VIX squared and propose a joint calibration strategy that leverages information from both equity and volatility derivatives.*

ORAL ID 309 (02)

Polynomial Path-Dependent Volatility models

Fabio Baschetti (*University of Verona, Italy*); **Guido Gazzani** (*University of Verona, Italy*); **Julien Guyon** (*Ecole des Ponts ParisTech - CERMICS, France*)

Abstract: *We bridge the fine structure of polynomial processes to the realm of path-dependent volatility (PDV) models. The result is a rich class of models that exhibits excellent performance under the empirical measure and jointly fits SPX and VIX market data. Calibration enjoys semi-closed evaluation of the VIX via the moment formula. We prove well-posedness of the underlying SDE and derive conditions for positivity of the variance process. A forward variance specification of the model is also derived based on the theory of deterministic integral Volterra equations and resolvents of the second type.* [*Joint work with G. Gazzani and J. Guyon*]

ORAL ID 313 (03)

Wealth dynamics in a multi-aggregate closed monetary system

Adamaria Perrotta (*University College Dublin, Ireland*); **Andrea Monaco** (*University College Dublin, Ireland*); **Matteo Ghio** (*New Line Ricerche di Mercato, Italy*)

Abstract: *In this work we examine the statistical properties of a closed monetary economy with multi-aggregates interactions. Building upon Yakovenko's single-agent monetary model (Dragulescu and Yakovenko, 2000), we investigate the joint equilibrium distribution of aggregate size and wealth. By comparing theoretical and simulated data, we validate our findings and investigate the influence of both micro dynamics and macro characteristics of the system on the distribution. Additionally, we analyse the system's convergence towards equilibrium under various conditions. Our laboratory model may offer valuable insights into macroeconomic phenomena allowing to reproduce typical wealth distribution features observed in real economy.*

ORAL ID 230 (04)

No-Arbitrage Valuation of Residential Real Estate: Evidence from Rent-to-Own Contracts

Yildiray Yildirim (*Baruch college, United States*); **Robert Jarrow** (*Cornell University, United States*)

Abstract: *We propose a no-arbitrage valuation framework for illiquid residential real estate that complements hedonic and machine-learning automated valuation models by providing a consistent pricing kernel for claims written on housing. We decompose each property's value into a component spanned by a traded residential REIT index and the default-free term structure, priced under a risk-neutral measure, and a residual idiosyncratic component valued under the physical measure. We calibrate the model using 674,629 Georgia MLS transactions from 2007 to 2019 and validate it on 926 homes acquired by Home Partners of America.*

Commodity and Volatility Models - Aula Filopanti

ORAL ID 64 (01)

Revisiting the Gibson-Schwartz and Schwartz-Smith Commodity Models

Lorenz Schneider (*EMLYON Business School, France*); **Pierre Six** (*NEOMA Business School, France*); **Bertrand Tavin** (*EMLYON Business School, France*)

Abstract: *We extend the popular Gibson & Schwartz (1990) and Schwartz & Smith (2000) two-factor models for the spot price of a commodity to include stochastic volatility and correlation. This generalization is based on the Wishart variance-covariance matrix process. The original models are known to fit the term-structure of implied volatility in futures and options markets very well. However, the extended models are also able to match volatility smiles observed in these markets. Introducing time-varying correlation via the Wishart process allows us to study its empirical behaviour in commodity markets through the use of filtering techniques.*

ORAL ID 274 (02)

Model calibration with no-arbitrage constraints on the option prices and on the implied volatility

Lorenzo Lombardi (*University of Salerno, Italy*); **Rosaria Cerrone** (*University of Salerno, Italy*); **Guido Germano** (*University College London, United Kingdom*)

Abstract: *The performance of the calibration of stochastic volatility models is improved by static no-arbitrage constraints on call and put prices or on the implied volatility both in the choice of the initial guess and the optimisation, quickly finding with a local optimiser what is likely the global minimum, as shown by numerical tests on the Heston and double Heston models. The initial guess improves with preliminary fits of the at-the-money variance, skew and curvature, although this requires specific expressions for each model. We discuss details of the solver configuration (optimisation algorithm, loss functions, elastic-net regularisation, etc.) and provide open-source code.*

ORAL ID 428 (03)

Rough volatility dynamics in commodity markets

Roberto Daluiso (*Intesa Sanpaolo, Italy*); **Héctor Folgar Cameán** (*Department of Mathematics and CITIC, Universidade da Coruña, Spain*); **Andrea Pallavicini** (*Intesa Sanpaolo, Italy*); **Carlos Vázquez** (*Department of Mathematics and CITIC, Universidade da Coruña, Spain*)

Abstract: *We develop a general rough volatility model for commodities that provides an automatic calibration of the initial term structure of the futures prices and an appropriate treatment of the Samuelson effect. After the theoretical analysis of this general model, we focus on the rBergomi and rHeston models and their calibration to market data of vanilla futures options on WTI Crude Oil, the roughness of whose volatility we also support by a historical analysis. The numerical results illustrate the performance of the proposed rough volatility models for commodities pricing.*

ORAL ID 485 (04)

Implied volatility expansions in forward variance models for VIX options

Ying Liao (*University of Glasgow, United Kingdom*); **Ankush Agarwal** (*University of Western Ontario, Canada*); **Florian Bourgey** (*Bloomberg, United States*)

Abstract: *We develop closed-form approximations for the implied volatility of VIX options within the class of forward variance models. Our approach builds on weak-approximation techniques for VIX option prices and yields explicit implied volatility expansions with computable correction terms. The resulting formulas enable fast and accurate calibration without requiring numerical root-finding. We illustrate the performance of the proposed approximations in both standard and rough Bergomi-type models, as well as in mixed specifications, and demonstrate their accuracy through numerical experiments.*

Martingale Optimal Transport and friends: new frontiers, numerics and applications - Aula A

Organized by: **Jan Obloj** and **Gudmund Pammer**

MINI-SYMPOSIUM (ID 298): ID 624 (01)

The Martingale Sinkhorn Algorithm

Manuel Hasenbichler (*Graz University of Technology, Austria*); **Benjamin Joseph** (*University of Oxford, United Kingdom*); **Gregoire Loeper** (*BNP ParisBas, France*); **Jan Obloj** (*University of Oxford, United Kingdom*); **Gudmund Pammer** (*TU Graz, Austria*)

Abstract: *We develop a numerical method for the martingale Benamou–Brenier problem, which seeks a martingale interpolating two prescribed marginals which is closest to the Brownian motion. We introduce an iterative scheme, a martingale analogue of the celebrated Sinkhorn algorithm, and prove its convergence in arbitrary dimension under minimal assumptions. The proof relies on a strict descent property for the dual value of the martingale Benamou–Brenier problem. While the descent property admits a direct verification in the case of compactly supported marginals, obtaining uniform control on the iterates without assuming compact support is substantially more delicate and constitutes the main technical challenge.*

MINI-SYMPOSIUM (ID 298): ID 715 (02)

From entropic transport to martingale transport, and applications to model calibration

Gregoire Loeper (*BNP ParisBas, France*); **Benjamin Joseph** (*University of Oxford, United Kingdom*); **Manuel Hasenbichler** (*Graz University of Technology, Austria*); **Jan Obloj** (*University of Oxford, United Kingdom*); **Gudmund Pammer** (*TU Graz, Austria*)

Abstract: *We propose a discrete time formulation of the semi martingale optimal transport problem based on multi-marginal entropic transport. This approach offers a new way to formulate and solve numerically the calibration problem proposed by Guo, Loeper, Wang, 2022, using a multi-marginal extension of Sinkhorn algorithm. In the limit when the time step goes to zero we recover a semi-martingale process, solution to a semi-martingale optimal transport problem, with a cost function involving the so-called specific entropy.*

MINI-SYMPOSIUM (ID 298): ID 600 (03)

Regularity of the Wasserstein projections in the convex order

Benjamin Jourdain (*Ecole des Ponts ParisTech - CERMICS, France*); **Aurélien Alfonsi** (*Ecole des Ponts ParisTech - CERMICS, France*)

Abstract: *We show continuity of both Wasserstein projections in the convex order when they are unique. We also check that, in arbitrary dimension* d*, the quadratic Wasserstein projection of a probability measure* μ *on the set of probability measures dominated by* ν *in the convex order is non-expansive in* μ *and Hölder continuous with exponent 1/2 in* ν*. We finally make the quadratic Wasserstein projections explicit when* μ *and* ν *are Gaussian.*

MINI-SYMPOSIUM (ID 298): ID 636 (04)

Generative Transfer for Entropic Optimal Transport with Unknown Costs

Antoine Debouchage (*University Evry Paris-Saclay, France*); **Xiaozhen Wang** (*Université Paris Dauphine, France*); **Zhenjie Ren** (*Université Evry Paris-Saclay, France*); **François Buet-Golfouse** (*Barclays, United Kingdom*)

Abstract: *This paper addresses the practical challenge in Entropic Optimal Transport (EOT) where the underlying ground cost function is typically latent and unobserved. Rather than assuming a fixed geometric cost, we adopt a data-driven approach where a shared cost is revealed only through samples from a reference optimal coupling. We propose a generative transfer framework employing an iterative path-wise tilting algorithm to recover optimal couplings for new marginals. This approach evolves the coupling along a transport path, effectively moving mass beyond the reference support. By integrating this dynamics with Conditional Flow Matching, we produce a practical sampler for generating paired data.*

Rough, pathwise and mean-field analysis in finance - Part 1 - Aula G

Organized by: **Anna Kwossek** and **Paul Hager**

MINI-SYMPOSIUM (ID 102): ID 754 (01)

Rough PDEs for Local Stochastic Volatility Models

Peter Bank (*Technische Universitat Berlin, Germany*); **Christian Bayer** (*WIAS Berlin, Germany*); **Peter K. Friz** (*Technische Universitat Berlin, Germany*); **Luca Pelizzari** (*University of Vienna, Austria*)

Abstract: *In this work, we introduce a novel pricing methodology in general, possibly non-Markovian local stochastic volatility (LSV) models. We observe that by conditioning the LSV dynamics on the Brownian motion that drives the volatility, one obtains a time-inhomogeneous Markov process. We describe how to precisely understand the conditional LSV dynamics and reveal their Markovian nature. The latter allows us to connect the conditional dynamics to so-called rough partial differential equations (RPDEs), through a Feynman-Kac type of formula. We can compute conditional European option prices by solving the corresponding linear RPDEs, and then average over samples to find unconditional prices.*

MINI-SYMPOSIUM (ID 102): ID 665 (02)

Rough differential equations for volatility

Ofelia Bonesini (*London School of Economics and Political Sciences, United Kingdom*); **Emilio Rossi Ferrucci** (*University of Oxford, United Kingdom*); **Ioannis Gasteratos** (*TU Berlin, Germany*); **Jack Jacquier** (*Imperial College London, United Kingdom*)

Abstract: *We introduce a canonical way of performing the joint lift of a Brownian motion and a low-regularity adapted stochastic rough path. We use this to model rough volatility with the versatile toolkit of rough differential equations (RDEs), namely by taking the price and volatility processes to be the solution to a single RDE. We establish a lead-lag approximation theory for the rough path in the correlated case. Continuity of the solution map transforms it into a numerical scheme for RDEs. We numerically test this framework and use it to calibrate a simple new rough volatility model to market data.*

MINI-SYMPOSIUM (ID 102): ID 758 (03)

Duality Methods for Stochastic Control with Random Coefficients via Rough HJB Equations

Peter Bank (*Technische Universitat Berlin, Germany*); **Janns Dause** (*Technische Universitat Berlin, Germany*); **Filippo De Feo** (*Technische Universitat Berlin, Italy*); **Peter K. Friz** (*Technische Universitat Berlin, Germany*)

Abstract: *We consider a stochastic control problem with controlled doubly-stochastic dynamics driven by two independent noises B and W and random cost functionals, where all coefficients depend progressively on the noise W. In particular the resulting stochastic control problem is non-Markovian and thus not treatable by classical methodology. However by methods from BS(P)DE-theory, we are able to relate this stochastic control problem to a penalized version of the original control problem, where W may now be treated as a 'frozen' i.e. deterministic (but irregular) path. Most importantly this 'dual problem' is now Markovian and may thus be treated by classical methods.*

MINI-SYMPOSIUM (ID 102): ID 545 (04)

Rough SDEs and Robust Filtering for Jump-Diffusions

Andrew Allan (*Durham University, United Kingdom*); **Jost Pieper** (*Durham University, United Kingdom*); **Josef Teichmann** (*ETH Zurich, Switzerland*)

Abstract: *Rough analysis provides a theory for nonlinear systems driven by highly oscillatory (deterministic) signals, which is inherently distinct from that of classical stochastic calculus. The introduction of the stochastic sewing lemma has paved the way for a unified theory which can efficiently handle hybrid systems driven by both rough and stochastic noise. We will discuss how this can be done in a general setting with jump discontinuities in both sources of noise. As an application, we will then investigate the existence of a robust representation of the conditional distribution in a stochastic filtering model for multidimensional correlated jump-diffusions.*

Memory in Quantitative Finance - Part 2 - Aula B

Organized by: **Eduardo Abi Jaber**

MINI-SYMPOSIUM (ID 40): ID 691 (01)

Functional Expansions and Path Dependent Options

Bruno Dupire (*Bloomberg, United States*)

Abstract: *The classical Taylor expansion is obtained by iterating the fundamental theorem of calculus. We apply the same principle to the functional Stratonovich formula from the functional Itô calculus to obtain a functional Taylor expansion. It is a sum over the words of the functional derivative with respect to this word at the origin times the signature (iterated integral of the path) associated to the word. When applied to the intrinsic value of a path dependent option, it gives a simple representation that can be iterated, leading to the Intrinsic Expansion of a functional. This is joint work with Valentin Tissot-Daguette*

MINI-SYMPOSIUM (ID 40): ID 713 (02)

Dynamic universal approximation and modeling with signature SDEs

Tomás Carrondo (*University of Vienna, Austria*); **Christa Cuchiero** (*University of Vienna, Austria*); **Paul Hager** (*University of Vienna, Austria*); **Sara Svaluto-Ferro** (*University of Verona, Italy*)

Abstract: *Motivated by signature-based generative models in finance, we analyze signature stochastic differential equations (SDEs), whose coefficients depend on the path signature of the solution. While classical approximation results are static in nature, we establish a dynamic universal approximation theorem at the level of SDE solutions. We show that generic classes of path-dependent SDEs can be approximated by suitable signature SDEs in expected Hölder norms. To achieve this, we develop a dedicated well-posedness theory for signature SDEs based on novel existence and uniqueness results for path-dependent SDEs whose coefficients depend on the Stratonovich lift of the solution path.*

MINI-SYMPOSIUM (ID 40): ID 714 (03)

Signature-inspired advances in non-Markovian optimal control: open-loop, closed-loop, analytic, kernel-based, and dual

Paul Peter Hager (*University of Vienna, Austria*)

Abstract: *Stochastic control for rough signals and path-dependent objectives is reshaping areas of mathematical finance, driven by non-Markovian dynamics, path-dependent payoffs, and model-free data-driven pricing. Numerically, the most natural route is to "lift" path dependence to a Markovian state approximation. Among such lifts, path signatures provide a canonical, model-agnostic choice, generated by the universal linear controlled system defining the signature. This talk presents signature-inspired advances in non-Markovian control: open- and closed-loop parametrizations via generalized universal systems, an analytic-coefficient regime yielding infinite-dimensional HJB–Riccati structure, extensions incorporating Volterra kernels, and dual formulations where signature expansions produce pathwise penalties.*

MINI-SYMPOSIUM (ID 40): ID 675 (04)

Optimal Consumption in non-Markovian Stochastic Factor Models

Eduardo Abi Jaber (*Ecole Polytechnique, France*); **Florian Gutekunst** (*University of Warwick, United Kingdom*); **Martin Herdegen** (*Universität Stuttgart, Germany*); **David Hobson** (*University of Warwick, United Kingdom*)

Abstract: *We study optimal investment and consumption over the infinite horizon under power utility in a non-Markovian incomplete stochastic factor model such as the (hyper-)rough Heston model. Using the method of sub- and supersolutions, we prove the existence of a solution to an associated infinite horizon BSDE, obtain tight bounds on the optimal consumption rate, and prove a verification theorem. We apply our theory to the (hyper-)rough Heston model. Based on joint work with Eduardo Abi Jaber, Martin Herdegen, and David Hobson.*

Topics in Contemporary Stochastic Control of Interacting Particle Systems - Aula C

Organized by: **Camilo Hernández** and **Fabrice Djete**

MINI-SYMPOSIUM (ID 54): ID 542 (01)

Variance strikes back: sub-game–perfect Nash equilibria in time-inconsistent N-player games, and their mean-field sequel

Dylan Possamaï (*ETH Zurich, Switzerland*); **Chiara Rossato** (*ETH Zurich, Switzerland*)

Abstract: *We investigate a time-inconsistent finite-player game, where each player's objective functional depends non-linearly on the expected value of the state process. Since the Bellman optimality principle no longer applies, we adopt a two-layer game-theoretic framework and seek sub-game–perfect Nash equilibria both at the intra-personal level and at the inter-personal level. We first characterise sub-game–perfect Nash equilibria and the value processes of all players through a system of BSDEs. We then analyse the mean-field counterpart, described by a system of McKean-Vlasov BSDEs. Building on this, we prove the convergence of sub-game–perfect Nash equilibria and their value processes to their mean-field counterparts.*

MINI-SYMPOSIUM (ID 54): ID 607 (02)

Quantitative propagation of chaos and fluctuation limits for non-exchangeable diffusions

Lane Chun Yeung (*Illinois Institute of Technology, United States*)

Abstract: *We study a system of interacting diffusions with heterogeneous pairwise interaction strengths, so the particle system is non-exchangeable. In the first part of the talk, we develop a quantitative, non-asymptotic approach to mean field approximation by proving sharp relative entropy bounds between the law of any subcollection of particles and a suitable product measure. In the second part, we address central limit theorems for fluctuations of the empirical measure around the McKean-Vlasov limit. We show that when the underlying weighted graph encoding the interaction strengths is sufficiently dense, the fluctuation limits coincide with those in the classical mean field framework.*

MINI-SYMPOSIUM (ID 54): ID 752 (03)

The convergence problem for ergodic mean field game

Ludovic Tangpi (*Princeton University, United States*)

Abstract: *We discuss ergodic N-player games and their mean field limits in a setting of controlled common noise and non-linear dynamics. Assuming that the game is displacement monotone, we derive a quantitative convergence result, which demonstrates that as the number of players increases, the openloop Nash equilibria in Markovian form of the N-player game converge to the MFE. Along the way, we also provide a general existence result for mean field equilibria. The work is based on a join work with Kaiwen Zhan.*

ORAL ID 417 (04)

Convergence for linear quadratic potential mean field games

Alekos Cecchin (*University of Padova, Italy*); **Jodi Dianetti** (*Department of Economics and Finance, University of Rome Tor Vergata, Italy*)

Abstract: *We study the limits of empirical means of open-loop Nash equilibria of linear-quadratic stochastic differential games as the number of players goes to infinity, under the key assumption of the corresponding mean field game to be potential. Via weak compactness arguments, the limit points are characterized as optimal trajectories of the related deterministic control problem, thus ruling out some of the mean field equilibria. In cases of multiple optimizers, we focus on examples to show that some symmetry of the data ensures that the sequence admits a random limit which is distributes uniformly among the minimizers of the potential.*

Learning in Dynamic Games: Theory, Algorithms and Applications - Part 1 - Aula D

Organized by: **Mathieu Laurière** and **Yufei Zhang**

MINI-SYMPOSIUM (ID 426): ID 544 (01)

Learning Distributed Equilibria in Linear-Quadratic Stochastic Differential Games: An alpha-Potential Approach

Philipp Plank (*Imperial College London, United Kingdom*); **Yufei Zhang** (*Imperial College London, United Kingdom*)

Abstract: *This talk analyzes independent policy-gradient learning in N-player linear-quadratic stochastic differential games. Each player employs a distributed policy that depends only on its own state and updates its policy independently by following the gradient of its own objective. We show that the game admits an α-potential structure, where α is determined by the degree of pairwise interaction asymmetry. We further establish global linear convergence of these methods to an approximate equilibrium, with suboptimality proportional to the degree of asymmetry. We also construct an affine distributed equilibrium beyond the mean field setting for both symmetric and asymmetric interactions.*

MINI-SYMPOSIUM (ID 426): ID 551 (02)

Learning Mean Field Games via Mean Field Actor Critic Flow

Mo Zhou (*University of California, Los Angeles, United States*); **Haosheng Zhou** (*University of California, Santa Barbara, United States*); **Ruimeng Hu** (*University of California, Santa Barbara, United States*)

Abstract: *We introduce the Mean-Field Actor-Critic (MFAC) flow, a continuous-time learning dynamics for solving mean-field games (MFGs), drawing ideas from reinforcement learning, generative modeling, and optimal transport. MFAC jointly evolves the actor, critic, and distribution through gradient-based updates, with the distribution governed by a novel Optimal Transport Geodesic Picard (OTGP) flow. The OTGP flow drives the distribution toward equilibrium along Wasserstein-2 geodesics. We analyze the MFAC flow using Lyapunov functionals and establish global exponential convergence under suitable time scales. The analysis highlights the coupled structure and offers guidelines for choosing learning rates. Numerical results support the theory and demonstrate the effectiveness.*

MINI-SYMPOSIUM (ID 426): ID 595 (03)

Deep learning algorithms for FBSDEs with jumps: Applications to a MFG model for smart grids

Clémence Alasseur (*Électricité de France (EDF), France*); **Zakaria Bensaid** (*Le Mans University, France*); **Roxana Dumitrescu** (*CREST, ENSAE, Institut Polytechnique de Paris, France*); **Xavier Warin** (*Électricité de France (EDF), France*)

Abstract: *In this paper, we introduce various machine learning solvers for (coupled) forward-backward systems of stochastic differential equations (FBSDEs) driven by a Brownian motion and a Poisson random measure. In particular, we show the efficiency of the deep-learning algorithms to solve a coupled multi-dimensional FBSDE system driven by a time-inhomogeneous jump process with stochastic intensity, which describes the Nash equilibria for a specific mean-field game (MFG) problem for which we also provide the complete theoretical resolution.*

MINI-SYMPOSIUM (ID 426): ID 626 (04)

Iterative Schemes for Markov Perfect Equilibria

Felix Hoefer (*Princeton University, United States*); **Mete Soner** (*Princeton University, United States*); **Mathieu Laurière** (*NYU Shanghai, China*); **Qinxin Yan** (*Princeton University, United States*)

Abstract: *We study Markov perfect equilibria in continuous-time stochastic games among finitely many players. In the finite-state space problems we consider, the corresponding Nash system becomes a nonlinear ordinary differential equation admitting a unique classical solution. Leveraging this uniqueness, we prove the convergence of both Picard and weighted Picard iterations, yielding efficient computational methods. Numerical experiments confirm the effectiveness of algorithms based on this approach.*

Advances in optimal control with applications in finance - Aula E

Organized by: **Xiang Yu** and **Zhou Zhou**

MINI-SYMPOSIUM (ID 88): ID 538 (01)

On the Well-Posedness of Extended HJB Equations for Time-Inconsistent Control Problems

Zhenhua Wang (*Shandong University, China*); **Zhenhua Wang** (*Shandong University, China*); **Xiang Yu** (*The Hong Kong Polytechnic University, Hong Kong*); **Jingjie Zhang** (*University of International Business and Economics, China*); **Zhou Zhou** (*University of Sydney, Australia*)

Abstract: *We develop a general framework for solving extended HJB equations in time-inconsistent control problems via an entropy-regularization approach. Since standard equilibrium strategies may fail to exist, we consider relaxed equilibria. By introducing a weighted entropy regularization, we establish the existence of equilibria for the regularized problem and prove global Hölder regularity of the associated value functions, which is essential for the subsequent verification argument. We then show, as the entropy parameter vanishes, the regularized equilibria converge to an equilibrium of the original control problem. This talk is based on joint work with Xiang Yu, Jingjie Zhang, and Zhou Zhou.*

MINI-SYMPOSIUM (ID 88): ID 539 (02)

Optimal Information Disclosure In A Stackelberg Game

Ruyi Liu (*University of New South Wales, Australia*); **Zhou Zhou** (*University of Sydney, Australia*)

Abstract: *We investigate a leader-follower game in which the leader hires the follower to complete a project with the presence of a random shock time. The shock time is observable by the leader, but not by the follower. The leader strategically discloses information about the shock time, while the follower chooses effort, which affects the project completion time. We characterize the leader's value and optimal information disclosure strategy. By expressing the leader's value as a function of the follower's utility and belief, we derive dynamic programming equations that characterize the leader's value and yield an* (ε-)*optimal strategy.*

MINI-SYMPOSIUM (ID 88): ID 629 (03)

Stackelberg stopping games

Jingjie Zhang (*University of International Business and Economics, China*); **Zhou Zhou** (*University of Sydney, Australia*)

Abstract: *We study a Stackelberg variant of the classical discrete-time Dynkin game. This leader–follower structure induces an optimal control problem for the leader and gives rise to intrinsic time-inconsistency. We clarify notions of precommitment and equilibrium strategies in the Stackelberg setting, and contrast them with the Nash equilibrium in the standard Dynkin game using a finite-horizon example. We analyzing these concepts in an infinite-horizon framework with time-homogeneous Markov chain taking values in a general Polish state space. We characterize the leader's value function under precommitment strategies and established existence of a regular randomized equilibrium strategy in an entropy-regularized Stackelberg stopping game.*

MINI-SYMPOSIUM (ID 88): ID 651 (04)

Mean-field games with rough common noise: the compactification approach

Erhan Bayraktar (*University of Michigan, United States*); **Xihao He** (*University of Michigan, United States*); **Xiang Yu** (*The Hong Kong Polytechnic University, Hong Kong*); **Fengyi Yuan** (*Chinese University of Hong Kong (Shenzhen), China*)

Abstract: *We study mean-field game (MFG) problems with rough common noise where the representative state dynamics is governed by a controlled rough stochastic differential equation driven by an idiosyncratic Brownian motion and a deterministic rough path noise affecting the whole population. Within this new framework, we introduce a canonical weak formulation based on relaxed controls and rough martingale problems. We prove the existence of a pathwise mean-field equilibrium in this context by developing new technical tools. Finally, we discuss the relationship between the pathwise problem and the classical MFG problem with randomized Brownian common noise.*

Stochastic Volterra models - Aula F

Organized by: **Sergio Pulido**

MINI-SYMPOSIUM (ID 101): ID 549 (01)

Weak error approximation for rough and Gaussian mean-reverting stochastic volatility models

Aurélien Alfonsi (*Ecole des Ponts ParisTech - CERMICS, France*)

Abstract: *For a class of stochastic models with Gaussian and rough mean-reverting volatility that embeds the genuine rough Stein-Stein model, we study the weak approximation rate when using a Euler type scheme with integrated kernels. Our first result is a weak convergence rate for the discretised rough Ornstein-Uhlenbeck process, that is essentially in* $\min(3\alpha - 1, 1)$*, where* $\frac{t^{\alpha-1}}{\Gamma(\alpha)}$ *is the fractional convolution kernel with* $\alpha \in (1/2, 1)$*. Then, our main result is to obtain the same convergence rate for the corresponding stochastic rough volatility model with polynomial test functions.*

MINI-SYMPOSIUM (ID 101): ID 572 (02)

Kolmogorov equations for stochastic Volterra processes with singular kernels

Alexandre Pannier (*Université Paris Cité - LPSM, France*); **Ioannis Gasteratos** (*TU Berlin, Germany*)

Abstract: *In this talk, I will present backward and forward Kolmogorov equations associated to a class of fully nonlinear Stochastic Volterra Equations with convolution kernels that are singular at the origin. This is achieved by lifting the solution to a carefully chosen Hilbert space and deriving an appropriate Itô formula. In the special case of singular power-law kernels, the backward equation is well-posed if either the noise is additive or if the Hurst exponent* $\mathrm{H}>1/4$*. We conclude with a few applications to option pricing.*

MINI-SYMPOSIUM (ID 101): ID 667 (03)

Explosions of stochastic Volterra equations

Sergio Pulido (*ENSIIE, France*); **Alessandro Bondi** (*Luiss University Rome, Italy*)

Abstract: *We present a Feller-type test for explosions of one-dimensional continuous stochastic Volterra processes of convolution type. We focus on dynamics driven by nonsingular kernels, which preserve the semimartingale property of the processes while incorporating memory effects through a path-dependent drift. For the Volterra square-root diffusion, also known as the Volterra CIR process, we provide a detailed discussion of the approximation of the singular fractional kernel by a sum of exponentials, a technique commonly used in the mathematical finance literature.*

MINI-SYMPOSIUM (ID 101): ID 690 (04)

Osgood-type criteria for stochastic Volterra equations with additive noise

Alessandro Bondi (*Luiss University Rome, Italy*); **Sergio Pulido** (*ENSIIE, France*)

Abstract: *In this presentation, I will discuss conditions for global existence of real-valued maximal solutions to one-dimensional stochastic Volterra equations (SVEs) of convolution type driven by additive noise. The focus will be on an Osgood-type criterion for explosion to infinity for a class of kernels that includes the fractional kernel. I will also investigate stability results for explosion times with respect to the kernels, including the case of an Euler-Maruyama approximation scheme.*

Machine Learning for Asset Pricing and Forecasting - Aula P

ORAL ID 36 (01)

Machine learning approach for asset pricing

Daisuke Yoshikawa (*Kansai University, Japan*)

Abstract: *Factor models are well established in organized markets, such as the stock market; i.e., stock returns may be represented as linear combinations of factors, such as the market return, HML, and SMB. However, it may be difficult to extend this logic to a more distorted market, such as the cryptocurrency market, due to the nonlinearity. In this study, we employ machine learning methods to capture the non-linear properties of asset prices, such as Logistic Regression, LightGBM, Random Forests, and Transformers. We aim to construct a benchmark for how we process the data, construct features, and determine the best model.*

ORAL ID 122 (02)

Beyond the Mean: A Probabilistic Linear Factor Model

Andrea Ruglioni (*EPFL, Switzerland*); **Damir Filipović** (*EPFL, Switzerland*)

Abstract: *We propose a bilinear Gaussian process framework that fuses the clarity of linear factor models with nonparametric flexibility. Moving beyond simple point forecasts, our approach targets the full predictive distribution of returns, deriving analytic higher-order moments directly from the model structure. To ensure tractability in large cross-sections, we develop a scalable structured variational inference procedure that explicitly preserves latent dependencies between characteristic-driven loadings and macro-driven factors. The result is a unified Bayesian framework that bridges economic theory and data-driven adaptation, providing rigorous uncertainty quantification and decision-ready outputs for risk management and portfolio construction.*

ORAL ID 148 (03)

What Drives Stock Return Predictability: Models, Data, or Market Regimes?

Yihe Qian (*The Hong Kong Polytechnic University, Hong Kong*); **Yang Zhang** (*University of Macau, Macao*)

Abstract: *We ask what drives stock returns, better models, richer data, or changing market regimes. We address this question using a panel of 5,175 stocks, with 758,649 stock-month observations, and 122 predictors spanning firm ratios, trading signals, and macro indicators. We compare 14 machine learning models and find Random Forest performs best on average, but predictability is largely regime- and data-driven: performance rises broadly in the most recent turbulent period and clusters by testing years in a train-year × test-year design. Signals are structured around valuation, liquidity, and price trends, with NFCI capturing macro-financial conditions. Simple forecast-based portfolios outperform S&P 500.*

ORAL ID 293 (04)

A structural-deep Bayesian framework for uncertainty-aware forecasting and macroeconomic shock modelling in financial markets

Energy Sonono (*North-West University, South Africa*); **Saratiel Musvoto** (*University of South Africa, South Africa*)

Abstract: *Financial markets are volatile, with stock returns driven by shifting interactions among firm fundamentals, market conditions, and macroeconomic forces. This study proposes a structural-deep Bayesian framework that integrates Bayesian Structural Time Series (BSTS) and Bayesian LSTM models for uncertainty-aware return forecasting. The BSTS component provides an interpretable macro-financial layer that captures time-varying effects, regime shifts, credible intervals, and shock attribution. The Bayesian LSTM captures nonlinear and path-dependent return dynamics from market, firm-level, and technical indicators. The framework is evaluated using historical equity and macro-financial data, including identified stress episodes.*

Term-Structure Models - Aula Q

ORAL ID 474 (01)

Data-driven Heath-Jarrow-Morton models

Christa Cuchiero (*University of Vienna, Austria*); **Claudio Fontana** (*University of Padova, France*); **Alessandro Gnoatto** (*Università degli studi di Verona, Italy*)

Abstract: *We develop a data-driven version of Heath-Jarrow-Morton models in the context of interest rate modeling. We consider models driven by a linear functional of the yield curve, such as a family of representative forward rates. The volatility is parameterized by a neural network, the parameters of which are learned by calibration to past market yield curves. This results in a data-driven arbitrage-free model for the prediction of yield curves. Our setup allows for the possibility of scheduled jumps, which can arise from monetary policy decisions. We illustrate our deep learning procedure by reconstructing and forecasting the Euro area yield curves.*

ORAL ID 182 (02)

Stochastic Short Rate Interpolation of Monetary Policy Decision Updates

Ali Movahhedrad (*Universtiy college London Department of Mathematics, United Kingdom*); **Andrea Macrina** (*Department of Mathematics, University College London, United Kingdom*); **David Skovmand** (*University of Copenhagen Department of Mathematics, Denmark*)

Abstract: *We develop a continuous-time interest rate term structure approach, where a central bank reviews the base-rate at pre-specified monetary policy meeting dates. The stochastic short-rate process is constructed by using randomised arcade processes, which interpolate between successive base-rate realisations and ensure exact matching at the policy meeting dates. Stochastic filtering that underlies the discount bond price process, treats the base-rate as a latent signal of which partial information is reflected by the short-rate dynamics. Within this framework, we derive semi-analytical expressions for discount bond prices, perform sensitivity analysis, and study the pricing of European-style options written on a discount bond.*

ORAL ID 464 (03)

Term Structure Shapes in the Hull-White Model with Svensson-Parameterized Initial Yield Curves

Felix Sachse (*Saarland University, Germany*)

Abstract: *The shape of the term structure is a fundamental economic indicator and it encodes important information on market preferences for short-term vs. long-term investments, on expectations of central bank decisions and on the general economic outlook. Using Tchebycheff systems and envelopes, we determine the attainable shapes of forward and yield curves in the Hull-White model, when the initial yield curve is Svensson-parameterized. We study their dynamic evolution and asymptotic behaviour.*

ORAL ID 84 (04)

Sensitivity of the Euro OIS Term Structure to ECB Policy Rate Surprises

Stefano Herzel (*University of Rome - Tor Vergata, Italy*); **Marco Nicolosi** (*University of Rome - La Sapienza, Italy*)

Abstract: *We analyze the sensitivity of the euro-area yield curve to revisions in market expectations of the ECB policy rate. Using changes in the maintenance-period forward OIS as a market-based measure of policy-rate surprises, we document that yield responses vary systematically across maturities. To interpret these patterns, we adopt a short-rate model with stochastic jumps occurring only at scheduled ECB meeting dates and derive closed-form expressions for the conditional sensitivity of yields to changes in the expected jump size. The model reproduces the cross-sectional shape and magnitude of observed sensitivities.*

Credit Risk/Credit Portfolios - Aula H

ORAL ID 19 (01)

Loss-given-default modeling by post-last passage time process

Masahiko Egami (*Kyoto University, Japan*); **Rusudan Kevkhishvili** (*Hokkaido University, Japan*)

Abstract: *This study proposes a stochastic model for loss-given-default (LGD) which provides the LGD distribution explicitly based on credit market and company-specifics. The model utilizes last passage time of a linear diffusion (representing firm value) to a certain threshold point, after which default occurs as a surprising event, leading to a hybrid model. We provide a computationally simple estimation procedure and real-world examples of estimated* entire *LGD distribution implied in CDS market. The analysis is further enriched by our additional mathematical contributions to occupancy time above a threshold point.*

ORAL ID 127 (02)

The Softmax of Default: Exact Pricing and Analytic Risk Attribution for First-to-Default Basket Swaps with Heterogeneous Recoveries

Pasquale Cirillo (*ZHAW School of Management and Law, Switzerland*)

Abstract: *First-to-Default Basket Swaps with name-specific recoveries are often Monte-Carlo priced, even under independent defaults, because the payoff depends on who defaults first. We give an exact, simulation-free pricing and attribution engine for separable exponential race intensities (Cirillo, 2026). The first-defaulter identity follows closed-form softmax weights and is independent of the first-default time, so the protection leg splits into severity (expected LGD of the winner) and timing (a first-default claim). We also generalize to common multiplicative frailty, preserving the same identity allocation, and demonstrate diagnostics on public data.*

ORAL ID 136 (03)

Option-implied asset volatility surfaces

Federico Maglione (*University of Florence, Italy*); **Laura Ballotta** (*Bayes Business School, United Kingdom*)

Abstract: *Asset volatility is a key determinant of firm value, yet its empirical properties remain poorly understood due to limited debt market data. We propose a novel approach to recover firm-level and market-wide asset volatility surfaces directly from equity option prices under alternative structural default models. By jointly matching equity and option prices, we estimate option-implied asset volatilities and study their relation to equity volatility dynamics. Our results highlight the role of leverage and default risk in shaping volatility surfaces and reveal substantial differences between short-maturity option-implied and long-maturity credit-implied asset volatilities.*

ORAL ID 359 (04)

Optimal collateralization levels in OTC-trading networks

Alexander Herbertsson (*University of Gothenburg, Sweden*)

Abstract: *We analyze optimal collateralization in exchangeable, non-cleared OTC trading networks, where collateral represents initial margin mitigating counterparty default losses. We model a homogeneous static credit portfolio of defaultable entities trading bilaterally with random exposures, and derive tractable analytical results for expected individual losses and the optimal collateral level as functions of model parameters. Exposures depend on defaults, capturing increased volatility during stress. We prove uniqueness and non-negativity conditions for the optimal collateralization level and obtain semi-closed-form solutions. Under constant exposure volatility, we derive explicit formulas linking optimal margin to default probabilities and pairwise default correlations. Numerical studies illustrate model behavior.*

Systemic Risk - Aula I

ORAL ID 20 (01)

Bond Pricing in Financial Networks

Dohyun Ahn (*The Chinese University of Hong Kong, Hong Kong*); **Agostino Capponi** (*Columbia University, United States*)

Abstract: *The valuation of bonds in highly interconnected financial networks poses a significant challenge due to interbank exposures. Standard simulation methods struggle to capture rare-yet-critical default events, while existing rare-event techniques fail to account for higher-order network effects and scale poorly as network size increases. We propose a novel Monte Carlo approach,* Bi-Level Importance Sampling with Splitting, *which addresses these limitations by characterizing an individual bank's default condition in a way that decouples it from the network's fixed-point dynamics. We demonstrate that the proposed method is both scalable and asymptotically optimal, and we validate its effectiveness through numerical studies.*

ORAL ID 203 (02)

Fair Control of Financial Networks via Reinforcement Learning

Nils Detering (*Heinrich Heine University Düsseldorf, Germany*); **Florian Grell** (*Heinrich Heine University Düsseldorf, Germany*); **Thilo Meyer-Brandis** (*Ludwigs Maximilian University Munich, Germany*)

Abstract: *We study a reinforcement learning framework for reducing systemic risk in financial networks under fairness and explainability constraints. The problem is motivated by lender-of-last-resort interventions, where institutions with identical attributes should be treated equally. Modeling the financial system as a network, we design policies using message-passing neural networks that enforce fairness by construction. We further derive a bound on the Lipschitz constant of the policy score function and empirically analyze the performance trade-off induced by regulatory fairness constraints on synthetic networks with Eisenberg–Noe-type contagion, extended by fire sales and default costs.*

ORAL ID 361 (03)

A Gibbs Sampler for Financial Network Models with multiple CCPs

Markus Karl (*LSE, United Kingdom*); **Luitgard Veraart** (*LSE, United Kingdom*)

Abstract: *We consider a network reconstruction problem for markets with multiple central counterparties (CCPs) that are subject to bilateral netting. We propose a Gibbs sampler to reconstruct bilateral cleared amounts from aggregate information. We prove theoretical properties of the Gibbs sampler. We apply it to compute default probabilities in a Cover-2 standard stress test in stylized networks to demonstrate its application to systemic risk assessment.*

ORAL ID 482 (04)

Assessing and Mitigating Systemic Cyber Risk in Financial Networks

Alexander Voß (*Leibniz Universität Hannover, Germany*); **Gregor Svindland** (*Leibniz Universität Hannover, Germany*); **Christoph Fricke** (*Deutsche Bundesbank, Germany*)

Abstract: *We introduce a macroprudential decision-making framework to support regulators in assessing systemic cyber risk in financial networks and implementing cyber risk mitigants. Utilizing systemic cyber risk stress tests, the framework evaluates different systemic tolerance objectives and the effectiveness of operational mitigants in diverse scenarios, including malware attacks and third-party provider outages. Advanced resilience assessments outperform threshold-based approaches in robustness. The results emphasize the need for regulators to incorporate broad scenario sets and sophisticated systemic tolerance objectives to design effective instruments for controlling cyber risks at the macroprudential level.*

Stochastic Dynamics, Control and Risk Models - Aula L

ORAL ID 279 (01)

Interacting particle systems on sparse W-random graphs

Carla Crucianelli (*Princeton University, United States*); **Ludovic Tangpi** (*Princeton University, United States*)

Abstract: *We consider an interacting particle system on a random graph and study its large population limit. When the sequence of interaction graphs converges to a graphon, we show convergence of the particle system to a system of uncountably many McKean-Vlasov type SDEs driven by a continuum of Brownian motions, namely a graphon SDE. We analize this system in a Fubini extension to retain joint measurability and essentially pairwise independence of the driving Brownian motions. The convergence result covers nonlinear interactions and various examples of sparse graphs. Moreover, we extend the results to unbounded graphons. Joint work with Ludovic Tangpi.*

ORAL ID 408 (02)

SELF-INSURANCE AND SELF-PROTECTION FOR GENERAL RISK MODELS VIA A BSDE APPROACH

Claudia Ceci (*Sapienza Università di Roma, Italy*)

Abstract: *We investigate an optimal prevention and insurance problem in a general risk setting, where a representative agent is exposed to potential losses. The agent adopts a strategy that combines self-protection, aimed at reducing the frequency of claims, and self-insurance, aimed at mitigating their severity. The problem, which consists in maximizing the expected exponential utility of terminal wealth, is formulated as a stochastic control problem and solved by means of BSDEs. Our approach, based on a general Bellman Optimality Principle does not require specification of the underlying filtration structure, making it applicable to a broad class of risk models.*

ORAL ID 452 (03)

Infinite-Horizon Optimal Control of Jump-Diffusion Models for Pollution-Dependent Disasters

Daria Sakhanda (*ETH Zürich, Department of Mathematics, Switzerland*); **Joshué Helí Ricalde Guerrero** (*ETH Zürich, Department of Mathematics, Switzerland*)

Abstract: *This paper develops a unified framework for stochastic growth models with environmental risk, in which rare but catastrophic shocks interact with capital accumulation and pollution. The analysis is based on a Poisson point process, yielding non-local Hamilton–Jacobi–Bellman equations with closed-form solutions and a composite state variable measuring exposure to rare shocks. Disaster risk is endogenized through pollution-dependent intensity and extended to state-dependent events of varying magnitude. The framework shows how environmental degradation amplifies macroeconomic vulnerability and strengthens abatement incentives. Technically, it delivers tractable jump-diffusion control problems whose HJB equation decomposes into capital and pollution components under a power-type value function.*

ORAL ID 431 (04)

A Schrödinger Bridge approach for the generation of OHLC financial data

Davide Zanni (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Stefano De Marco** (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Marius Chevallier** (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*)

Abstract: *We propose a generative modeling framework for financial OHLC data based on a Schrödinger bridge formulation on path space. By constraining the joint distribution of opening, high, low, and closing prices over a fixed time interval, we construct a stochastic process that minimally deviates from Brownian motion in an entropic sense. The resulting process admits a path-dependent optimal drift derived via functional Itô calculus. A data-driven approximation of the drift enables efficient generation of synthetic OHLC data, with numerical experiments illustrating applications to volatility estimation using the Garman–Klass estimator and out-of-sample validation on real financial datasets.*

Option Pricing with Levy and Volatility Models - Aula M

ORAL ID 27 (01)

Pricing of geometric Asian options in the Volterra-Heston model

Sascha Desmettre (*Johannes Kepler University Linz, Austria*); **Florian Aichinger** (*Johannes Kepler University Linz, Austria*)

Abstract: *This paper is concerned with the pricing of Geometric Asian options in Volterra-Heston models, covering the rough Heston model. We derive semi-closed formulas for the prices of geometric Asian options with fixed and floating strikes for this class of stochastic volatility models. These formulas require the explicit calculation of the conditional joint Fourier transform of the logarithm of the stock price and the logarithm of the geometric mean of the stock price. Linking our problem to affine Volterra processes, we find a representation of this Fourier transform as a stochastic exponential, which depends on the solution of a Riccati-Volterra equation.*

ORAL ID 112 (02)

Parametric local volatility: exact prices lead to sound continuous Markovian models

Marco Vitelli (*Università di Bologna, Italy*); **Lorenzo Torricelli** (*Università di Bologna, Italy*); **Michele Azzone** (*Politecnico di Milano, Italy*)

Abstract: *We introduce a class of continuous Markovian asset pricing models with closed-form option prices, leading to identifiable risk-neutral marginal distributions, and then specialize to a significant instance where the SDE well-posedness can be shown, the generalized beta local volatility (GBLV) model. The GBLV marginal distribution coincide with those of a known discontinuous martingale model that exhibits an at-the-money implied volatility skew divergence. These findings contrast with the commonly accepted wisdom that LV is unsuitable for capturing the IV surface's singular behavior as time-to-maturity approaches zero, and that option prices from jump models cannot be fitted by continuous Markov models.*

ORAL ID 305 (03)

Numerical Valuation of European Options under Two-Asset Infinite Activity Exponential Lévy Models

Massimiliano Moda (*University of Antwerp, Belgium*); **Karel In 'T Hout** (*University of Antwerp, Belgium*); **Michèle Vanmaele** (*Ghent University, Belgium*); **Fred Espen Benth** (*BI Norwegian Business School, Norway*)

Abstract: *We propose a numerical method for approximating the values of European-style financial derivatives, based on a two-asset exponential Lévy model for the underlying dynamics. The resulting Feynman-Kac partial-integro-differential equation (PIDE) is solved by combining finite-difference schemes for the differential terms with suitable quadrature formulas for the non-local integral operator. The scheme accounts for both finite- and infinite-activity in the jump components.*

ORAL ID 249 (04)

Option price asymptotics under stochastic volatility Lévy models with infinite activty jumps

Josep Vives Santa Eulalia (*Universitat de Barcelona, Spain*); **Òscar Burés** (*Universitat de Barcelona, Spain*); **Hossein Jafari** (*Chabahar Maritime University, Iran, Islamic Republic of*); **Yiquiang Zhao** (*Carleton University, Canada*)

Abstract: *In this talk, using Malliavin-Skorohod calculus techniques, we study the small-time behaviour of the European call option price for a general stochastic volatility Lévy model with infinite activity jumps (including the infinite variation case) for the at-the-money (ATM), in-the-money (ITM) and out-of-the-money (OTM) cases. The volatility process is correlated with the underlying Lévy process of the model. We apply the well-known Lévy-It^o decomposition of a Lévy process and a decomposition of the European call option price formula (Hull-White formula) to obtain an exact small-time limit. Similar results are obtained for the European put option price.*

Optimal Execution, Liquidity and Market Making - Aula Filopanti

ORAL ID 191 (01)

Log optimality with small liability stream

Michail Anthropelos (*University of Piraeus, Greece*); **Constantinos Kardaras** (*London School of Economics and Political Sciences, United Kingdom*); **Konstantinos Stefanakis** (*University of Piraeus, Greece*)

Abstract: *In an incomplete financial market with general continuous semimartingale dynamics, we consider a log-utility investor who, besides initial capital, receives ε units of a non-traded endowment. We derive a fourth-order expansion of the (primal) value function in ε, which in turn supports a second-order expansion of the optimal wealth in this context. The key processes driving these expansions are expressed through Kunita–Watanabe projections, in close analogy with existing lower-order results. Both the case of finite and infinite horizons are treated in a unified manner.*

ORAL ID 373 (02)

Trading with the flow: Optimal execution and liquidity provision in a stylized limit order book model

Peter Bank (*Technische Universitat Berlin, Germany*); **Alvaro Cartea** (*University of Oxford, United Kingdom*); **Gemma Sedrakjan** (*Technische Universitat Berlin, Germany*)

Abstract: *We propose a stylized LOB model where price and liquidity dynamics are determined by the order flow. Order arrival rates depend on available liquidity. The presence of a strategically trading agent necessitates prohibiting manipulative strategies, such as wash trades. We formulate the agent's expected utility maximization problem, which is controlled by her decisions regarding liquidity provision and market orders. To determine optimal investment and execution strategies, we derive the corresponding HJBQVI. We investigate the time-varying use of limit and market orders, in view of real-world market phenomena such as market making, trend following and reactions to volume imbalances.*

ORAL ID 447 (03)

Unified Signal-Driven Optimal Quoting Strategies

Fenghui Yu (*TU Delft, Netherlands*)

Abstract: *This talk presents optimal execution strategies for sequentially placing limit orders at adaptive quote prices in a limit order book (LOB). Unlike classical approaches that focus on trading speed, we study signal-driven quoting strategies that account for execution risk and price impact. We consider four settings: risk-neutral execution, execution with running inventory risk, exponential utility, and their combination. For general price impact and inventory risk functions, we derive the corresponding HJB equations and show that all problems reduce to a unified structure admitting fully explicit solutions. We illustrate the effectiveness of the optimal strategies using signals learned from LOB data.*

ORAL ID 495 (04)

Optimal Market-Making with Hawkes Process: A Markovian Approximation Approach via Mercer's Expansion

Alex Tse (*Department of Mathematics, University College London, United Kingdom*); **Nicholas Martin** (*Department of Mathematics, University College London, United Kingdom*)

Abstract: *Many market-making models assume memoryless order flow and liquidity level. Previous work has studied self-exciting order flow using Hawkes processes, but has not provided a tractable control framework because of the non-Markovian structure. We address this limitation by approximating Hawkes kernels through truncated Mercer's expansions and verify the convergence to the true value function. This yields a finite-dimensional lifted state that enables dynamic programming and in turn computationally feasible procedures to solve the market making problem. Our findings highlight that ignoring order flow persistence underestimates adverse selection risk, whereas explicitly modelling it improves the robustness and profitability of market-making strategies.*

Stochastic Games in Environmental Finance - Aula A

Organized by: **Igor Cialenco** and **Mike Ludkovski**

MINI-SYMPOSIUM (ID 99): ID 532 (01)

Comparison of Tax and Cap-and-Trade Carbon Pricing Schemes

Stéphane Crépey (*Universite Paris-Cite, France*); **Samuel Drapeau** (*Shanghai Jiao Tong University, China*); **Mekonnen Tadese** (*Mathematics Department, Woldia University, Ethiopia*)

Abstract: *Carbon taxes and emissions trading systems (ETS) are the two dominant carbon mitigation policies. Although economic theory suggests these instruments are equivalent under idealized assumptions, their performance diverges in practice due to market imperfections. A particularly less explored dimension of this divergence concerns the role of financial intermediaries in emissions trading markets. This paper develops a unified framework to compare the economic and environmental performance of tax- and market-based schemes, explicitly incorporating the involvement of intermediaries. Our results suggests that the presence of intermediaries in ETS reduces regulatory revenues and the aggregate profits of economic actors relative to carbon taxation.*

MINI-SYMPOSIUM (ID 99): ID 648 (02)

Cooperation, Competition, and Common Pool Resources in Mean Field Games and extensions with Learning

Gokce Dayanikli (*University of Illinois Urbana-Champaign, United States*)

Abstract: *Tragedy of the commons (TOTC) srares that individual incentives lead to overuse of common pool resources (CPRs), though real-life outcomes often avoid exhaustion through mutual restraint of individuals, as noted by Nobel Laureate Elinor Ostrom. In mean field games (MFGs), however, fully non-cooperative agents make TOTC inevitable, motivating models that mix selfishness and altruism. We introduce mixed-individual and mixed-population MFGs and outline their equilibrium characterizations. A fisheries example illustrates modeling, existence, uniqueness, and experimental results. Finally, since intervention design requires knowing typically unobservable altruism levels, we discuss how these can be learned from observed data by using inverse reinforcement learning.*

MINI-SYMPOSIUM (ID 99): ID 700 (03)

Dynamic Multi-Period Groundwater Markets

Mike Ludkovski (*University of California, Santa Barbara, United States*); **Igor Cialenco** (*Illinois Institute of Technology, United States*)

Abstract: *We construct and analyze dynamic groundwater markets. Economic agents receive stochastic water allocations each period and make competitive decisions on water consumption in order to produce a basket of agricultural goods. The market allows agents to trade their groundwater rights or to bank them for future periods. We define the discrete-time non-zero sum game and develop a dynamic programming algorithm to solve for its sub-game perfect Nash equilibria characterized by the groundwater price process $\{p(t)\}$. Numeric case studies illustrate the role of groundwater recharge dynamics, agents' risk aversion and value of banking, providing insights for environmental markets design.*

MINI-SYMPOSIUM (ID 99): ID 622 (04)

Pro-Rata Market Design for Natural Resource Allocation

Igor Cialenco (*Illinois Institute of Technology, United States*); **Mike Ludkovski** (*University of California, Santa Barbara, United States*)

Abstract: *Motivated by groundwater markets, we develop and analyze a pro-rata mechanism within a competitive market in which agents trade allocated natural resources among themselves. We consider a general Markovian market framework in which prices are determined as a Nash equilibrium of a non-cooperative stochastic game. We show that the proposed pro-rata mechanism induces a unique allocation of the traded natural resource. Finally, by introducing an additional strategic agent acting as a regulator, endowed with her own action set, we propose several market design mechanisms aimed at ensuring the long-term sustainability of the underlying ecosystem.*

Cyber Risk Modeling and Control under Ambiguity and Asymmetry - Aula G

Organized by: **Thibaut Mastrolia** and **Wissal Sabbagh**

MINI-SYMPOSIUM (ID 139): ID 523 (01)

Closed-loop equilibria in leader-follower games with private and common information

Filippo Beretta (*ETH Zurich, Switzerland*); **Dylan Possamaï** (*ETH Zurich, Switzerland*); **Eyal Neuman** (*Imperial College London, United Kingdom*)

Abstract: *We study a Stackelberg stochastic differential game between a more informed leader and a follower. Similar models are attracting increasing attention in Finance, with a wide range of recent applications ranging from price impact to climate finance. In contrast with most of the existing partial-information literature, we focus on closed-loop equilibria, which are more natural for applications and better suited for filtering techniques. By restricting the leader to linear strategies, we establish the existence of an equilibrium. Moreover, we characterize the equilibrium through a system of FBODEs.*

MINI-SYMPOSIUM (ID 139): ID 654 (02)

Optimal Impulse Control for Cyber Risk Management

Wissal Sabbagh (*Le Mans University, France*)

Abstract: *We explore an optimal impulse control problem wherein an electronic device owner strategically calibrates protection levels against cyber attacks. Utilizing epidemiological compartment models, we characterize the dynamics of cyber attacks within the network. We determine optimal protective measures by formulating and solving a stochastic control problem with optimal switching. We show that the value function is a viscosity solution to a system of coupled variational inequalities associated with a fully coupled RBSDE. We devise an algorithm and verification procedure to determine optimal protection timing across cyber attack scenarios. Numerical approximations using deep Galerkin methods illustrate optimal protection strategies in two attack scenarios.*

MINI-SYMPOSIUM (ID 139): ID 688 (03)

Agency Problems and Adversarial Bilevel Optimization under Uncertainty and Cyber Threats

Haoze Yan (*UC Berkeley, United States*); **Thibaut Mastrolia** (*UC Berkeley, United States*)

Abstract: *We study a continuous-time agency problem formulated as an adversarial bilevel stochastic control problem under model uncertainty and jump risk. The agent controls a diffusion with contagion-type dynamics, while the principal designs incentives under volatility ambiguity. Using 2BSDEs with jumps, we characterize incentive compatibility and reformulate the principal's problem as an integro-HJBI equation, proving uniqueness of the viscosity solution. Cybersecurity investment provides a motivating application.*

MINI-SYMPOSIUM (ID 139): ID 738 (04)

Stress scenarios of cyber loss processes with dependencies

Caroline Hillairet (*ENSAE, France*); **Thomas Peyrat** (*ENSAE, France*); **Anthony Reveillac** (*Institut Mathématique de Toulouse, France*); **Yousra Cherkaoui** (*CREST, ENSAE, Institut Polytechnique de Paris, France*)

Abstract: *Cyber risk has become one of the most critical threats to organizations because of its contagious nature and its dependence on vulnerability disclosures. These features make systemic exposure difficult for insurers to assess and relevant stress tests difficult to design. We develop a cyber loss model within the MSPD framework that explicitly accounts for the role of vulnerabilities in cyber attack dynamics. We derive closed-form expressions for the expectation and variance of the cyber loss process, as well as for the surplus under two stress scenarios: excess claims and massive disclosures of critical vulnerabilities.*

Distributionally Robust Optimisation Methods in Finance - Aula B

Organized by: **Jan Obloj**

MINI-SYMPOSIUM (ID 233): ID 322 (01)

Bayesian Distributionally Robust Merton Problem with Nonlinear Wasserstein Projections

Jose Blanchet (*Stanford University, United States*); **Jiayi Cheng** (*New York University, United States*); **Hao Liu** (*Stanford University, United States*); **Yang Liu** (*The Chinese University of Hong Kong, Shenzhen, China*)

Abstract: *We revisit Merton's continuous-time portfolio selection through a data-driven, distributionally robust lens. Our aim is to tap the benefits of frequent trading over short horizons while acknowledging that drift is hard to pin down. We place a single ambiguity set on the drift prior within a Bayesian Merton model, which preserves learning and tractability: a minimax swap reduces the robust control to optimizing a nonlinear functional of the prior. We characterize small-radius worst-case priors under Wasserstein uncertainty via an explicit asymptotically optimal pushforward of the nominal prior. Synthetic and real-data studies demonstrate improved performance over myopic DRO-Markowitz under frequent rebalancing.*

MINI-SYMPOSIUM (ID 233): ID 615 (02)

Robust hedging under small model uncertainty and transaction costs

Yifan Jiang (*Imperial College London, United Kingdom*); **Johannes Muhle-Karbe** (*Imperial, United Kingdom*)

Abstract: *In this talk, we investigate the joint impact of two primary frictions in risk management: model uncertainty and transaction costs. While both frictions have been studied extensively in isolation, their joint effect has lacked systematic integration. To address this gap, we establish a bivariate asymptotic expansion of the associated Hamilton–Jacobi–Bellman–Isaacs (HJBI) equation for small uncertainty aversion and transaction costs. At the leading order, dynamic trading in the underlying is determined by transaction costs, while model uncertainty contributes to the overall hedging error. Furthermore, this asymptotic formula yields computable utility-risk indifference prices and semi-static hedging strategies.*

MINI-SYMPOSIUM (ID 233): ID 661 (03)

Robust Q-learning Algorithm for Mean Field Control Problems under Wasserstein Uncertainty

Mathieu Laurière (*NYU Shanghai, China*); **Ariel Neufeld** (*Nanyang Technological University, Singapore*); **Kyunghyun Park** (*Nanyang Technological University, Singapore*)

Abstract: *In this talk, we present a robust Q-learning algorithm for mean field control problems under Wasserstein uncertainty. We establish non-asymptotic convergence guarantees as well as demonstrate the practical applicability of the proposed method through numerical experiments. This talk is based on joint works with Mathieu Laurière and Kyunghyun Park.*

MINI-SYMPOSIUM (ID 233): ID 725 (04)

Distributional Adversarial Attacks and Training in Finance

Guangyi He (*Imperial College London, China*); **Lukas Gonon** (*University of St. Gallen, Switzerland*); **Tobias Sutter** (*University of St. Gallen, Switzerland*)

Abstract: *We study the robustness of classical deep hedging strategies under distributional shifts by leveraging the concept of adversarial attacks. We propose an adversarial training framework tailored to increase the robustness of deep hedging strategies. This enables the efficient training of hedging strategies that are resilient to distributional perturbations. We show that adversarially trained deep hedging strategies consistently outperform their classical counterparts in terms of out-of-sample performance and resilience to model misspecification. Additional results indicate that the robust strategies maintain reliable performance on real market data and remain effective during periods of market change.*

Rough Volatility in 2026 part 1: Mathematical foundations and econometric methodologies - Aula C

Organized by: **Mathieu Rosenbaum**

MINI-SYMPOSIUM (ID 165): ID 591 (01)

A unified theory of order flow, market impact, and volatility

Youssef Ouazzani Chahdi (*Université Paris-Saclay, Centrale-Supélec, France*); **Johannes Muhle-Karbe** (*Imperial, United Kingdom*); **Mathieu Rosenbaum** (*Université Paris Dauphine, France*); **Grégoire Szymanski** (*University of Luxemburg, Luxembourg*)

Abstract: *We propose a microstructural model for the order flow in financial markets that distinguishes between* core orders *and* reaction flow*, both modeled as Hawkes processes. This model has a natural scaling limit that reconciles a number of salient empirical properties: persistent signed order flow, rough trading volume and volatility, and power-law market impact. In our framework, all these quantities are pinned down by a single statistic* H_0*, which measures the persistence of the core flow.*

MINI-SYMPOSIUM (ID 165): ID 707 (02)

Intraday Volatility Dynamics

Carsten Chong (*The Hong Kong University of Science and Technology, Hong Kong*); **Marc Hoffmann** (*Université Paris Dauphine PSL, France*); **Mathieu Rosenbaum** (*Université Paris Dauphine, France*); **Grégoire Szymanski** (*University of Luxemburg, Luxembourg*)

Abstract: *We present a robust inference method for the autocorrelation of intraday volatility changes that overcomes the latency of volatility and potential biases due to jumps and microstructure noise. Our procedure rests on two results: First, we show that the existence of a limiting autocorrelation function of volatility increments at high frequency implies that the latter must be of regular variation. Second, we show a feasible CLT for the sample autocovariances of estimated spot volatility increments without requiring any debiasing or denoising of the spot volatility estimates. In an empirical application, we document widespread predictability of intraday volatility changes.*

MINI-SYMPOSIUM (ID 165): ID 718 (03)

On Inhomogeneous Affine Volterra Processes: Stationarity and Applications to the Volterra Heston Model

Emmanuel Gnabeyeu Mbiada (*Sorbonne Université, France*); **Gilles Pagès** (*Sorbonne Université, France*); **Mathieu Rosenbaum** (*Université Paris Dauphine PSL, France*)

Abstract: *True Volterra equations are inherently non stationary and therefore do not admitgenuine stationary regimesover finite horizons. This motivates the study of finite-time behavior of solutions to scaled Stochastic Volterra equations through the lens of weaker notion of stationarity entitledfake stationary regimein the sense that all marginal distributions share the same expectation and variance. As a first application, we introduce theFake stationary Volterra Heston modeland derive a closed-form expression for its characteristic function. Having established this finite-time proxy for stationarity, we investigate the asymptotic behavior to assess whether genuine stationary regimes emerge in the limit.*

MINI-SYMPOSIUM (ID 165): ID 749 (04)

Microstructural Foundation of Rough Log-Normal Volatility Models

Paul Peter Hager (*University of Vienna, Austria*); **Ulrich Horst** (*HU Berlin, Germany*); **Thomas Wagenhofer** (*Department of Mathematics, Technical University Berlin, Germany*); **Wei Xu** (*School of Mathematics and Statistics, Beijing Institute of Technology, China*)

Abstract: *We establish a microstructural foundation of the rough Bergomi model. Specifically, we consider a sequence of order driven financial market models where orders to buy or sell an asset arrive according to a Poisson process and have a long lasting impact on volatility. Using a recently established C-tightness result for cadlag processes we establish the weak convergence of the price-volatility process to a log-normal rough volatility model. Our weak convergence result is accompanied by weak error rates that employ a recently established Clark-Ocone formula for Poisson processes and turn our microstructure model into viable alternative to classical simulation schemes.*

Operator Learning in Stochastic Analysis, Control, and Mathematical Finance - Aula D

Organized by: **Filippo De Feo**

MINI-SYMPOSIUM (ID 95): ID 364 (01)

The power of neural operators in games and control

Anastasis Kratsios (*McMaster University, Canada*); **Ibrahim Ekren** (*University of Michigan, United States*); **Xuwei Yang** (*McMaster University, Canada*); **Guillermo Alonso Alvarez** (*University of Michigan, United States*); **Dena Firoozi** (*University of Toronto, Canada*); **Ariel Neufeld** (*Nanyang Technological University, Singapore*); **Philipp Schmocker** (*ETH Zurich, Switzerland*); **Takashi Furuya** (*Doshida University, Japan*); **Dylan Possamaï** (*ETH Zurich, Switzerland*); **Bogdan Raonić** (*ETH Zurich, Switzerland*)

Abstract: *Neural operators (NOs) offer a promising framework for simultaneously solving entire families of stochastic control problems and games. In this talk, building on several recent papers (including work in* JMLR *and ongoing preprints), we show that NOs can approximate: (i) best-response maps in general dynamic Stackelberg games; (ii) families of MFGs, (iii) broad classes of (2)FBSDEs parameterized by their terminal conditions and generators; and (iv) optimal investment strategies under liquidity constraints. In the latter two settings, we establish polynomial and, respectively, sub-linear parametric complexity bounds, using new techniques that fundamentally exploit the deep structural properties of our custom neural-operator architectures.*

MINI-SYMPOSIUM (ID 95): ID 552 (02)

Deep Hilbert-Galerkin Methods for Infinite-Dimensional PDEs and Optimal Control

Samuel Cohen (*Mathematical Institute, University of Oxford, United Kingdom*); **Filippo De Feo** (*Technische Universitat Berlin, Italy*); **Jackson Hebner** (*University of Oxford, United Kingdom*); **Justin Sirignano** (*Mathematical Institute, University of Oxford, United Kingdom*)

Abstract: *We develop deep learning-based methods for fully nonlinear second-order PDEs on Hilbert spaces and prove sufficiently powerful Universal Approximation Theorems. In particular, we prove UATs for functions on Hilbert spaces, together with their Fréchet derivatives up to second order, and for unbounded operators applied to the first derivative, ensuring all PDE terms are approximated. We develop numerical methods, which we call Deep Hilbert-Galerkin Methods, for these problems by training on the whole Hilbert space, not just a projected PDE to finite dimensions. We numerically solve Kolmogorov and HJB PDEs related to the optimal control of stochastic heat and Burgers' equations.*

MINI-SYMPOSIUM (ID 95): ID 525 (03)

Deep Hilbert Galerkin Methods for PDEs on Hilbert spaces via derivative-informed operator learning with applications to infinite-dimensional optimal control

Samuel Cohen (*Mathematical Institute, University of Oxford, United Kingdom*); **Filippo De Feo** (*Institut für Mathematik, Technische Universität Berlin, Germany*); **Jackson Hebner** (*Mathematical Institute, University of Oxford, United Kingdom*); **Justin Sirignano** (*Mathematical Institute, University of Oxford, United Kingdom*)

Abstract: *Hilbert Neural Operators are able to approximate classical solutions of fully nonlinear second-order partial differential equations on Hilbert spaces, such as Hamilton-Jacobi-Bellman and backwards Kolmogorov equations. Based on this result, we propose two actor-critic algorithms for solving Hilbert-valued HJB equations and two algorithms for solving Hilbert-valued backwards Kolmogorov equations. We then apply these algorithms to the control of the stochastic heat equation, a stochastic delay equation, the stochastic Burgers equation, and a mean-field control problem. To the best of our knowledge, these algorithms are the first methods for solving PDEs directly on their whole Hilbert space domain.*

MINI-SYMPOSIUM (ID 95): ID 680 (04)

Learning operators on labelled conditional distributions with applications to mean field control of non exchangeable systems

Samy Mekkaoui (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Huyen Pham** (*University of Oxford, France*); **Xavier Warin** (*Électricité de France (EDF), France*)

Abstract: *We study the approximation of operators acting on probability measures on a product space with prescribed marginal. Let I be a label space endowed with a reference measure λ, and define $\mathcal{M}_\lambda$ as the set of probability measures on $I \times \mathbb{R}^d$ with first marginal λ. Our main theoretical result establishes a universal approximation theorem for continuous operators on $\mathcal{M}_\lambda$ relying on a DeepONet-type branch-trunk neural architecture combined with cylindrical approximations of probability measures. We apply the method to the numerical resolution of mean-field control problems with heterogeneous interactions. Numerical experiments illustrate the accuracy and computational effectiveness of the proposed framework.*

Price Impact and Transaction Costs - Aula E

ORAL ID 86 (01)

Relative Arbitrage with Price Impact

David Itkin (*London School of Economics and Political Sciences, United Kingdom*)

Abstract: *Relative arbitrage is when one portfolio outperforms another with probability one. Going back to Fernholz (2002), many researchers have constructed arbitrages with respect to the market portfolio using functional generation. However, these portfolios constantly trade, while the market portfolio does not so the relative performance suffers from transaction costs. We present first theoretical results on relative arbitrage with frictions, valid for a general class of price impact models. We show that relative arbitrage remains possible under similar assumptions to the frictionless case, but it may not be scalable and to achieve it the investor must appropriately modulate their trading speed.*

ORAL ID 179 (02)

Optimal Execution under Liquidity Uncertainty

Yadh Hafsi (*Ecole Polytechnique, France*); **Sergio Pulido** (*ENSIIE, France*); **Vathana Ly Vath** (*ENSIIE - LaMME Paris-Saclay, France*); **Etienne Chevalier** (*Université Paris-Saclay, France*)

Abstract: *We study optimal execution for purchasing a large block over a fixed horizon under transient price impact with market resilience and general limit order book shapes. Resilience is driven by a stochastic volume effect that governs the decay of the deviation between impacted and unaffected prices, and liquidity conditions switch across regimes via a Markov chain. The problem is formulated as a singular control problem. The value function satisfies a system of HJBQVIs and is the unique viscosity solution. We study the free boundary separating the execution and continuation regions, and provide numerical examples illustrating the optimal execution strategy.*

ORAL ID 407 (03)

On the utility problem in a market where price impact is transient

Lorant Nagy (*HUN-REN Alfred Renyi Institute of Mathematics and Budapest University of Technology and Economics, Hungary*); **Miklós Rásonyi** (*HUN-REN Alfred Renyi Institute of Mathematics and Budapest University of Technology and Economics, Hungary*)

Abstract: *We consider a discrete-time model of a financial market in which a risky asset is bought and sold with transactions that have a transient price impact. We show that the corresponding utility maximization problem admits a solution and, furthermore, that some unnatural restrictions on the market depth and resilience processes, which were present in earlier work, can be removed. A distinctive and highly unusual feature of the problem is that the set of attainable portfolio values may lack the convexity property.*

ORAL ID 454 (04)

No-Arbitrage, Superreplication and Utility Maximisation for Propagator Price Impact Models

Christoph Czichowsky (*London School of Economics and Political Sciences, United Kingdom*)

Abstract: *Propagator models describe transient price impact by allowing execution prices to depend on the entire history of past trades through a Volterra kernel. While such models capture empirically observed features of market microstructure, they lead to infinite-dimensional and non-Markovian optimisation problems. In this talk, I develop a comprehensive mathematical finance framework for propagator models, including a fundamental theorem of asset pricing, a superreplication theorem with liquidity-adjusted risk measures, and a convex-duality approach to utility maximisation. Despite non-linear preferences and path-dependent price impact, optimal strategies are obtained by solving an equivalent frictionless optimisation problem for a suitably constructed shadow price.*

Theoretical and empirical analysis of market microstructure - Aula F

Organized by: **Charles-Albert Lehalle**

MINI-SYMPOSIUM (ID 374): ID 664 (01)

Information dynamics under heavy-tailed irrationality: a multi-period equilibrium in limit order markets

Umut Cetin (*London School of Economics and Political Sciences, United Kingdom*); **Mingwei Lin** (*London School of Economics and Political Sciences, United Kingdom*); **Giulia Livieri** (*London School of Economics and Political Sciences, United Kingdom*)

Abstract: *We study a discrete-time multiperiod limit order market with asymmetric information and heavy-tailed noise trading. In each period, informed and uninformed order flow is batched and executed against the limit order book formed by competitive liquidity suppliers. We characterise equilibrium via a sequence of fixed-point equations, establish convergence of posterior beliefs despite dependence induced by sequential trading, and derive power-law asymptotics for price impact under heavy-tailed noise.*

MINI-SYMPOSIUM (ID 374): ID 672 (02)

Market Making with Fads, Informed, and Uninformed Traders

Emilio Barucci (*Politecnico di Milano, Italy*); **Adrien Mathieu** (*University of Oxford, United Kingdom*); **Leandro Sánchez-Betancourt** (*University of Oxford, United Kingdom*)

Abstract: *We characterise the solutions to a continuous-time optimal liquidity provision problem in a market populated by informed and uninformed traders. In our model, the asset price exhibits fads these are short-term deviations from the fundamental value of the asset. Conditional on the value of the fad, we model how informed traders and uninformed traders arrive in the market. The market maker knows of the two groups of traders but only observes the anonymous order arrivals. We study both, the complete information and the partial information versions of the control problem faced by the market maker.*

MINI-SYMPOSIUM (ID 374): ID 677 (03)

Why is the estimation of metaorder impact with public market data so challenging?

Fabrizio Lillo (*Scuola Normale Superiore di Pisa, Italy*); **Giacomo Bormetti** (*Università di Pavia, Italy*); **Manuel Naviglio** (*Scuola Normale Superiore di Pisa, Italy*); **Francesco Campigli** (*Scuola Normale Superiore di Pisa, Italy*); **German Rodikov** (*Università di Bologna, Italy*)

Abstract: *Estimating market impact and transaction costs of large trades is a very important topic in finance. However, using models of price and trade based on public data provide average price trajectories which are qualitatively different from what is observed during real metaorder executions. We claim that this is a generic phenomenon due to the fact that even sophisticated statistical models are unable to correctly describe the origin of the autocorrelation of the order flow. We propose a modified Transient Impact Model which provides more realistic trajectories by assuming that only a fraction of the metaorder trading triggers market order flow.*

MINI-SYMPOSIUM (ID 374): ID 685 (04)

Lessons from empirical modeling of multivariate intraday dynamics with diffusion generative models

Marie Scheid (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Marie Scheid** (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Alain Durmus** (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Charles-Albert Lehalle** (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*)

Abstract: *Realistic intraday financial generation requires matching marginal distributions, temporal dependence, and cross-feature structure while retaining diversity. We train diffusion models on 5-minutes multivariate daily sequences (returns, bid–ask spread, order-book imbalance, traded volume) using a denoiser adapted to time series; no stylized facts are imposed. Evaluation combines standard synthetic-time series metrics (discriminative and predictive scores, Context-FID, correlational score, MMD, MSLE) with finance diagnostics: heavy tails, weak return autocorrelation, volatility clustering, and multivariate links such as leverage and volume–volatility relations. We compare univariate return-only diffusion to multivariate diffusion to assess whether liquidity channels improve return realism across assets and intraday regimes.*

MINI-SYMPOSIUM (ID 374): ID 748 (05)

Prisoner's Dilemma in Dealer Markets

Eyal Neuman (*Imperial College London, United Kingdom*); **Robert Boyce** (*Imperial College London, United Kingdom*)

Abstract: *We model a market with multiple dealers who dynamically update their prices for a risky asset to compete for clients' order flow. These dealers aim to maximise expected profits while managing inventory risk, which they can partially offload through position externalisation. We show that in the presence of dealers who are native externalisers, internalisers are incentivised to behave as if they were externalisers. This strategic shift of the equilibrium ultimately lowers the P&L for all dealers in the market and leads to substantially increased spread costs for clients.*

Energy Finance - Aula P

ORAL ID 770 (01)

Understanding Modern Energy Markets: From Fundamentals to Weather Volatility Modelling

Giacomo Masato (*Illumia, Italy*)

Abstract: *The landscape of wholesale electricity markets has undergone a profound transformation over the last 15 years, driven by a dramatic shift in global supply and demand fundamentals. This talk provides an accessible yet rigorous overview of modern power market mechanics. We will first demystify wholesale price formation through the concept of the merit-order stack, explore key market drivers, and contextualize how the rise of renewable energy has reshaped today's grid. Building on these fundamentals, the presentation will then demonstrate a practical application of quantitative modelling, illustrating how weather volatility directly impacts market trends and how fundamental analysis maps these environmental factors to predict price fluctuations.*

ORAL ID 761 (02)

Systematic Approach to Energy Trading

Tommaso Mengoli (*Illumia, Italy*); **Giacomo Masato** (*Illumia, Italy*)

Abstract: *This talk provides a high-level introduction to systematic trading in energy markets, focusing on how quantitative methods can turn market information into structured trading decisions. The presentation introduces the main features of energy markets and the role of futures products in trading price dynamics across different countries, delivery periods and maturities. It explores the core elements of a systematic strategy: building a trading signal and defining the rules used to translate it into positions. Two approaches to signal generation are compared: technical-signals, based on market data, and fundamental signals, based on physical market drivers such as weather, demand and supply.*

ORAL ID 413 (03)

Hedging Power Purchase Agreements: A Cointegration Model

Benjamin Bitterlich (*University of Bielefeld, Germany*); **Maren Schmeck** (*University of Bielefeld, Germany*); **Fred Espen Benth** (*BI Norwegian Business School, Norway*)

Abstract: *This paper presents a mathematical hedging framework for wind-based power purchase agreements (PPAs) that considers their underlying price and volume risks. We model spot prices and wind energy generation as cointegrated exponential Ornstein-Uhlenbeck processes. Using the Clark-Ocone formula and Malliavin calculus, we derive explicit hedging positions based on electricity and wind swaps. This approach allows us to quantify the unhedgeable volume risk and a hedging position in the price swap, including an economic interpretation of the price hedging strategy. The results provide a robust tool for managing the risk of volatility and cannibalisation effects in renewable energy markets.*

ORAL ID 319 (04)

An ambit field framework for the full panel of day-ahead electricity prices

Thomas Kloster (*University of Aarhus, Denmark*)

Abstract: *We consider the often overlooked fact that electricity spot prices evolve as a high dimensional panel structure. A general continuous time framework is developed by formulating the panel as an ambit field on a cylinder surface, where the cross-sectional dimension is represented by a circle. This generalises volatility modulated Lévy-driven Volterra processes, which have previously been studied for energy markets, to space-time. The pricing of electricity derivatives turns out to be essentially as analytically tractable as in the univariate setting. We establish useful formulas for the pricing of derivatives, a simulation scheme, and study the model dependence structure in detail.*

ORAL ID 500 (05)

A Temperature-Driven Stochastic Volatility Model for the Evolution of Day-Ahead Prices in Gas and Power Markets

Stefania Ottaviano (*University of Padova, Italy*); **Marco Rossi** (*University of Verona, Italy*); **Piergiacomo Sabino** (*University of Vaasa, Finland*); **Tiziano Vargiolu** (*University of Padova, Italy*)

Abstract: *We develop a stochastic volatility model for energy derivatives where volatility is driven explicitly by observable temperature deviations rather than latent processes. Temperature anomalies are linked to price volatility through a squared Ornstein-Uhlenbeck process. Under suitable assumptions similar to Heston's framework, the model admits an affine structure with closed-form characteristic functions via confluent hypergeometric functions. We derive a modified Carr-Madan methodology enabling efficient option pricing through Fast Fourier Transform algorithms. Empirical implementation on the Dutch TTF natural gas market demonstrates the feasibility of modeling volatility through exogenous meteorological data, offering an alternative to conventional latent volatility specifications in energy markets.*

Neural Networks and Deep Learning - Aula Q

ORAL ID 221 (01)

Neural network empowered liquidity pricing in a two-price economy under conic finance settings

Diogo Franquinho (*University of Lisbon, Portugal*); **Matteo Michielon** (*ABN Amro Bank N.V.,, Netherlands*); **Asma Khedher** (*University of Amsterdam, Netherlands*); **Peter Spreij** (*University of Amsterdam, Netherlands*); **Alessandro Gentile** (*Dexter Energy B.V., Netherlands*)

Abstract: *This article focuses on the calibration of conic financial market models using neural networks to capture liquidity effects. Neural networks are employed within a two-price economy to efficiently calibrate prices and Greeks of derivatives, significantly improving computational performance over traditional conic Monte Carlo methods. The proposed calibration framework is model-agnostic and can be applied to a wide class of valuation models in conic finance. In addition, contingent claims are calibrated under conic assumptions using local stochastic volatility models, where local volatility surfaces are learned through neural networks. The approach also constructs hybrid distortion functions to fit implied market liquidity effectively.*

ORAL ID 384 (02)

Theory of graph neural networks and applications to systemic risk

Lukas Gonon (*University of St. Gallen, Switzerland*); **Thilo Meyer-Brandis** (*Ludwigs Maximilian University Munich, Germany*); **Niklas Weber** (*Ludwigs Maximilian University Munich, Germany*)

Abstract: *This talk presents graph neural networks, a class of neural network architectures designed to process data represented as graphs—collections of nodes connected by edges. We will discuss results on key theoretical properties, including universal approximation, approximation rates, and generalization bounds. As an application in finance, we demonstrate how graph neural networks can be employed to compute systemic risk measures.*

ORAL ID 155 (03)

Approximation error bounds for quantum neural networks

Lukas Gonon (*University of St. Gallen, Switzerland*); **Jack Jacquier** (*Imperial College London, United Kingdom*)

Abstract: *Quantum neural networks have recently emerged as novel machine learning tool, suitable for implementation on quantum computing hardware. In this talk, we present quantum neural network expressivity bounds for functions with sufficient Fourier integrability. In particular, we provide a bound on the quantum circuit complexity required to achieve a prescribed approximation accuracy. We show that for integrable functions with integrable Fourier transform, the required circuit size only grows logarithmically in the reciprocal of the desired approximation accuracy. The obtained approximation rates are free from the curse of dimensionality. As an application, we consider option pricing in exponential Lévy models.*

ORAL ID 234 (04)

Deep Learning for Reflected BSDEs: Regularization and Convergence Analysis

Ruimeng Hu (*University of California, Santa Barbara, United States*); **Yihan Zou** (*University of Glasgow, United Kingdom*)

Abstract: *In this paper, we develop a numerical scheme for solving reflected backward stochastic differential equations (RBSDEs) based on the deep backward neural network architecture of Wang, Chen, Sudjianto, Liu, and Shen (2018, arXiv:1807.06622). The proposed method approximates solutions to regularized BSDEs, and the approximation error is bounded by the associated training loss, which can be made sufficiently small under the universal approximation capability of neural networks. Numerical experiments on American-style option pricing problems demonstrate that the proposed deep solver achieves high accuracy and strong performance in high-dimensional settings.*

Recent advances in Transform (Fourier/Laplace) methods for computational finance and risk management - Part 1 - Aula H

Organized by: **Michael Samet**

MINI-SYMPOSIUM (ID 126): ID 558 (01)

Efficient random quadrature methods for Fourier valuation of multi-asset options

Laura Ballotta (*Bayes Business School, United Kingdom*); **Ziyang Huang** (*Bayes Business School, United Kingdom*)

Abstract: *We develop an efficient Monte Carlo integration method based on adaptive multiple importance sampling which deals with the selection of the parameters of the importance function by running basic Importance Sampling in an iterative way. We also study the effectiveness of a stopping rule for the adaptive loop based on relative statistical errors, which allows to pre-fix the level of accuracy significantly improving computational efficiency. The performance of the algorithms is studied for the pricing of rainbow and basket options under several multidimensional models.*

MINI-SYMPOSIUM (ID 126): ID 611 (02)

Quasi-Monte Carlo with Domain Transformation for Efficient Fourier Pricing of Multi-Asset Options

Chiheb Ben Hammouda (*Utrecht University, Netherlands*); **Michael Samet** (*RWTH Aachen University, Germany*); **Michael Samet** (*RWTH Aachen University, Germany*); **Antonis Papapantoleon** (*TU Delft, Netherlands*); **Christian Bayer** (*Weierstrass Institute for Applied Analysis and Stochastics, Germany*); **Raul Tempone** (*King Abdullah University of Science and Technology, Saudi Arabia*)

Abstract: *This work introduces an efficient Fourier pricing methodology for high-dimensional multi-asset options based on randomized quasi–Monte Carlo (RQMC). To overcome the poor scaling of tensor-product quadrature, we employ RQMC in the Fourier domain, which requires mapping the unbounded integration domain R^d to the unit hypercube $[0,1]^d$. We design a domain transformation based on boundary growth conditions to prevent loss of regularity and ensure fast convergence. Extensive numerical experiments across various pricing models, payoffs, and dimensions confirm the superior performance of our Fourier–RQMC approach over Monte Carlo and tensor-product methods.*

MINI-SYMPOSIUM (ID 126): ID 638 (03)

Single- and Multi-Level Fourier-RQMC Methods for Multivariate Shortfall Risk

Truong Nguyen Ngoc (*Utrecht University, Netherlands*); **Chiheb Ben Hammouda** (*Utrecht University, Netherlands*)

Abstract: *Multivariate shortfall risk measures provide systemic-risk-aware capital allocations before aggregation, but existing Monte Carlo estimators are computationally expensive. We introduce single- and multilevel numerical algorithms for estimating multivariate shortfall risk and the associated optimal allocations, combining Fourier inversion with randomized quasi–Monte Carlo (RQMC) sampling and leveraging the geometric convergence of the deterministic optimizer. We develop a rigorous mathematical framework for the Fourier–RQMC estimators, including convergence analysis and complexity bounds. Numerical experiments demonstrate that the proposed methods outperform sample average approximation (SAA) and stochastic approximation (SA) in terms of accuracy and computational cost across a range of risk-factor and loss models.*

MINI-SYMPOSIUM (ID 126): ID 647 (04)

Fast reliable pricing and calibration of the rough Heston model

Sergei Levendorskii (*Calico Consulting, United States*); **Svetlana Boyarchenko** (*University of Texas at Austin, United States*); **Marco De Innocentis** (*Deutsche Bank, London, United Kingdom*)

Abstract: *We combine a modification of the Adams method with the SINH-acceleration method to price vanilla options under the rough Heston model. For moderate or long maturities and strikes near spot, thousands of prices are computed in several milliseconds (ms) in Matlab on a Mac with moderate specs, with relative errors $< 10^{-4}$; options close to expiry and far-OTM are priced in few tens or hundreds of ms. Robust error control is ensured by Conformal Bootstrap principle applicable to many Fourier-pricing methods ensures ensures robust error control and enables accurate calibration procedures hundreds of times faster methods used in the industry.*

Hedging - Aula I

ORAL ID 114 (01)

Discrete approximation of risk-based prices under volatility uncertainty

Jonas Blessing (*ETH Zurich, Switzerland*); **Michael Kupper** (*University of Konstanz, Germany*); **Alessandro Sgarabottolo** (*Ludwigs Maximilian University Munich, Germany*)

Abstract: *We discuss the asymptotic behaviour of risk-based indifference prices of European contingent claims in discrete-time financial markets under volatility uncertainty as the number of intermediate trading periods tends to infinity. The asymptotic risk-based prices form a strongly continuous convex monotone semigroup which is uniquely determined by its infinitesimal generator and therefore only depends on the covariance of the random factors. We further compare the risk-based prices with the worst-case prices given by the G-expectation and investigate their asymptotic behaviour as the risk aversion of the agent tends to infinity. The theoretical results are illustrated with several examples and numerical simulations.*

ORAL ID 343 (02)

M-method Estimation of Jump-diffusion OU Processes: an Application to Energy Markets

Piergiacomo Sabino (*University of Vaasa, Finland*); **Dario Gasbarra** (*University of Vaasa, Finland*)

Abstract: *We investigate the application of the continuous generalized method of moments (CGMM), based on the characteristic function, to the estimation of Ornstein–Uhlenbeck processes of jump–diffusion type. The proposed estimation framework is computationally simpler than existing approaches and relies on a numerically efficient optimization procedure. Moreover, we demonstrate that the commonly suggested EM-based estimation strategy is, in practice, infeasible for this class of models. Finally, we provide an empirical application illustrating the estimation of the structural parameters governing real day-ahead gas price dynamics.*

ORAL ID 427 (03)

Deep Option Hedging From Simulation To Reality

Michele Colombi (*Scuola Normale Superiore di Pisa, Italy*); **Pietro Rossi** (*Prometeia, Italy*); **Marco Di Francesco** (*University of Bologna, Italy*)

Abstract: *We study sim-to-real reinforcement learning for option hedging under realistic market features. Beyond discrete-time trading and transaction costs, we explicitly account for volatility risk by allowing a two-instrument Delta–Vega hedge. The agent observes a parsimonious, market-observable state without relying on latent volatility inputs, yielding a partially observable decision problem. To generate the large number of training episodes required by deep RL without nested Monte Carlo pricing, we use a neural network surrogate trained to approximate the model's implied volatility map. We train PPO and evaluate it in simulated and empirical settings against benchmark hedging strategies.*

ORAL ID 446 (04)

Algorithmic strategies in continuous-time hedging and stochastic integration

Uwe Schmock (*FAM @ TU Wien, Vienna, Austria, Austria*); **Aleksandar Arandjelovic** (*ETH Zurich, Switzerland*)

Abstract: *We develop a rigorous framework for continuous-time algorithmic trading strategies. For this, we establish a universal approximation theorem for neural networks on locally convex spaces with respect to topologies in Orlicz spaces. When the underlying sigma-algebra is generated by an (uncountable) family of random variables, we prove that neural networks - through functional representations - can approximate functions in these Orlicz spaces arbitrarily well. Our main result represents algorithmic strategies as simple predictable processes to establish their approximation capabilities in spaces of stochastic (integral) processes. As applications, we prove that algorithmic strategies can approximate mean-variance optimal hedging strategies arbitrarily well.*

Mean Field Control/Mean Field Games - Aula L

ORAL ID 257 (01)

Learning Algorithms for Mean-Field Coarse Correlated Equilibrium: A Linear Programming Approach

Ioannis-Paraskevas Tzouanas (*University of Bielefeld, Germany*); **Luciano Campi** (*University of Milan, Italy*); **Federico Cannerozzi** (*University of Bielefeld, Germany*)

Abstract: *We investigate the approximation of Coarse Correlated Equilibrium (CCE) within the framework of continuous-time mean-field games. In this setting, a regulator (or a correlation device) recommends strategies that agents have no unilateral incentive to deviate from. We begin by introducing the concept of optimal CCE and reformulating the problem using a linear programming approach to demonstrate existence under weak assumptions. Then, we focus on the approximation of these equilibria, we propose a novel no-regret primal-dual learning algorithm and prove its convergence. Finally, we provide numerical examples to illustrate our results.*

ORAL ID 342 (02)

Optimal Loss Allocation as a Singular McKean-Vlasov Control Problem in Systemic Risk Modeling

Yucheng Guo (*Princeton University, United States*); **Qinxin Yan** (*Princeton University, United States*)

Abstract: *We consider the problem faced by a central planner who optimally allocates the loss incurred by the defaults of financial institutions to maintain maximal overall health of the system. We prove the optimality of the "taxing-the-richest" scheme under suitable assumptions and characterize the continuous-time mean-field limit as the number of institutions grows and the delay time of the loss diminishes. In the course of the proof, we establish a comparison principle for the viscosity solution of the singular McKean-Vlasov control problem, and the well-posedness of a free boundary problem with reflection, two technical results of interest in their own interests.*

ORAL ID 365 (03)

Convergence and turnpike properties of linear-quadratic mean field control problems with common noise

Erhan Bayraktar (*University of Michigan, United States*); **Jiamin Jian** (*University of Michigan, United States*)

Abstract: *Within a unified framework, we analyze a finite-horizon social optimization problem, its mean field control limit, and the corresponding ergodic mean field control problem. The finite-horizon problems are characterized by coupled Riccati differential equations, whereas the ergodic problem is addressed via a Bellman equation on the Wasserstein space, which reduces to a system of stabilizing algebraic Riccati equations. By deriving estimates for these Riccati systems, we establish a turnpike property for the finite-horizon mean field control problem and obtain quantitative convergence results from the social optimization problem to its mean field limit and the associated ergodic control problem.*

ORAL ID 520 (04)

Limiting Mean-Field Games and Structural Decomposition of Equilibria for Portfolio Games of Optimal Hedging

Dirk Becherer (*Humboldt University of Berlin, Germany*); **Stefanie Hesse** (*Humboldt University of Berlin, Germany*)

Abstract: *We present new results on mean-field games of optimal investment and hedging with relative performance concerns under CARA preferences. Equilibria are fully characterized by McKean-Vlasov BSDEs which are well-posed. Our proof yields a constructive description of the mean-field equilibrium: one first solves a classical single-agent control problem, then a linear projection problem on the common-noise filtration. This relies on our structural decomposition, which reveals how interaction, investment, and hedging combine in equilibrium. We further identify two limiting mean-field games arising as absolute risk aversion tends to zero and to infinity, yielding novel types of portfolio games.* (*Partly based on arXiv:2408.01175.*)

Option Pricing and Model Calibration - Aula M

ORAL ID 304 (01)

Parameter estimation for dynamically recalibrated affine models in finance

Ivo Richert (*Kiel University, Germany*); **Jan Kallsen** (*Kiel University, Germany*)

Abstract: *Recalibration of option pricing models is a widely used practice that, however, lacks a mathematical foundation and leads to highly model-dependent hedging strategies. We address this gap by modeling the driving factors of implied volatility by unobserved states of an affine background model, which is estimated in two steps: First, unobservable states are calibrated to options using least-squares optimisation before risk-neutral and physical parameters are jointly estimated to fit the calibrated trajectories. We derive tractable estimators with desirable asymptotic properties based on estimating function theory and illustrate our approach using market data of European and American options and the VIX.*

ORAL ID 475 (02)

Monotonic transformation, implied stock price process and market consistent pricing of derivatives contracts

Gianluca Fusai (*Bayes Business School, United Kingdom*); **Giovanni Longo** (*U. Piemonte Orientale, Italy*)

Abstract: *Fusai (2024) introduces a method to construct a stochastic price process aligning with observed option prices. It models stock returns using a monotonic transformation, termedg-transformation, of arithmetic Brownian motion (ABM). Applying Ito's lemma togfacilitates straightforward derivation of log-return dynamics, overcoming challenges in Dupire (1994). This paper extends these concepts by detailing the model implementation in WTI Crude Oil products and pricing calendar spread options, in a fully consistent way with the observed volatility surface. The application to other exotic options like Asian and barriers is also briefly discussed-.*

ORAL ID 383 (03)

Moments-Informed Neural Networks for Option Pricing when the Characteristic Function is Unavailable

Riccardo Brignone (*University of Pavia, Italy*); **Bartolomeo Fanciulli** (*University of Freiburg, Germany*); **Sven Knaust** (*University of Freiburg, Germany*); **Eva Lütkebohmert** (*University of Freiburg, Germany*)

Abstract: *This paper proposes a novel deep learning framework that incorporates risk-neutral cumulants into neural networks for option pricing. We focus on settings where moments can be computed although characteristic functions are unavailable. First, we address the pricing of European options under polynomial stochastic volatility models, where moments of log-returns can be computed and used as inputs to train ANNs that learn the pricing functional. Second, we study the pricing of Asian options in exponential Lévy, affine, and polynomial models, where the characteristic function of integrated asset prices is generally unavailable but moments of arithmetic averages or integrated log-returns are tractable.*

ORAL ID 347 (04)

Total Positivity Properties of American Options

Paul Glasserman (*Columbia University, United States*); **Dan Pirjol** (*Stevens Institute of Technology, United States*)

Abstract: *We derive conditions under which the prices of American (or Bermudan) call options are totally positive of order 2 as functions of strike and number of exercise opportunities. We derive conditions for the corresponding property for American (or Bermudan) puts. Surprisingly, we show that these properties often hold for American (or Bermudan) options even when they fail for otherwise identical European options. We discuss implications and applications of these properties.*

Optimal Trading and Portfolio Choice - Aula Filopanti

ORAL ID 142 (01)

Optimal Liquidity Taking in an Automated Market Maker

Jack Kerr (*Universität Stuttgart, Germany*); **Martin Herdegen** (*Universität Stuttgart, Germany*)

Abstract: *We study optimal liquidity taking inside an automated market maker (AMM), within a discrete time, finite-horizon framework. An agent trades exclusively in an AMM and values their terminal wealth using an exogenous oracle price. We characterise optimal strategies under risk neutral and general concave risk preferences, showing that optimal trades align the post-trade AMM marginal price to a utility adjusted expectation of the oracle price. The model is then extended to include transaction costs, multi-period trading with random liquidity provision and competition between multiple optimally trading agents. The talk is based on joint work with Martin Herdegen.*

ORAL ID 175 (02)

Learning an Optimal Investment Policy with Transaction Costs via a Randomized Dynkin Game

Min Dai (*The Hong Kong Polytechnic University, Hong Kong*); **Yuchao Dong** (*Tongji University, China*); **Zhichao Lu** (*The Hong Kong Polytechnic University, Hong Kong*)

Abstract: *We reformulate multi-asset portfolio selection with transaction costs as a system of Dynkin game, enabling us to capture the timing of buy and sell decisions under market frictions. To overcome the computational difficulties posed by the discontinuous nature of stopping decisions, we introduce a randomized Dynkin game approach that incorporates entropy regularization to balance exploration and exploitation. Building on this formulation, we develop an interpretable reinforcement learning algorithm capable of learning near-optimal trading policies directly from market data. Using theoretical analysis, numerical experiments, and empirical tests, we demonstrate that our method effectively approximates optimal trading boundaries and outperforms benchmark strategies.*

ORAL ID 435 (03)

Geometric Integrability of the Hamilton-Jacobi-Bellman associated to the Portfolio Choice with Illiquid asset.

Claudio Tebaldi (*Università Commerciale L. Bocconi, Italy*)

Abstract: *We establish a rigorous connection between the two-dimensional Hamilton-Jacobi Bellman analyzed in Schwartz Tebaldi (2006) and a dispersionless integrable hierarchy of Toda type which describes a flow of conformal mappings of the unit disc in the complex plane. This result paves the way to more accurate numerical and analytical approaches to the determination of the liquid value of an illiquid activity exposed to unhedgeable risk.*

ORAL ID 353 (04)

Optimal autonomous trading strategies in Heston-type models of stochastic volatility

Pavel Gapeev (*LSE, United Kingdom*)

Abstract: *The problem of autonomous trading consists of searching for the optimal random times of buying the underlying risky asset at lower prices and then selling it at higher prices or vice versa. We derive closed-form solutions to the corresponding optimal double-stopping problems related to the pricing of such pairs of trading strategies on the risky asset-price processes for small investors in Heston-type stochastic volatility models with square-root (Feller's or Cox-Ingersoll-Ross model) and linear (Shiryaev's model) diffusion coefficients of the volatility rates over an infinite-time horizon. We derive Fredholm-type nonlinear integral equations for the optimal autonomous trading (buying and selling) boundaries.*

Path-dependent Stochastic Analysis and Control and Applications in Finance and Economics - Aula A

Organized by: **Filippo de Feo**

MINI-SYMPOSIUM (ID 96): ID 560 (01)

Stochastic Optimal Control of Particle Systems in Hilbert Spaces and Applications

Filippo De Feo (*Institut für Mathematik, Technische Universität Berlin, Germany*); **Fausto Gozzi** (*Luiss University Rome, Italy*); **Andrzej Swiech** (*Georgia Institute of Technology, United States*); **Lukas Wessels** (*Universite Cote d'Azur, France*)

Abstract: *We will present results about optimal control of interacting particle systems with common noise driven by SPDE in Hilbert spaces. We will discuss convergence of value functions u_n for control problems of n particles to a function V corresponding to a limit control problem, which is the viscosity solution of HJB equation in the Wasserstein space of measures. We will show how PDE techniques allow to prove that V, when restricted to averages of point measures, projects precisely onto u_n. We will discuss applications to a problem arising in economics where the particles are modeled by stochastic delay differential equations.*

MINI-SYMPOSIUM (ID 96): ID 716 (02)

On Mean Field Games and Mean Field Control of Stochastic Delay Equations

Fausto Gozzi (*Luiss University Rome, Italy*)

Abstract: *In this talk we present some recent and partly ongoing results on Mean Field Games and Mean Field Control when the state variables are governed by a Stochastic Delay Equation. We also provide some motivating examples and some ideas of the techniques.*

MINI-SYMPOSIUM (ID 96): ID 730 (03)

Optimal control of stochastic Volterra integral equations with completely monotone kernels and stochastic differential equations on Hilbert spaces with unbounded control and diffusion operators

Gabriele Bolli (*Sapienza Università di Roma, Italy*); **Filippo De Feo** (*Institut für Mathematik, Technische Universität Berlin, Germany*)

Abstract: *We address the optimal control of Stochastic Volterra Integral Equations (SVIEs) with completely monotone kernels, a framework essential for rough volatility modeling. By applying a Markovian lift, we reformulate the problem as an SDE on Hilbert spaces with unbounded control and diffusion operators. We introduce a novel smoothing property for the associated Ornstein-Uhlenbeck transition semigroup, enabling the first proof of existence and uniqueness for mild HJB solutions in this setting. Our results include a verification theorem and the construction of optimal feedback controls for this complex infinite-dimensional class.*

MINI-SYMPOSIUM (ID 96): ID 673 (04)

Randomization method and BSDEs representation for optimal control of stochastic Volterra equations

Niccolò Fontana (*Politecnico di Milano, Italy*); **Fulvia Confortola** (*Politecnico di Milano, Italy*); **Huyen Pham** (*Ecole Polytechnique, France*)

Abstract: *We consider a stochastic control problem for Volterra equations where the kernel is completely monotone. By rewriting the control problem for the lifted process, we exploit the Markovianity to prove the equivalence, in terms of the value function, between the lifted problem and a randomized control problem where the place of the control is taken by a piecewise constant process associated with a Poisson random measure. Lastly, we prove a representation of the value function through the solution to a BSDE with constrained jumps and a randomized Dynamic Programming principle.*

Recent developments in interest rate modeling - Part 2 - Aula G

Organized by: **Claudio Fontana** and **Alessandro Gnoatto**

MINI-SYMPOSIUM (ID 70): ID 586 (01)

Transfer Learning Across Fixed-Income Product Classes

Damir Filipović (*EPFL, Switzerland*); **Nicolas Camenzind** (*EPFL, Switzerland*)

Abstract: *Motivated by challenges in estimating discount curves from sparse or noisy data, we extend kernel ridge regression (KR) to a vector-valued setting, formulating a convex optimization problem in a vector-valued reproducing kernel Hilbert space (RKHS). Each component of the solution corresponds to the discount curve implied by a specific product class. We introduce an additional regularization term motivated by economic principles, and show that it leads to a valid separable kernel structure. We further provide a Gaussian process interpretation of vector-valued KR, enabling quantification of estimation uncertainty. An extensive masking experiment demonstrates that transfer learning significantly improves extrapolation performance.*

MINI-SYMPOSIUM (ID 70): ID 547 (02)

Invariant Spaces for Kernel Interpolation Schemes of the Discount Curve

Andreas Celary (*WU Vienna, Austria*); **Zehra Eksi-Altay** (*WU Vienna, Austria*); **Paul Eisenberg** (*WU Vienna, Austria*); **Damir Filipović** (*EPFL, Switzerland*)

Abstract: *We aim at developing a framework to use an affine set of curves to model possible zero coupon bond price curves. We use a combination of kernel ridge regression and a dimensional reduction scheme based on the Nyström algorithm to identify this set of curves. The methodology is specifically set up in a way such that unconstrained volatility estimation remains possible after the affine set of possible bond price curves has been estimated.*

MINI-SYMPOSIUM (ID 70): ID 590 (03)

Cross-Currency Heath-Jarrow-Morton Framework in the Multiple-Curve Setting

Silvia Lavagnini (*BI Norwegian Business School, Norway*); **Alessandro Gnoatto** (*Università degli studi di Verona, Italy*)

Abstract: *We provide a general HJM framework for forward contracts written on abstract market indices with arbitrary fixing and payment adjustments, and collateralization in any currency denomination. First, we study cross-currency markets under collateralization and incompleteness. Then, we treat collateral dislocations by describing the instantaneous cross-currency basis spreads by means of HJM models. This framework simultaneously covers forward-looking risky IBOR rates, such as EURIBOR, and backward-looking rates based on overnight rates, such as SOFR. Given the discrepancies in market conventions of different currency areas created by the benchmark transition, this is pivotal for describing multi-currency interest-rate portfolios.*

MINI-SYMPOSIUM (ID 70): ID 729 (04)

On the Hull-White model with volatility smile for Valuation Adjustments

Lech Grzelak (*University of Utrecht, Mathematical Institute, Mathematical Modelling, Netherlands*); **Thomas Van Der Zwaard** (*Rabobank, Netherlands*); **Cornelis Oosterlee** (*University of Utrecht, Mathematical Institute, Mathematical Modelling, Netherlands*)

Abstract: *Affine Diffusion (AD) models are widely used in xVA calculations for their analytic tractability but cannot capture market-implied skew and smile. We address this by introducing an SDE with state-dependent coefficients formed as a convex combination of multiple AD dynamics. Specifically, we combine Hull–White one-factor models with one varying parameter and parameterize the mixture using the Randomized AD (RAnD) technique, yielding the rHW model. The framework enables semi-analytic calibration to European swaptions while preserving Hull–White tractability. Using regression-based Monte Carlo, we compute exposures and show that skew and smile significantly influence exposures and xVAs for linear and early-exercise derivatives.*

Stochastic control, Reinforcement learning and applications in finance - Aula B

Organized by: **Jiacheng Zhang** and **Shuoqing Deng**

MINI-SYMPOSIUM (ID 107): ID 570 (01)

Optimization of win martingales

Xin Zhang (*New York University, United States*); **Julio Backhoff** (*University of Vienna, Austria*); **Zhizhang Wang** (*Fudan University, China*)

Abstract: *Prediction market is a market where people can trade based on outcomes of future events. It is widely used in sports games, elections, and pricing of digital options. In math finance, prediction markets can be modeled by the so-called win martingales, which are continuous time martingales that end up with Bernoulli distributions. In this talk, choosing different divergences as objective functionals, we will solve a class of optimal win martingales. In some cases, we will get explicit formulas of optimizers, and make connections to Schrödinger, filtering problems, Wright-Fisher diffusion, and the problem of identifying most exciting games.*

MINI-SYMPOSIUM (ID 107): ID 693 (02)

Simple Policies for Long Horizons: Reinforcement Learning in Finite-Horizon LQ Control

Anran Hu (*Columbia University, United States*)

Abstract: *Finite-horizon LQ control problems typically require time-varying policies, which are computationally and statistically expensive to learn. We propose a "simple-agent' ' perspective, restricting learning to stationary policies to leverage simpler policy classes and lower-variance gradient estimates. We prove this restriction is asymptotically cost-free in long-horizon tasks, as the performance gap vanishes as the horizon grows. We establish that stationary-policy gradient methods converge to near-optimal controllers in both fully known model and reinforcement learning settings. Numerical experiments confirm the theory and illustrate the practical efficiency gains from learning stationary controllers in long-horizon tasks.*

ORAL ID 507 (03)

Firm's Response to Adverse Weather Events: Risk Management or Market Exit?

Carlos Miguel Dos Santos Oliveira (*ISEG Lisbon School of Economics and Management, Portugal*); **Rita Pimentel** (*NTNU Trondheim, Norway*)

Abstract: *As climate-related adverse events become more frequent, firms face growing exposure to sudden revenue losses. While some losses can be compensated ex post, their long-run economic effects may persist, raising a fundamental strategic question: should the firm exit immediately or invest in mitigation measures that reduce the impact of future shocks, preserving the option to exit later? We model this trade-off as an optimal stopping problem with revenue following a geometric Brownian motion and adverse events arriving via a Poisson process. The optimal policy features a disconnected stopping region, reflecting the interaction between revenue risk, irreversible losses, and mitigation incentives.*

Asset Allocation/Optimal Investment/Portfolio Theory - Aula C

ORAL ID 492 (01)

Carbon-Sensitive Fund Construction and Hedging for Green Unit-Linked Life Insurance

Daniele Mancinelli (*Politecnico di Milano, Department of Mathematics, Italy*); **Katia Colaneri** (*University of Rome - Tor Vergata, Italy*); **Alessandra Cretarola** (*University of Chieti-Pescara, Italy*); **Edoardo Lombardo** (*Department of Economics and Finance, University of Rome Tor Vergata, Italy*)

Abstract: *We study the problem of hedging unit-linked life insurance policies whose benefits depend on an investment fund meeting environmental criteria. Offering such products poses two key challenges: constructing a green investment fund and developing a hedging strategy for policies written on that fund. We address these issues separately. First, we propose a portfolio selection rule based on firms' carbon intensity that endogenously selects assets, avoiding ad hoc pre-screening based on ESG scores. Second, we tackle the hedging problem using a quadratic approach. Finally, we conduct a numerical analysis to assess hedging performance.*

ORAL ID 282 (02)

Incentives of Defined-Contribution Pension Managers

Ho Man Tai (*University of Sydney, Australia*); **Paolo Guasoni** (*Dublin City University, Italy*); **Bohan Li** (*Soochow University, China*); **Tak Kwong Wong** (*Shenzhen University, China*); **Sheung Chi Phillip Yam** (*The Chinese University of Hong Kong, Hong Kong*)

Abstract: *We study how common asset-based fees shape investment in defined-contribution pension funds. We model a manager with intertemporal utility who invests a constant stream of contributions over members' working lives. Unlike standard risk-shifting results, a manager with the same preferences as members optimally takes* less *risk than members would choose, due to consumption smoothing and fees tied to current assets rather than total wealth. We characterize the problem via a fully nonlinear HJB equation, prove the value function is well posed, and compute optimal strategies using an efficient numerical scheme suited to the equation's nonlinearity and unbounded domain.*

ORAL ID 372 (03)

Climate-Driven Financial Risk and Optimal Portfolio Choice with Temperature-Linked Derivatives

Immacolata Oliva (*Sapienza Università di Roma, Italy*); **Giacomo Zarfati** (*Sapienza Università di Roma, Italy*); **Fred Espen Benth** (*BI Norwegian Business School, Norway*)

Abstract: *Climate change has been strongly affecting the economy. Temperature, extreme heat or cold waves, matter for markets and investment decisions. Evidence links temperature variability to output, productivity, and employment, with larger impacts in poorer economies. This motivates demand for instruments that hedge temperature risk, including HDD and CDD futures. We propose an optimal investment strategy that adds a temperature-linked derivative to a dynamic portfolio choice problem. Interest rates follow a CIR process and temperature follows a seasonal mean reverting model. Under CRRA utility, we solve by dynamic programming and compare strategies with and without weather hedges using synthetic performance measures.*

ORAL ID 244 (04)

Periodic Evaluation with Non-Concave Utility

Cong Qin (*Shanghai University of Finance and Economics, China*); **Chen Yang** (*The Chinese University of Hong Kong, Hong Kong*); **Harry Zheng** (*Imperial College London, United Kingdom*)

Abstract: *The performance of fund managers is periodically evaluated against benchmarks, and they face constraints like limited leverage and forced liquidation. We model the manager's strategy through a periodic evaluation problem with non-concave utility, a stochastic reference point, and trading constraints. The value function is characterized as the unique solution to an HJB equation with periodic terminal and boundary conditions, possibly with discontinuities. Interactions between non-concave utility and future opportunities cause substantial changes in risk aversion near evaluation time, leading to highly nonlinear investment strategies that help explain complex trading behaviors when the fund underperforms the benchmark.*

Econometrics and Financial Statistics - Aula D

ORAL ID 227 (01)

On lead-lag estimation of non-synchronously observed point processes

Takaaki Shiotani (*The University of Tokyo, Japan*); **Takaki Hayashi** (*Keio University, Japan*); **Takaki Hayashi** (*Keio University, Japan*); **Yuta Koike** (*The University of Tokyo, Japan*)

Abstract: *We introduce a new theoretical framework for analyzing lead-lag relationships between high-frequency order arrivals. Specifically, we formulate the problem in terms of the cross-pair correlation function (CPCF) of point processes and define the estimand as its peak location. This offers a statistical interpretation of the seminal Dobrev and Schaumburg's method. We then propose a more natural estimator based on kernel smoothing with an adaptive bandwidth selection procedure. We prove that our estimator achieves the near-optimal convergence rate for the peak estimation problem. We further validate the proposed method through simulations and real-data analysis, demonstrating its empirical advantages.*

ORAL ID 31 (02)

Prediction of linear fractional stable motions using codifference, with application to non-Gaussian rough volatility

Matthieu Garcin (*ESILV, France*); **Karl Sawaya** (*EPFL, Switzerland*); **Thomas Valade** (*Ecole Polytechnique, France*)

Abstract: *Time series of volatilities show fractal properties, consistently with the fractional Brownian motion (fBm) and the rough paradigm, but empirical studies show they are non-Gaussian. The fractal feature is to be decomposed in serial dependence and tailedness. The linear fractional stable motion (LFSM) extends the fBm by considering alpha-stable increments. We propose a method to forecast future increments of the LFSM from past discrete-time observations. It relies on the codifference, which describes the serial dependence of the process, instead of the covariance, which is infinite when alpha<2. Simulations and application to real volatility data confirm the relevance of the approach.*

ORAL ID 172 (03)

A New Coupling Construction for Markov Chains in Random Environments with Applications in Financial Mathematics

Attila Lovas (*HUN-REN Alfred Renyi Institute of Mathematics and Budapest University of Technology and Economics, Hungary*); **Miklos Rasonyi** (*Alfréd Rényi Institute of Mathematics and Eötvös Lorand University, Hungary*); **Lionel Truquet** (*CREST-ENSAI, UMR CNRS 9194, Bruz, France, France*)

Abstract: *We consider Markov chains in stationary random environments, defined as the sum of a contractive random mapping and a possibly unbounded perturbation. Under a novel, slightly nonstandard local minorization condition, we establish convergence to a unique limiting law with explicit rates. Furthermore, we prove strong mixing properties and provide estimates for the associated α-mixing coefficients. These results considerably extend the existing theory. Applications include a discrete-time stochastic volatility model for asset prices and iterative value-at-risk estimation via stochastic gradient Langevin dynamics, demonstrating the practical relevance of our theoretical results in financial mathematics.*

ORAL ID 7 (04)

Optimal Backtest Design: The Bias-Variance Tradeoff of Aggregated Backtests

Andrew Paskaramoorthy (*University of Cape Town, South Africa*); **Tim Gebbie** (*University of Cape Town, South Africa*); **Terence Van Zyl** (*University of Johannesburg, South Africa*)

Abstract: *Rolling-window backtests are widely used to evaluate portfolio rules but suffer from low statistical power. Naive bootstrap aggregation reduces variance but introduces bias by disrupting temporal dependence. We analytically quantify the bias-variance trade-off between preserving temporal structure and minimising variance via bagging. We demonstrate that both rolling-window and bagged estimators share an irreducible variance component associated with long-term performance, whereas the bias-variance trade-off is confined to the temporal predictability component. We derive a novel critical sample size threshold below which bagging yields a lower Mean Squared Error, challenging the exclusive reliance on rolling windows.*

Beyond Gaussian modelling in finance - Aula E

Organized by: **Giovanni Amici, Laura Ballotta** and **Patrizia Semeraro**

MINI-SYMPOSIUM (ID 147): ID 524 (01)

Navigating Supply Shocks: Sector Resilience and Production Prices through Stochastic Input-Output Modeling

Annamaria Gambaro (*Università del Piemonte Orientale, Italy*)

Abstract: *This study develops a novel multivariate stochastic framework for assessing systemic risks, such as climate and nature-related shocks, within production networks. By embedding a linear stochastic fluid network, interpretable as a generalized vector Ornstein-Uhlenbeck process, into the network of interdependent industries, the model captures how shocks propagate through input-output (IO) linkages and affect price dynamics. Contributing to the literature on Markovian networks, the model introduces the concept of divisible shocks, allowing for finer-grained simulation of adaptation responses across sectors. Empirical calibration leverages real-world economic data. Sensitivity analyses are conducted using distributional risk measures, offering new tools for stress testing.*

MINI-SYMPOSIUM (ID 147): ID 527 (02)

A Simulation Scheme for Martingale Diffusions with Explicit Marginals

Michele Azzone (*Politecnico di Milano, Italy*); **Lorenzo Torricelli** (*Università di Bologna, Italy*); **Marco Vitelli** (*Università di Bologna, Italy*)

Abstract: *We propose the Shifted Euler scheme to simulate local volatility models with short-time explosions, such as the Generalized Beta Local Volatility (GBLV) model. This framework features explicit marginal distributions compatible with a purely discontinuous martingale. Standard Euler schemes fail here due to the diffusion coefficient singularity at t=0. Our hybrid approach bypasses this by leveraging the explicit law for the first increment. We also detail strategies to accelerate local volatility evaluation, the primary numerical bottleneck. Experiments confirm superior efficiency and accuracy compared to standard techniques.*

MINI-SYMPOSIUM (ID 147): ID 564 (03)

Hierarchical NIG Factor Model: An EM-Based Estimation Approach

Luca Luigi Alberici (*Bayes Business School, United Kingdom*); **Laura Ballotta** (*Bayes Business School, United Kingdom*); **Gianluca Fusai** (*Bayes Business School, United Kingdom*)

Abstract: *The aim of this paper is to estimate a non-Gaussian factor model by exploiting a hierarchical representation of the underlying distributions, which allows the model to be naturally expressed in terms of latent variables and substantially simplifies statistical inference. Within this framework, parameter estimation is carried out using the EM algorithm, which efficiently leverages the mixture representation to handle latent components in an iterative and tractable manner. In particular, we revisit the multivariate NIG factor model, formulated as a Gaussian-Inverse Gaussian mixture, by allowing the latent mixing variable to affect both the mean and the variance of the Gaussian distribution.*

MINI-SYMPOSIUM (ID 147): ID 683 (04)

Additive time-change of multiparameter Markov processes

Giuseppe D'onofrio (*Politecnico di Torino, Italy*); **Alessandro Mutti** (*Politecnico di Torino, Italy*); **Patrizia Semeraro** (*Politecnico di Torino, Italy*)

Abstract: *In this work, we consider, in a general setting, multiparameter multidimensional Markov processes that are time-changed by an independent additive subordinator. By extending Phillips theorem, we show that the resulting process is a Feller evolution and we characterize its generator. We further derive its pseudo-differential representation and show that its symbol admits a Lévy-Khintchine representation. As an application, we consider a factor-based specification for the Ornstein-Uhlenbeck process subordinated by a Sato process. The constructive nature of this process is inspired by applications in finance.*

Rough Volatility in 2026 part 2: Modelling and pricing challenges for derivatives - Aula F

Organized by: **Mathieu Rosenbaum**

MINI-SYMPOSIUM (ID 166): ID 612 (01)

Volterra equations with affine drift: looking for stationarity with application to the quadratic rough Heston model

Gilles Pagès (*Sorbonne Université, France*)

Abstract: *We first prove that solutions of Volterra equations with affine mean-reverting drift have no stationary regime, except if the kernel is constant or in some degenerate settings. We introduce a deterministic "stabilizer" producing a fake stationary regime where all marginals share the same expectation and variance. Moreover, the paths of such stabilized processes are quadratically confluent When the diffusion coefficient is the square root of a positive quadratic polynomial, the shifted process weakly functionally converges toward anL^2-stationary process. We apply these results to quadratic rough volatility models when the kernel$K(t) = t^{H-1/2}/\Gamma(H+1/2), 0 < H < 1/2$.*

MINI-SYMPOSIUM (ID 166): ID 686 (02)

Quadratic Rough Heston: SPX, VIX, and the SSR

Florian Bourgey (*Bloomberg, United States*); **Jim Gatheral** (*Baruch college, United States*)

Abstract: *We extend the hybrid scheme of Gatheral (2022) and apply the finite difference methodology of Bourgey et al. (2024) to compute the skew-stickiness ratio (SSR) under quadratic rough Heston. We find that the quadratic rough Heston model not only provides good joint fits to both SPX and VIX volatility smiles but also produces credible SSR values, while remaining extremely parsimonious. By examining the historical evolution of the quadratic rough Heston model, and relating it to well-known classical stochastic volatility models, we can begin to understand the underlying reasons for its seemingly unreasonable effectiveness.*

MINI-SYMPOSIUM (ID 166): ID 696 (03)

Smile Dynamics and Rough Volatility

Florian Bourgey (*Bloomberg, United States*)

Abstract: *We study the Skew Stickiness Ratio (SSR) in rough volatility models and compare it with SPX data. Calibrated to the SPX implied volatility term structure, these models produce SSRs close to those of classical forward variance models, suggesting that roughness alone has limited impact on spot–volatility dynamics. Additionally, building on the Bergomi–Guyon expansion, we derive and validate next-to-leading order approximations for the SSR across several calibrated models. This is joint work with Stefano De Marco and Jules Delemotte.*

ORAL ID 152 (04)

Neural Stochastic Volterra Equations

Martin Bergerhausen (*University of Mannheim, Germany*); **David J. Prömel** (*University of Mannheim, Germany*); **David Scheffels** (*University of Mannheim, Germany*)

Abstract: *Stochastic Volterra equations (SVEs) generalize stochastic differential equations by allowing for memory effects and highly irregular paths, as required in modern financial models such as rough volatility. We present neural stochastic Volterra equations, a physics-inspired learning architecture for path-dependent dynamics, extending neural SDEs. We provide theoretical results on stability and approximation of SVEs and demonstrate the approach on several models, including the rough Heston model and a monetary reserve dynamics. Numerical experiments show substantial performance gains over neural SDEs and Deep Operator Networks.*

Reinforcement Learning and Stochastic Control - Aula P

ORAL ID 444 (01)

Thompson Sampling Algorithm for Stochastic Games

Yuqiong Wang (*University of Michigan, United States*); **Asaf Cohen** (*University of Michigan, United States*); **Ruolan He** (*University of Michigan, United States*)

Abstract: *We study a stochastic differential game with N competitive players in a linear-quadratic framework with ergodic cost, whered-dimensional diffusion processes govern the state dynamics with an unknown common drift (matrix). Assuming a Gaussian prior on the drift, we use filtering techniques to update its posterior estimates. Based on these estimates, we propose a Thompson-sampling-based algorithm with dynamic episode lengths to approximate strategies. We show that the Bayesian regret has an error bound of order $O(\sqrt{T\log(T)})$, where T is the time-horizon, independent of the number of players. Finally, we show that the algorithm results in a Nash equilibrium.*

ORAL ID 303 (02)

Markov Decision Processes of the Third Kind: Learning Distributions by Policy Gradient Descent

Athanasios Vasileiadis (*Karlsruhe Institute of T, Germany*); **Nicole Bäuerle** (*Karlsruhe Institute of T, Germany*)

Abstract: *In this talk we will introduce and analyze a Policy Gradient algorithm for distributional Markov Decision Processes as a class of control problems in which the objective is to learn policies that steer the distribution of a cumulative reward toward a prescribed target law, rather than optimizing an expected value or a risk functional. We prove convergence of the algorithm to stationary points using stochastic approximation techniques. Several numerical experiments illustrate the ability of the method to match complex target distributions, recover classical optimal policies when they exist, and reveal intrinsic non-uniqueness phenomena specific to distributional control.*

ORAL ID 395 (03)

Adaptive Partitioning and Learning for Stochastic Control of Diffusion Processes

Hanqing Jin (*University of Oxford, United Kingdom*); **Renyuan Xu** (*Stanford University, United States*); **Yanzhao Yang** (*University of Oxford, United Kingdom*)

Abstract: *We study reinforcement learning for controlled diffusion processes with unbounded continuous states, bounded actions, and polynomially growing rewards, motivated by applications in finance and operations research. We propose a model-based algorithm that adaptively partitions the state–action space, estimating drift, volatility, and rewards within each region and refining the partition when bias exceeds statistical confidence. This approach balances exploration and approximation in high-dimensional, unbounded domains. We derive regret bounds depending on horizon, dimension, reward growth, and a new zooming dimension for diffusions, recovering bounded-case results and extending guarantees to broader settings. Numerical experiments demonstrate strong performance, including in high-dimensional portfolio optimisation.*

ORAL ID 169 (04)

When Reinforcement Learning Aligns with Estimate-Then-Plug-In? Insights from Continuous-Time Portfolio Selection

Min Dai (*The Hong Kong Polytechnic University, Hong Kong*); **Yanwei Jia** (*The Chinese University of Hong Kong, Hong Kong*); **Zhichao Lu** (*The Hong Kong Polytechnic University, Hong Kong*)

Abstract: *Continuous-time RL methods are recently developed for dynamic financial decision-making; however, it remains an open question whether RL improves the traditional estimate-then-plug-in approach; and if so, where such improvements originate. In this paper, we investigate these questions in continuous-time portfolio optimization, specifically q-learning for Merton's problem with transaction costs. Our results demonstrate that the policy learned by RL, given any finitely-long continuous price trajectories, coincides with the solution obtained via the estimate-then-plug-in approach. By contrast, empirical studies reveal outperformance of the proposed RL method over the estimate-then-plug-in approach in realistic settings, owing to complex features of real-world price dynamics.*

Climate Finance - Aula Q

ORAL ID 224 (01)

Trapped by Climate Stress: Vulnerability Dynamics and Sovereign Credit Risk

Eva Lütkebohmert (*University of Freiburg, Germany*); **Hongyi Shen** (*University of Freiburg, Germany*)

Abstract: *We develop an integrated dynamic framework to assess how climate vulnerability affects sovereign credit risk. Climate vulnerability is modeled using a Hidden Markov Model with resilient and vulnerable states, whose transition probabilities depend endogenously on macro-fiscal stress. Vulnerability influences sovereign credit ratings both indirectly, through its impact on economic output and macro-fiscal performance, and directly, through perceptions of a country's capacity to absorb and recover from shocks. We incorporate both macro-fiscal variables and vulnerability into a random forest-based rating model and use SHAP values to quantify macro-fiscal stress and its interaction with climate vulnerability.*

ORAL ID 119 (02)

Decarbonization, Public Debt, and Sovereign Credit Risk in Europe: Interaction Effects and Spillovers

Luca Zanin (*Prometeia, Italy*); **Graziano Moramarco** (*University of Bologna, Italy*)

Abstract: *We investigate the hypothesis that a country's reduction in emissions, together with its public debt burden, jointly shape its sovereign credit risk. Our analysis focuses on 27 European countries over the period 2010-2024. Our findings suggest that a country's progress in decarbonization, along with its level of indebtedness, plays a significant role in determining sovereign risk. Delays in the decarbonization increase credit risk. Such an effect is amplified in the presence of high public debt. Moreover, Our results indicate that these transition-related effects on sovereign CDS propagate across borders through financial linkages, suggesting positive externalities of decarbonization for financial stability.*

ORAL ID 424 (03)

Optimal Dividend Policy under Global Warming

Moussa Diakho (*University of Rennes, France*); **Franck Moraux** (*University of Rennes, France*); **Franck Moraux** (*University of Rennes, France*)

Abstract: *This paper investigates how global warming affects the optimal dividend policy of heat-dependent firms. We embed global-warming dynamics into the De Finetti-style payout framework of Radner and Shepp (1996): rising temperatures induce a deterministic early termination of business activity. The optimal policy is obtained by solving a finite-horizon singular control problem with a temperature-driven terminal condition. The dividend barrier is time-varying and declines to zero as termination approaches, depleting cash reserves. Greater cash-flow volatility and lower preference for immediacy raise the dividend barrier. We examine one-time adaptation investments that increase the firm's tolerance to heat and postpone business termination.*

ORAL ID 252 (04)

Carbon Sink Valuation and Sovereign Risk: Modelling Carbon Offset Swap Lines and Forest Optimization under Climate Risk

Giorgio Bongermino (*Università di Bologna, Italy*); **Andrea Macrina** (*Department of Mathematics, University College London, United Kingdom*); **Silvia Romagnoli** (*Università di Bologna, Italy*)

Abstract: *This abstract develops a quantitative framework integrating carbon sink valuation, Carbon Offset Swap Line (COSL) pricing, and dynamic forest-use optimization under physical climate risk. Forests are modeled as productive natural assets generating stochastic sequestration cash flows subject to non-permanence risk. Carbon sink values are computed using flow-based and discounted cash-flow methods with climate-risk adjustments, linked econometrically to sovereign spreads, and used to derive risk-neutral COSL prices. Embedding these components in a dynamic control problem shows how COSLs raise optimal conservation and reduce external financing costs.*

Learning in Dynamic Games: Theory, Algorithms and Applications - Part 2 - Aula H

Organized by: **Mathieu Laurière** and **Yufei Zhang**

MINI-SYMPOSIUM (ID 426): ID 642 (01)

Population-Aware Imitation Learning in Mean-field Games with Common Noise

Grégoire Lambrecht (*New York University, United States*); **Mathieu Laurière** (*NYU Shanghai, China*)

Abstract: *Mean Field Games (MFGs) provide a framework for modeling large populations of interacting agents. We study imitation learning in MFGs with common noise, where the population distribution evolves stochastically and agents must adopt population-aware policies to respond to aggregate shocks. We consider two learning objectives: recovering a Nash equilibrium and matching the performance of an expert population. Using behavioral cloning and adversarial divergence as imitation proxies, we establish finite-sample error bounds controlling exploitability and performance gaps. We propose a numerical framework based on generalized Fictitious Play and deep learning, and show that population-unaware policies fail to capture equilibrium dynamics.*

MINI-SYMPOSIUM (ID 426): ID 650 (02)

A Two Time-Scale Evolutionary Game Approach to Multi-Agent Reinforcement Learning and Its Application in Algorithmic Collusion Studies

Nan Chen (*The Chinese University of Hong Kong, Hong Kong*); **Mingyue Zhong** (*The Chinese University of Hong Kong, Hong Kong*); **Yumin Xu** (*Peking University, China*); **Ruixun Zhang** (*Peking University, China*)

Abstract: *We propose a two-time-scale evolutionary game approach to multi-agent reinforcement learning. The algorithm combines perturbed best response for policy updates, fictitious play for belief updates, and separate learning rates for policies, beliefs, and Q-values. It provably converges to ε-Nash equilibria in general-sum MARL settings without restrictive assumptions. Motivated by concerns that AI pricing algorithms may learn to collude, our framework addresses the instability of standard Q-learning in multi-agent environments. It offers a tractable and robust foundation for studying algorithmic collusion. Numerical results show that initial hyperparameters and algorithmic sophistication significantly influence the likelihood of collusion emerging.*

MINI-SYMPOSIUM (ID 426): ID 682 (03)

On Approximate Nash Equilibria in Mean Field Games

Nizar Touzi (*New York University, United States*)

Abstract: *In the context of large population symmetric games, approximate Nash equilibria (NE) are introduced through equilibrium solutions of the corresponding mean field game in the sense that the individual gain from optimal unilateral deviation converges to zero in the large population size asymptotic. We show that these strategies satisfy an L-infinity notion of approximate NE which guarantees that the individual gain from unilateral deviation is small uniformly among players and uniformly on their characteristics. We establish these results in static and dynamic continuous time settings, allowing for agents' criteria depending on the conditional law of the controlled state process.*

MINI-SYMPOSIUM (ID 426): ID 687 (04)

Sample-Efficient Learning of Quantal Leader-Follower Mean-Field Games

Weizheng Zhang (*University of Toronto, Canada*); **Wenlong Mou** (*University of Toronto, Canada*); **Sebastian Jaimungal** (*University of Toronto, Canada*)

Abstract: *We study discrete-time episodic leader–follower mean-field games with a single leader and an infinite population of boundedly rational, myopic followers who respond via a quantal model. The leader seeks to maximize long-run reward while learning both the environment and the followers' response behavior under information asymmetry. We formulate learning the equilibrium using online RL and propose optimistic value-iteration algorithms with linear and RKHS function approximation. Our methods use parameter set elimination to infer followers' response models from aggregate data and establish high-probability sublinear regret bounds providing the first sample-efficient guarantees for learning such equilibria.*

Insurance and Actuarial Sciences - Aula I

ORAL ID 43 (01)

A stochastic SIR model for cyber contagion: application to granular growth of firms and to insurance portfolio

Lionel Sopgoui (*ENSAE, France*); **Caroline Hillairet** (*ENSAE, France*); **Olivier Lopez** (*ENSAE, France*)

Abstract: *This work assesses the impact of a cyber episode on firm financial health and an insurer's cyber portfolio. Building on empirical evidence of heavy-tailed firm dynamics and size-dependent cyber contagion, we develop a stochastic multi-group SIR model coupled with granular model of firm growth. Cyber-attack arrival and duration combine a Cox process for external contagion and a Bernoulli variable for intra-group spread. We establish existence, uniqueness, and stability results, and introduce CIR-driven SIR parameters to capture environmental variability. We use this model to quantify cyber-attack impacts on firms' financial health via revenue and on insurance portfolios via aggregate exceedance probability.*

ORAL ID 302 (02)

Optimal equilibrium in parametric insurance markets under basis risk

Davide Feleppa (*Sapienza Università di Roma, Italy*); **Immacolata Oliva** (*Sapienza Università di Roma, Italy*); **Andrea Macrina** (*Department of Mathematics, University College London, United Kingdom*)

Abstract: *This paper develops and solves a market equilibrium framework for parametric insurance in which the insurer acts as price maker, while the insured agent is price taker. The theoretical contribution of this paper is twofold. First, we propose a micro founded model in which the insurer strategically chooses the premium markup anticipating the insured's optimal demand for coverage. Second, we characterize the optimal insurance decision in the presence of basis risk and endogenous financing costs. The interaction between the two agents gives rise to a market equilibrium jointly defined by the optimal insurance markup and the equilibrium coverage level.*

ORAL ID 465 (03)

Threshold CPPI

Vinícius Grijó (*Vrije Universiteit Brussel, Belgium*); **Vinícius Grijó** (*Vrije Universiteit Brussel, Belgium*); **Carole Bernard** (*Vrije Universiteit Brussel, Belgium*)

Abstract: *High multipliers in Constant Proportion Portfolio Insurance (CPPI) increase expected returns but also the cash-lock risk. This work formally quantifies this risk in continuous time and introduces the Threshold CPPI, a two-regime extension designed to optimize this trade-off. We derive closed-form solutions for the strategy's moments, enabling analytic performance assessment. Results demonstrate that the Threshold CPPI yields a superior Sharpe ratio in high-volatility environments, while significantly mitigating cash-lock risk. This allows fund managers to employ aggressive multipliers that would be operationally infeasible in standard frameworks.*

ORAL ID 462 (04)

Insurance Risk Models with Epidemic Dynamics: Scaling Limits and Ruin Asymptotics

Jean-Francois Renaud (*Université du Québec à Montréal, Canada*)

Abstract: *Motivated by the interplay between epidemiological dynamics and insurance outcomes, we develop insurance risk models that link the claims process to the underlying status of an epidemic. More generally, our modelling framework applies to a portfolio of insurance policies that can be divided into sub-populations with different risk characteristics. We seek to understand the impact of contagion-driven transitions between health states on the aggregate claims process and, ultimately, the solvency of the portfolio. Our analysis focuses on two key aspects: scaling limits for the resulting risk processes, and bounds for the corresponding ruin probabilities.*

Signatures and Stochastic Dynamics - Aula L

ORAL ID 229 (01)

Semimartingality of signatures and applications to optimal control

Wouter Andringa (*University of Amsterdam, Netherlands*); **Drona Kandhai** (*University of Amsterdam, Netherlands*); **Michel Vellekoop** (*University of Amsterdam, Netherlands*); **Asma Khedher** (*University of Amsterdam, Netherlands*)

Abstract: *We consider utility indifference pricing and hedging in the signature volatility model. In this setting, the Markovian state space contains the signature of the Brownian motion driving the volatility. The derivation of the HJB equation demands semimartingality of this state space. We show that the signature of the Brownian motion is a semimartingale and we also give some extensions of this result by generalising a semimartingale convergence statement to Hilbert spaces. As a future work, we want to numerically solve the high-dimensional PDE by using the Deep 2BSDE method and we want to extend the semimartingality result to Lévy processes.*

ORAL ID 499 (02)

Linear independence properties of the signature components of time-augmented stochastic processes

Arthur Bourdon (*Ecole des Ponts ParisTech - CERMICS, France*); **Benjamin Jourdain** (*Ecole des Ponts ParisTech - CERMICS, France*); **Hervé Andrès** (*Milliman, France*)

Abstract: *Adding the time as a component of a path before computing its signature ensures injectivity and supports universal approximation results, but it induces linear dependence among terminal signature components. For a given order, terms associated with words of that length share the same span as those of lower orders. We identify other subfamilies of time-augmented signature components with identical spanning properties. We characterize bases of components which yields minimal computational cost using Chen's relation. We study linear independence of these families of signature terms for stochastic processes solving SDEs with additive Brownian noise and for sufficiently thin discretizations.*

ORAL ID 432 (03)

Universal Approximation for Functions of Infinite-Dimensional Signatures

Thijs Maessen (*University of Amsterdam, Netherlands*); **Asma Khedher** (*University of Amsterdam, Netherlands*); **Sonja Cox** (*University of Amsterdam, Netherlands*)

Abstract: *We establish universal approximation theorems for infinite-dimensional geometric rough paths, i.e., we show that continuous functions on the space of infinite-dimensional weakly geometric Hölder continuous rough paths can be approximated by functions that are linear in the signature of the path. The motivation for establishing universal approximation theorems lies in the desire to approximate quantities derived from the solution of a stochastic partial differential equation. More specifically, our universal approximation theorems form the foundations of a novel approach to e.g. pricing of forward rates within the Heath–Jarrow–Morton–Musiela framework.*

ORAL ID 360 (04)

Branching directed-chain diffusions with applications

Tomoyuki Ichiba (*University of California, Santa Barbara, United States*)

Abstract: *In this talk we discuss the system of branching diffusions interacting on infinite directed graph by a class of stochastic differential equations with distribution constraints. The distribution in the path space on infinite directed graph can be approximated quantitatively by the finite particle system. Combining neural network approximation with these diffusions of branching and voting schemes in genealogical trees, we propose a hybrid algorithm that solve high-dimensional parabolic PDEs with nonlinear interactions. We also discuss some financial application of such systems such as generative adversarial network and mean-field game problems.*

Recent Advances in Transform (Fourier/Laplace) Methods for Computational Finance and Risk Management - Part 2 - Aula M

Organized by: **Chiheb Ben Hammouda**

MINI-SYMPOSIUM (ID 759): ID 645 (01)

Efficient pricing of options on realized variance and volatility

Svetlana Boyarchenko (*University of Texas at Austin, United States*); **Sergei Levendorskii** (*Calico Consulting, United States*)

Abstract: *We construct several accurate and fast methods for pricing options on realized variance, realized volatility and quadratic variation in Lévy models. Generalizations to regime-switching Lévy models and stochastic volatility models are developed as well. We explain and illustrate with numerical examples that standard versions of Laplace inversion technique are less accurate and slower in applications to pricing options on realized variance, and not applicable for pricing options on realized volatility.*

MINI-SYMPOSIUM (ID 759): ID 634 (02)

Hierarchical Fourier Quadrature for Option Pricing under Rough Heston Models

Chiheb Ben Hammouda (*Utrecht University, Netherlands*); **Abderrahmene Ben Romdhane** (*King Abdullah University of Science and Technology | KAUST, Saudi Arabia*); **Michael Samet** (*RWTH Aachen University, Germany*); **Michael Samet** (*RWTH Aachen University, Germany*); **Raul Tempone** (*King Abdullah University of Science and Technology, Saudi Arabia*)

Abstract: *There is a resurgence of the use of Fourier methods for option pricing problems in models which exhibit memory effects. Particularly, Fourier pricing under the rough Heston model is challenging because it requires solving a fractional Riccati equation at each quadrature node. Observing that using a uniform discretization of the Riccati equation for all nodes is suboptimal, we design a hierarchical multilevel Fourier pricing method that adapts the time discretization across nodes. By combining multilevel quadrature with fractional Adams scheme, we significantly reduce the computational complexity for a prescribed accuracy. Numerical experiments confirm substantial runtime improvements over standard single-level approaches.*

MINI-SYMPOSIUM (ID 759): ID 628 (03)

Pricing path dependent options under stochastic volatility models with arbitrary accuracy. Part I: Theory and Methodology

Gero Junike (*LMU Munich, Germany*); **Riccardo Brignone** (*University of Pavia, Italy*)

Abstract: *We propose a methodology for pricing general path-dependent options, whose main benefit over existing literature consists in simple and effective error control. A practitioner simply provides two parameters: i) a probability q; ii) an error tolerance epsilon. Then, our algorithm provides a price approximation that differs by no more than epsilon from the true unknown option price with probability q. The methodology works for a broad class of stochastic volatility models and path-dependent payoffs, and it is based on the Monte Carlo-Conditional Fourier-cosine method. In this talk, we focus on theoretical aspects of methodology.*

MINI-SYMPOSIUM (ID 759): ID 641 (04)

Pricing path dependent options under stochastic volatility models with arbitrary accuracy. Part II: Applications and numerical performance

Riccardo Brignone (*University of Pavia, Italy*); **Gero Junike** (*LMU Munich, Germany*)

Abstract: *We propose a methodology for pricing general path-dependent options, whose main benefit over existing literature consists in simple and effective error control. A practitioner simply provides two parameters: i) a probability q; ii) an error tolerance epsilon. Then, our algorithm provides a price approximation that differs by no more than epsilon from the true unknown option price with probability q. The methodology works for a broad class of stochastic volatility models and path-dependent payoffs, and it is based on the Monte Carlo-Conditional Fourier-cosine method. In this talk, we focus on computing time management techniques, applications and numerical results.*

Path-dependent and signature modeling in finance - Part 1 - Aula A

Organized by: **Christa Cuchiero** and **Luca Pelizzari**

MINI-SYMPOSIUM (ID 312): ID 566 (01)

A joint framework for SPX, VIX and VXX

Andrea Stanghellini (*University of Verona, Italy*); **Sara Svaluto-Ferro** (*University of Verona, Italy*); **Martino Grasselli** (*University of Padova, Italy*)

Abstract: *This article introduces a signature-based framework for the joint modeling of the S&P 500 index, the CBOE Volatility Index (VIX), and the iPath S&P 500 VIX Short-Term Futures ETN (VXX). The VIX is modeled as a linear functional of the signature of an underlying polynomial process, allowing us to derive closed-form dynamics for VIX futures and the VXX by exploiting explicit formulas for expected signatures. Using the analytical definition of the VIX, we also recover the SPX volatility as a signature functional. The model yields a coherent description of the joint dynamics and delivers consistent results across the three markets.*

MINI-SYMPOSIUM (ID 312): ID 578 (02)

Universal approximation with signatures of non-geometric rough paths

Mihriban Ceylan (*University of Mannheim, Germany*); **Anna Kwossek** (*University of Vienna, Austria*); **David J. Prömel** (*University of Mannheim, Germany*)

Abstract: *Recently, data-driven methods based on path signatures have gained prominence in mathematical finance. They rely on universal approximation theorems stating that continuous functionals on path space can be approximated by linear functionals of the signature. In financial applications, this has led to the use of Stratonovich-signatures, although Itô integration is the natural modeling framework. In this talk, we establish a universality result for signatures of non-geometric rough paths. By extending the path with its rough path bracket, we obtain a quasi-shuffle structure providing the algebraic basis for universality. In probabilistic settings, this yields a universal approximation property for Itô-signatures.*

MINI-SYMPOSIUM (ID 312): ID 579 (03)

The Volterra signature

Luca Pelizzari (*University of Vienna, Austria*); **Paul Peter Hager** (*University of Vienna, Austria*); **Fabian Harang** (*BI Norwegian Business School, Norway*); **Samy Tindel** (*Purdue University, United States*)

Abstract: *In this talk, we introduce the Volterra signature—an extension of Chen's path signature that incorporates memory kernels into the iterated integrals. The additional flexibility provided by the kernel yields a memory-aware feature map for machine-learning applications to time-series data. In the first part, we discuss learning-theoretic results, including universal approximation theorems on path spaces and PDE-based kernel tricks for the associated RKHS. Moreover, we present practical algorithms to compute Volterra signatures and demonstrate first applications on synthetic and real data. If time permits, we discuss ongoing research on stochastic Volterra signatures, including expected signatures, stochastic Taylor expansions, and approximation results.*

MINI-SYMPOSIUM (ID 312): ID 583 (04)

The Fading Memory Signature

Eduardo Abi Jaber (*Ecole Polytechnique, France*); **Dimitri Sotnikov** (*Ecole Polytechnique, France*)

Abstract: *We introduce a time-invariant version of the signature: the fading-memory signature, and establish powerful algebraic, analytic and probabilistic properties with applications to learning stationary relationships in time series. This is based on joint work with Dimitri Sotnikov.*

Rough, pathwise and mean-field analysis in finance - Part 2 - Aula G

Organized by: **Anna Kwossek** and **Paul Hager**

MINI-SYMPOSIUM (ID 102): ID 660 (01)

Fractional invariance principles and rough paths

Dörte Kreher (*Humboldt University of Berlin, Germany*); **Tomás Laengle-Aliaga** (*Humboldt University of Berlin, Germany*)

Abstract: *In this talk, we present a fractional invariance principle in rough path topology, i.e. we consider a centered, strictly stationary discrete-time process, satisfying a long-range dependence condition, and establish weak convergence of the canonical lift of the linearly interpolated scaled random walk towards enhanced fractional Brownian motion with Hurst parameter $1/3<H<1/2$ under suitable moment conditions. By continuity of the Itô–Lyons map, the result directly allows to study weak convergence of solutions to random RDEs. We study several examples, including scheduled traffic processes, moving average processes, and negatively correlated random walks.*

MINI-SYMPOSIUM (ID 102): ID 633 (02)

Signature McKean-Vlasov Equations

Julian Pachschwöll (*University of Vienna, Austria*); **Christa Cuchiero** (*University of Vienna, Austria*)

Abstract: *In this talk, based on joint work with Christa Cuchiero, we introduce a tractable class of law-dependent SDEs coined Signature McKean-Vlasov SDEs. The interaction is driven by the truncated expected signature of the underlying process. We show that the latter satisfies a non-linear finite-dimensional ODE with a unique global solution, effectively decoupling the macroscopic law from the microscopic agent dynamics. We establish global existence for the full system, addressing non-Lipschitz square-root diffusion coefficients by lifting the problem to the tensor algebra and applying the Positive Maximum Principle. Finally, we extend this framework to include common noise for systemic risk applications.*

MINI-SYMPOSIUM (ID 102): ID 546 (03)

Universal approximation on non-geometric rough paths and applications to financial derivatives pricing

Fride Straum (*NTNU Trondheim, Norway*); **Fabian Harang** (*BI Norwegian Business School, Norway*); **Fred Espen Benth** (*BI Norwegian Business School, Norway*)

Abstract: *We present a novel perspective on the universal approximation theorem for rough path functionals, introducing a polynomial-based approximation class. We extend universal approximation to non-geometric rough paths within the tensor algebra. This development addresses critical needs in finance, where no-arbitrage conditions necessitate Itô integration. Furthermore, our findings motivate a hypothesis for payoff functionals in financial markets, allowing straightforward analysis of signature payoffs proposed in Arribas 2018.*

MINI-SYMPOSIUM (ID 102): ID 526 (04)

Pathwise stochastic integration for model-free finance

Purba Das (*King's College London, United Kingdom*); **Anna Kwossek** (*University of Vienna, Austria*); **David J. Prömel** (*University of Mannheim, Germany*)

Abstract: *In this talk, we take a model-free approach to mathematical finance and study a pathwise construction of stochastic integrals: Using the concepts of quadratic variation and Lévy area of a continuous path along a sequence of time partitions, we construct a pathwise integral as a limit of Riemann sums. In a probabilistic framework when the underlying process is a semimartingale, this notion of integration is consistent with stochastic (Itô) integration. Furthermore, we state necessary and sufficient conditions for the quadratic variation and Lévy area of a continuous path to be invariant with respect to the choice of the partition sequence.*

Optimal Transport and Robust Modeling - Aula B

Organized by: **Armand Ley, Evgeny Kolosov, Antonio Marini**

MINI-SYMPOSIUM (ID 513): ID 543 (01)

q-Bass martingales: properties and applications

Antonio Marini (*ETH Zurich, Switzerland*)

Abstract: *This talk presents recent progress on q-Bass martingales, a martingale optimal transport–inspired construction that extends the Bass martingale by replacing the Gaussian reference with a general distribution q. Focusing on the one-dimensional setting, a geometric perspective on the associated existence problem is developed based on integrated quantile functions. This viewpoint clarifies the structure of the fixed-point distribution behind the construction and highlights its key properties. I will also discuss the calibration of generalizations of the Bass-LV model based on q-Bass martingales and outline connections with optimal reinsurance problems where Bass-type constructions yield tractable solutions under distributional constraints.*

MINI-SYMPOSIUM (ID 513): ID 627 (02)

Brenier's Theorem for $\mathcal{P}_2(\dots \mathcal{P}_2(H)\dots)$ and Applications to Adapted Transport

Gudmund Pammer (*TU Graz, Austria*); **Mathias Beiglböck** (*University of Vienna, Austria*); **Stefan Schrott** (*University of Vienna, Austria*)

Abstract: *We establish a Brenier theorem for iterated Wasserstein spaces. For a separable Hilbert space H and $N \geq 1$, we construct a full-support probability $\Lambda \in \mathcal{P}_2^N(H)$ that is transport regular: for all $P, Q \in \mathcal{P}_2^N(H)$ with $P \ll \Lambda$, the $\mathcal{W}_2^2$-optimal transport from P to Q is unique and of Monge type. In the first non-classical case $N = 2$ we show that optimal transports are given by the $\mathcal{W}_2$-gradient (Lions' derivative) of an L-convex functional. For general N we develop adapted notions of Lions' lift, L-convexity and Lions' derivative, which we apply to the adapted Wasserstein distance $\mathcal{AW}_2$, obtaining a first Brenier theorem for $\mathcal{AW}_2$.*

MINI-SYMPOSIUM (ID 513): ID 662 (03)

Scaling limits of multi-period distributionally robust optimization problems

Max Nendel (*University of Waterloo, Canada*); **Ariel Neufeld** (*Nanyang Technological University, Singapore*); **Kyunghyun Park** (*Nanyang Technological University, Singapore*); **Alessandro Sgarabottolo** (*Ludwigs Maximilian University Munich, Germany*)

Abstract: *We examine the scaling limit of multi-period distributionally robust optimization (DRO) problems via a semigroup approach. Each period involves a worst-case maximization over distributions in a Wasserstein ball around the transition probability of a reference process. We show that the scaling limit of the multi-period DRO, as the length of each period tends to zero, is a strongly continuous monotone semigroup on C_b. Furthermore, we show that its infinitesimal generator is equal to the generator associated with the non-robust scaling limit plus an additional perturbation term induced by the Wasserstein uncertainty.*

MINI-SYMPOSIUM (ID 513): ID 694 (04)

Entropic martingale optimal transport

Armand Ley (*University of Vienna, Austria*); **Julio Backhoff** (*University of Vienna, Austria*); **Mathias Beiglböck** (*University of vienna, Austria*); **Giorgia Bifronte** (*University of Vienna, Austria*)

Abstract: *After recalling the optimal transport problem, its entropic regularization, and the martingale optimal transport (MOT) problem, we focus on the entropic regularization of MOT. Based on its relations with its dual counterpart and a variational problem, we propose a Sinkhorn-type algorithm to compute its minimizer. We then analyse it and compare it with existing results. Finally, we briefly explain why solving this problem permits finding the "most Gaussian" martingale with prescribed initial and terminal marginals, in the sense of minimal relative entropy.*

MINI-SYMPOSIUM (ID 513): ID 720 (05)

On Arbitrage-Free Prices of American Options

Evgeny Kolosov (*ETH Zurich, Switzerland*); **Mathias Beiglböck** (*University of Vienna, Austria*); **Gudmund Pammer** (*TU Graz, Austria*); **Beatrice Acciaio** (*ETH Zurich, Switzerland*)

Abstract: *One of the key questions in robust finance is the construction of arbitrage-free models consistent with observed derivative prices. While European option prices determine marginal distributions and lead to convex order conditions, American option prices provide only partial information, making the problem substantially more complex. We study conditions for the existence of arbitrage-free models consistent with observed American option prices and introduce an extension of convex order, called the biased convex order. We analyse its structural properties and establish a Strassen-type characterization describing compatibility with arbitrage-free models.*

Rough Volatility in 2026 part 3: Numerics, forecasting and market impact - Aula C

Organized by: **Mathieu Rosenbaum**

MINI-SYMPOSIUM (ID 167): ID 666 (01)

The Quadratic Rough Heston+ Model for Short-Dated Options

Grégoire Szymanski (*University of Luxemburg, Luxembourg*); **Florian Bourgey** (*Bloomberg, United States*); **Patrick Noble** (*No affiliation, Australia*); **Ingi Petursson** (*No affiliation, United States*); **Mathieu Rosenbaum** (*Université Paris Dauphine, France*)

Abstract: *We introduce the Quadratic Rough Heston+ (QRH+) model, a minimal extension of the Quadratic Rough Heston model, which accurately captures the extreme skews and curvatures of short-dated SPX options, including zero days to expiry (0DTE) options. By adding a single path-dependent boosting term, the model achieves near-perfect calibration across maturities while preserving parsimony and computational efficiency. The model also reproduces realistic skew-stickiness ratios, confirming that it captures both the static and dynamic features of short-term volatility.*

MINI-SYMPOSIUM (ID 167): ID 719 (02)

Efficient simulation of a new class of Volterra-type SDEs

Giorgia Callegaro (*University of Padova, Italy*); **Ofelia Bonesini** (*London School of Economics and Political Sciences, United Kingdom*); **Gilles Pagès** (*Paris Sorbonne, France*); **Martino Grasselli** (*University of Padova, Italy*)

Abstract: *We propose a new theoretical framework that exploits convolution kernels to transform a Volterra-type path-dependent (non-Markovian) stochastic process into a standard (Markovian) diffusion process. Remarkably, it is also possible to go back, i.e., the transformation is reversible. We discuss existence and path-wise regularity of solutions for our class of stochastic differential equations. In the fractional kernel case, when* $H \in (0, \frac{1}{2})$*, where* H *is the Hurst coefficient, we propose a numerical simulation scheme which exhibits a remarkable strong convergence rate of order* $1/2$*, which constitutes a bold improvement when compared with the performance of available Euler schemes.*

MINI-SYMPOSIUM (ID 167): ID 732 (03)

The multivariate fractional Ornstein–Uhlenbeck process and applications

Ranieri Dugo (*University of Rome - Tor Vergata, Italy*); **Giacomo Giorgio** (*CDP, Italy*); **Paolo Pigato** (*Roma Tor Vergata, Italy*)

Abstract: *Starting from the notion of multivariate fractional Brownian Motion, we define a multivariate fractional Ornstein-Uhlenbeck process. This multivariate Gaussian process is stationary, ergodic and allows for different Hurst exponents on each component. Besides the marginal parameters, the cross correlation between one-dimensional marginal components is ruled by two parameters. We consider the inference problem in different settings, establish the corresponding asymptotic theory and confirm the results on simulated data. We apply this modelling framework to multivariate empirical time series with rough properties and discuss the results. Finally, we analyse spillover effects within the model and on the empirical time series.*

MINI-SYMPOSIUM (ID 167): ID 762 (04)

Multivariate Fractional Brownian Motion – How correlations improve volatility forecasting and statistical inference

Markus Bibinger (*Marburg University, Germany*); **Jun Yu** (*University of Macau, Macao*); **Chen Zhang** (*Sun Yat-sen University, China*)

Abstract: *Recent research emphasizes rough fractional volatility as a central feature of financial markets. This has important implications and, in particular, has been shown to provide accurate risk forecasts. We pioneer multivariate fractional volatility models with componentwise Hurst exponents to model and forecast realized volatility. We study the interplay between correlation parameters and Hurst exponents, and propose estimators for all model parameters, establishing their consistency and asymptotic normality. We show how the multivariate structure yields efficiency gains, reducing risk in both forecasting and statistical inference. Empirical results demonstrate that the forecasts surpass standard time-series benchmarks.*

Mean-field games in economics I - Aula D

Organized by: **Roxana Dumitrescu** and **Peter Tankov**

MINI-SYMPOSIUM (ID 180): ID 668 (01)

Entropy Regularization in MFGs of Optimal Stopping

Jodi Dianetti (*Department of Economics and Finance, University of Rome Tor Vergata, Italy*); **Roxana Dumitrescu** (*CREST, ENSAE, Institut Polytechnique de Paris, France*); **Giorgio Ferrari** (*University of Bielefeld, Germany*); **Renyuan Xu** (*Stanford University, United States*)

Abstract: *We study mean-field games of optimal stopping (OS-MFGs) with randomized stopping strategies and introduce an entropy-regularized framework to enable learning-based solution methods. By utilizing randomized stopping times, we reformulate the OS-MFG as a mean-field game of singular controls with entropy regularization. We establish the existence of equilibria and prove their stability as the entropy parameter vanishes. The Fictitious play algorithm is introduced, and its convergence is shown under either Lasry–Lions monotonicity or supermodularity of the reward functional. Our model-based analysis lays the theoretical foundation for model-free learning approaches to OS-MFGs.*

MINI-SYMPOSIUM (ID 180): ID 723 (02)

Ranking Quantilized Mean-Field Games with an Application to Early-Stage Venture Investments

Rinel Foguen Tchuendom (*Department of Decision Sciences, HEC Montréal, Canada*); **Dena Firoozi** (*University of Toronto, Canada*); **Michèle Breton** (*Department of Decision Sciences, HEC Montréal, Canada*)

Abstract: *Quantilized mean-field game models involve quantiles of the population's distribution. We study a class of such games with a capacity for ranking games, where the performance of each agent is evaluated based on its terminal state relative to the population'sα-quantile value,$\alpha \in (0,1)$. This evaluation criterion is designed to select the top$(1-\alpha)\%$performing agents. We then propose an application to early-stage venture investments, where a venture capital firm supports a group of startups competing over a finite horizon, aiming to identify and fund the top-performing fraction at the end of the period.*

MINI-SYMPOSIUM (ID 180): ID 766 (03)

Mean Field Games in Hilbert spaces: new results and applications to economics

Salvatore Federico (*University of Bologna, Italy*); **Daria Ghilli** (*University of Pavia, Italy*); **Daria Ghilli** (*University of Pavia, Italy*); **Fausto Gozzi** (*Luiss University Rome, Italy*); **Michele Ricciardi** (*University of Padova, Italy*)

Abstract: *We study a class of linear quadratic MFG in infinite dimension, where the state variable lives in a Hilbert space. Our motivations are problems where the state equation is a PDE or a delay equation. This type of state equation arises frequently in economics, such as in vintage capital models and systemic risk. Infinite-dimensional techniques allow us to write such state equations as an ODE in a suitable Hilbert space. We show the existence and uniqueness of solutions and the convergence of the Nash system to the MFG.*

MINI-SYMPOSIUM (ID 180): ID 533 (04)

Propagation of carbon price shocks through the value chain: the mean-field game of defaults

Zorana Grbac (*Université Paris Cité - LPSM, France*); **Simone Pavarana** (*University of Freiburg, Germany*); **Thorsten Schmidt** (*University of Freiburg, Germany*); **Peter Tankov** (*CREST, ENSAE, Institut Polytechnique de Paris, France*)

Abstract: *We develop a mean-field game framework to study carbon pricing in a multi-sector economy with defaultable firms. In each sector, firms produce a homogeneous good and choose inputs—labor, emissions, and intermediate goods—while taking endogenous prices as given and optimally deciding default timing. The economy is modeled as a system of coupled optimal stopping mean-field games, which admits a linear programming formulation characterizing Nash equilibria via population measure flows. We prove existence and uniqueness of the equilibrium price system. Numerical experiments with CES technologies highlight substitution effects and significant cross-sector spillovers driven by carbon price shocks.*

Data-Driven Learning for Stochastic Models - Aula E

ORAL ID 265 (01)

Data-driven generative simulation of SDEs using diffusion models

Xunyu Zhou (*Columbia University, United States*)

Abstract: *This paper introduces a new approach to generating sample paths of unknown stochastic differential equations (SDEs) using diffusion models, a class of generative AI models commonly employed in image and video applications. Our method takes a model-free, data-driven approach. Given a finite set of sample paths from an SDE, we utilize conditional diffusion models to generate new, synthetic paths of the same SDE. We conduct a simulation experiment to compare our method with alternative benchmarks. Furthermore, in an empirical study we leverage these synthetically generated sample paths to enhance the performance of reinforcement learning algorithms for continuous-time mean–variance portfolio selection.*

ORAL ID 378 (02)

Learning the exact SABR model

Pietro Rossi (*Prometeia, Italy*); **Giorgia Rensi** (*University, Italy*); **Marco Bianchetti** (*University, Italy*)

Abstract: *SABR is a cornerstone of interest rate volatility modeling, but its practical application relies heavily on the analytical approximation by Hagan et al., whose accuracy deteriorates for high volatility, long maturities, and out-of-the-money options, admitting arbitrage. While machine learning approaches have been proposed to overcome these limitations, they have often been limited by simplified SABR dynamics or a lack of systematic validation against the full spectrum of market conditions.e develop a novel SABR DNN, a specialized Artificial Deep Neural Network (DNN) architecture that learns the true SABR stochastic dynamics using an unprecedented large training dataset of interest rate Cap/Floor volatility*

ORAL ID 177 (03)

Data-driven Learning of Value Paths in Continuous Time and Space: A Reproducing Kernel Hilbert Space Approach

Bingyu Hu (*The Chinese University of Hong Kong, Hong Kong*); **Lingfei Li** (*The Chinese University of Hong Kong, Hong Kong*)

Abstract: *We study policy evaluation in continuous-time reinforcement learning under general path-dependent rewards and dynamics. Existing approaches focus on learning scalar-valued value functions within Markovian frameworks, leaving uncertainty quantification underexplored. We introduce an operator-based paradigm that learns a value operator mapping state paths to value paths, thereby unifying Markovian and non-Markovian cases. Leveraging vector-valued reproducing kernel Hilbert spaces, we derive an explicit kernel-based estimator for the value operator and establish finite sample and asymptotic theories together with universal approximation guarantees. Our framework enables uncertainty quantification for value paths. Numerical experiments in option pricing demonstrate the effectiveness of our approach.*

ORAL ID 409 (04)

Neural importance sampling and stratification for Monte Carlo option pricing

Aleksandar Arandjelovic (*ETH Zurich, Switzerland*); **Pavel Shevchenko** (*Macquarie University, Australia*); **Patrick Cheridito** (*ETH Zurich, Switzerland*)

Abstract: *Monte Carlo simulation is widely used for option pricing, but rare-event and path-dependent payoffs call for effective variance reduction. We consider changes of measure in diffusion and jump-diffusion models: Brownian drift shifts and, for jumps, compensator tilts (Esscher-type), and we study stratification using Itô-integral conditioning variables. We discuss theoretical results motivating feedforward-network parameterizations (approximation of the optimal sampling measure; L^2-stability of conditional expectations under perturbations of the conditioning integral). Numerical experiments for barrier-type and high-dimensional basket options demonstrate the strength of this approach.*

Advances in FinTech and Financial Decision-Making - Part 1 - Aula F

Organized by: **Fay¸cal Drissi** and **Fenghui Yu**

MINI-SYMPOSIUM (ID 255): ID 769 (01)

Directed graph clustering for lead-lag structure: a market tug- of-war

Mihai Cucuringu (*UCLA, United States*)

Abstract: *We develop spectral methods for clustering directed networks, focusing on lead-lag structure in high-dimensional financial time series. Using statistical inference under directed stochastic block models, we derive a likelihood-based objective for community detection and show that its spectral relaxation yields an efficient clustering algorithm with theoretical guarantees. We briefly survey the lead-lag detection literature across finance, statistics, and machine learning. Constructing directed networks from overnight and daytime return decompositions, we uncover a market-wide "tug-of-war" between overnight speculation and intraday price correction. The resulting clusters reveal significant structure and economically meaningful cross-asset trading opportunities.*

MINI-SYMPOSIUM (ID 255): ID 733 (02)

AI Bubbles with Large Language Models

Álvaro Cartea (*Oxford-Man Institute, University of Oxford, United Kingdom*); **Patrick Chang** (*University of Oxford, United Kingdom*); **Nan Chen** (*The Chinese University of Hong Kong, Hong Kong*); **Mingyue Zhong** (*The Chinese University of Hong Kong, Hong Kong*)

Abstract: *AI agents participate in both rational and irrational bubbles. In a sequential bubble game, AI agents generate speculative trades even though there is a unique no-trade equilibrium. Increasing reasoning capacity reduces, but does not eliminate, such irrational bubbles. Chain-of-thought analysis shows that AI agents participate in irrational bubbles because they form incorrect beliefs through simplified expectations of the market, and they are sensitive to framing effects when forming their beliefs. When the environment admits both a no-trade equilibrium and a speculative bubble equilibrium, AI agents recognize this multiplicity and coordinate on the speculative equilibrium.*

MINI-SYMPOSIUM (ID 255): ID 601 (03)

Proactive Market Makers: Oracle-Aware Liquidity Provision and Loss-Versus-Rebalancing

Hamed Amini (*University of Florida, United States*); **Zachary Feinstein** (*Stevens Institute of Technology, United States*)

Abstract: *Automated Market Makers (AMMs) suffer adverse selection from informed order flow, a critical flaw for tokenized assets relying on off-chain price discovery. In this talk, we introduce Proactive Market Makers (PMMs), a novel framework integrating external oracle prices with internal reserves. We establish a structural characterization theorem for PMMs and derive a Loss-Versus-Rebalancing (LVR) decomposition that isolates adverse selection-induced costs from oracle errors. We demonstrate that PMMs permit lower LVR in practice while simultaneously increasing on-chain price discovery.*

MINI-SYMPOSIUM (ID 255): ID 698 (04)

A McKean–Vlasov Mean Field Game Model for Coupled Wealth–Human Capital Dynamics

Yuri Saporito (*Fundação Getulio Vargas (FGV), Brazil*); **Sebastian Jaimungal** (*University of Toronto, Canada*); **Felipe Antunes** (*Fundação Getulio Vargas (FGV), Brazil*)

Abstract: *We develop a mean field game model of wealth and human capital in which agents choose consumption and allocate time between work and education. Education lowers current income but raises future productivity, and wages and interest rates depend on the distribution of wealth and skills. Equilibrium is characterized by a McKean–Vlasov forward–backward stochastic differential equation system. We compute equilibria using a deep learning method for MV-FBSDEs with common noise based on Picard iterations and elicitability. The approach avoids nested simulations and efficiently approximates the backward component and conditional expectations. Numerical results illustrate the general equilibrium effects of educational choices.*

Ambiguity/Knightian Uncertainty/Robustness - Aula P

ORAL ID 111 (01)

Reinforcement Learning for Markov Games under Model Uncertainty

Johannes Langner (*Leibniz Universität Hannover, Germany*); **Ariel Neufeld** (*Nanyang Technological University, Singapore*); **Gregor Svindland** (*Leibniz Universität Hannover, Germany*)

Abstract: *We introduce a framework of Markov games under model uncertainty, extending the corresponding robust Markov decision problems to a two-agent setting in which we consider a second agent with a diametrically opposing goal. The initial agent's objective is to choose actions to maximize their worst-case expected reward with respect to the opponent's actions and feasible state transition kernels. We prove the existence of optimal strategies for both agents and the corresponding worst-case measure, and present a Q-learning algorithm to solve such robust Markov games where the ambiguity set of transition probabilities is a Wasserstein ball around a reference measure.*

ORAL ID 192 (02)

Empirical performances of the Bayesian generalized recovery

Sven Knaust (*University of Freiburg, Germany*); **Eva Lütkebohmert** (*University of Freiburg, Germany*); **Riccardo Brignone** (*University of Pavia, Italy*)

Abstract: *We propose a new approach to recover physical probabilities from quoted option prices by addressing data errors in the implied volatility surface. Building on the generalized recovery theorem of Jensen et al. (2019), we use Bayesian calibration with sequential Monte Carlo methods to account for model uncertainty. Our method improves upon existing techniques by incorporating the full posterior distribution of model parameters. We show that our approach produces robust physical densities, outperforming prior methods in portfolio optimization using a Mean-CVaR strategy. Our findings suggest that Bayesian-based recovery yields more accurate and predictive results than conventional methods.*

ORAL ID 260 (03)

Robust duality for L^1-spaces and an application to robust large binomial markets

Irene Klein (*University of Vienna, Austria*); **Christa Cuchiero** (*University of Vienna, Austria*); **Georg Köstenberger** (*University of Vienna, Austria*); **Thorsten Schmidt** (*University of Freiburg, Germany*)

Abstract: *Recent generalizations of the quantitative versions of the Halmos-Savage Theorems of Klein, Schachermayer (1996) for one probability P to the robust case of convex sets of probability measures require that a robust$L^\infty$is the dual space of an appropriate robustL^1. We find a post-hoc completion of a given robust model guaranteeing this duality. We apply this to a (one-step) robust binomial model (as in Blanchard, Carassus, 2020) and characterize no asymptotic arbitrage in robust large binomial markets. We relate this to no arbitrage in a "limit" robust binomial model including degenerate parameter values.*

ORAL ID 285 (04)

Distributionally robust Expected Shortfall for convex risks

Gusti Van Zyl (*University of Pretoria, South Africa*)

Abstract: *Viewing a risk measure as a mapping from payoff functions to the reals, the natural robustification of a coherent risk measure, over an ambiguity set of alternative distributions, is coherent. Considering application to portfolios, we derive the quadratic cost c-transform of the pointwise maximum of affine functionals on Rn , which turns out to have the same functional form with modified intercepts. A dual formulation of the robust Expected Shortfall problem yields a two-dimensional convex minimisation problem. These results combine to yield very tractable minimisation problems for some convex payoffs, and even closed form solutions in some cases.*

Equilibrium Models - Aula Q

ORAL ID 375 (01)

Adaptive Portfolio Choice and Bayesian Training of Trading Bots

Jan Vecer (*Charles University, Czechia*)

Abstract: *An agent starts from an uninformative position by selecting multiple trading algorithms, each interpreted as a likelihood model over market scenarios, and allocating to each a sub-fund. The algorithms trade and are validated through their realized P&L, which serves as likelihood-based model validation. The relative wealth of each sub-fund coincides with the Bayesian posterior distribution over models. Prices cleared by the aggregate fund correspond to Bayesian equilibrium prices for each market outcome. Validation can be performed fully internally, without market interaction, allowing trading algorithms to train and converge to equilibrium before deployment.*

ORAL ID 37 (02)

On the existence of personal equilibria

Laurence Carassus (*Université Paris-Saclay, Centrale-Supélec, France*); **Miklos Rasonyi** (*Alfréd Rényi Institute of Mathematics and Eötvös Lorand University, Hungary*)

Abstract: *We consider an investor who, while maximizing his/her expected utility, also compares the outcome to a reference entity. We recall the notion of personal equilibrium and show that, in a multistep, generically incomplete financial market model such an equilibrium indeed exists, under appropriate technical assumptions.*

ORAL ID 351 (03)

Robust Equilibrium Asset and Option Pricing

Carlos Miguel Glória (*European Central Bank and BRU-IUL, Portugal*); **José Carlos Dias** (*ISCTE-IUL and BRU-IUL, Portugal*); **João Pedro Ruas** (*ISCTE-IUL and BRU-IUL, Portugal*)

Abstract: *This paper studies asset and option pricing implications of Knightian uncertainty about capital shocks in a general equilibrium production-based jump-diffusion model with recursive preferences. Our model reproduces several directional properties of prices in financial markets such as negative variance premium, negative skewness premium and implied volatility skew. Our calibrated model to economic and financial data shows that options demand increases in the presence of ambiguity, which implies an upward shift in the implied volatility curve. Finally, we compute the maximum consumption tax that society would be willing to pay to change the economy so that model uncertainty is eliminated.*

ORAL ID 12 (04)

A Doubly Continuous Model for Equilibrium Trading Dynamics

Efstathios Avdis (*University of Alberta, Canada*); **Christoph Frei** (*University of Alberta, Canada*); **Sergei Glebkin** (*INSEAD, France*); **Raphael Huwyler** (*University of Alberta, Canada*)

Abstract: *We consider a continuous-time financial market with a continuum of agents. Investors receive an infinitesimal increment of private information, which is aggregated and revealed as a public signal via the price. Using a random field approach, we provide an explicit characterization of a dynamic rational expectations equilibrium with trade, where investors have general risk-averse preferences. This generality is valuable because closed-form solutions to utility maximization problems in equilibrium are typically restricted to particular utility functions. Moreover, the continuum of agents allows us to circumvent the no-trade conundrum, since fully rational investors usually do not trade in equilibrium.*

Mean-risk optimization and machine learning - Aula H

Organized by: **Giorgio Consigli**

MINI-SYMPOSIUM (ID 181): ID 557 (01)

The Role of Entropy Regularization in Linking Reinforcement Learning and Risk-Sensitive Investment Management

Sebastien Lleo (*NEOMA Business School, France*)

Abstract: *We establish a structural connection between risk-sensitive control and reinforcement learning based on the duality between free energy and relative entropy. Beginning from a non-standard risk-sensitive control problem for benchmark investment, we apply the duality to derive an equivalent Linear-Quadratic-Gaussian stochastic differential game under an appropriate probability measure with an endogenous entropy penalty. In contrast to Kuroda & Nagai, no preliminary change of measure is required. We solve the fully specified model and characterize the associated optimal feedback. When model coefficients are unknown, we adapt an actor-critic method based on q-learning to implement our approach.*

MINI-SYMPOSIUM (ID 181): ID 559 (02)

Real Estate Portfolio Valuation and Climate Risk Scenario Generation using Machine Learning Methods

Natalie Packham (*Berlin School of Economics and Law, Germany*); **Sami Alkhoury** (*Berlin School of Economics and Law, Germany*); **Christina Erlwein-Sayer** (*HTW Berlin, Department of Business Mathematics, Germany*)

Abstract: *This paper presents a data-driven framework for real estate portfolio valuation and climate risk assessment. We construct a dataset covering residential real estate transactions in France over the period 2014–2024, combining transaction records with geospatial information, macroeconomic indicators and energy efficiency data. The resulting dataset enables the training of machine learning models for property pricing and risk management on a portfolio level. We also demonstrate how the dataset can be used for causal analysis of physical climate risks. Using double ML techniques, we assess the impact of flood exposure on real estate prices while accounting for confounders and nonlinear relationships.*

MINI-SYMPOSIUM (ID 181): ID 561 (03)

Optimal multi-period portfolio risk-distribution based on reinforcement learning

Giorgio Consigli (*Khalifa University of Science and Technology, United Arab Emirates*); **Yerkin Kitapbayev** (*Khalifa University of Science and Technology, United Arab Emirates*); **Sanabel Bisharat** (*Khalifa University of Science and Technology, United Arab Emirates*)

Abstract: *This paper relies on the concept of* interval conditional value-at-risk*, a tail risk measure introduced in* (*2021*)*. We build on the concepts of assets' marginal risk contributions and portfolio* risk parity (*RP*) *to introduce a dynamic optimization problem based on their trade-off. The problem is solved relying on reinforcement learning. The bi-criteria objective helps clarifying the effects on risk allocation induced by a departure from RP towards a relative performance criterion. The adoption of a* reinforcement learning (*RL*) *approach is motivated by other methods' numerical drawbacks and the recent advances induced by the development of convex RL techniques.*

MINI-SYMPOSIUM (ID 181): ID 740 (04)

Guaranteed funds' replication by reinforcement learning

Michael Villaverde (*Pulsar Research, United Kingdom*); **Giorgio Consigli** (*Khalifa University of Science and Technology, United Arab Emirates*); **Harvir Hansra** (*Pulsar Research LLC, United Kingdom*); **Michael Dempster** (*University of Cambridge, United Kingdom*)

Abstract: *Guaranteed funds provide a protection vehicle for risk-averse investors during times of increasing market volatility. Protection may be on the capital invested or its return or both. In this article we focus on capital protection and address the fund manager replication problem relying on a reinforcement learning (RL) approach. By combining the learning process and the derivation of the optimal policy in a recursive manner, the RL method is able to solve the minimum guarantee fixed-mix problem in minutes, significantly improving classical solution times in stochastic optimization, yet considering a very rich uncertainty model based on a data-driven simulation method.*

Asset Allocation/Optimal Investment/Portfolio Theory - Aula I

ORAL ID 123 (01)

Options Hedging Forward

Radu Tunaru (*ICMA Centre, University of Reading, UK, United Kingdom*)

Abstract: *This paper shows a new framework for valuing multi-period claims contingent on the behaviour of external parties and the evolution of a linked index. The new framework is highly relevant when interest rates are considered stochastic. It is emphasized that several financial products should be valued using forward start options instead of full length options. The vehicle for exemplification on how to apply the new framework is the valuation of the no-negative equity guarantee for equity release mortgages required by the regulator. A two-factor model is discussed and the error of the version imposed by the regulator is derived analytically.*

ORAL ID 188 (02)

Characterizing and Computing Efficient Portfolios: A Stochastic Dominance Approach

Mohamed Amine Ben Ghalleb (*University of Twente, Netherlands*); **Berend Roorda** (*University of Twente, Netherlands*); **Laura Spierdijk** (*University of Twente, Netherlands*)

Abstract: *Stochastic dominance (SD) provides a framework for ranking uncertain outcomes consistent with expected utility theory. However, the absence of practical computational methods to identify thenth-order SD-efficient set has limited its widespread application in portfolio optimization. This study fills this gap by providing a complete mathematical characterization of the SD-efficient set for orders two and higher; that is, the set of all portfolios not dominated at that order. We derive key topological properties of this set and use them to construct a neighborhood-based search algorithm that approximates it. The algorithm's computational accuracy and efficiency are illustrated in an empirical application.*

ORAL ID 210 (03)

Benchmarking Emerging-Market Fine-Wine Indices against the Liv-ex 100: Risk, Dependence, and Portfolio Value

Mesias Alfeus (*Stellenbosch University, South Africa*); **Robert Faff** ((*Corvinus University of Budapest, Australia*)

Abstract: *We test whether fine wines from Australia, South Africa, Argentina, and Chile are investable alternatives to the Liv-ex 100. Using harmonized auction and secondary-market data (2019–2024), we build transparent country indices via a hybrid method with repeat-sales validation and benchmark them against global wine and traditional assets. Methods combine FIGARCH-filtered marginals, DCC/ADCC correlations, and generalized FEVD connectedness. Results: distinct risk–return profiles and regime-dependent drawdowns with episodic decoupling; dependence is persistent but state-contingent, with higher co-movement in stress; Australia and Liv-ex 100 are net transmitters; volatility networks are diffuse. Portfolio tests show 5–15% allocations shift efficient frontiers outward despite conservative frictions.*

ORAL ID 724 (04)

Mathematical Finance w/o probability: Path-dependent portfolio allocation

Henry Chiu (*University of Birmingham, United Kingdom*)

Abstract: *We introduce a non-probabilistic, path-by-path framework for continuous-time, path-dependent portfolio allocation. Extending the self-financing concept recently introduced in Chiu&Cont(2023), we characterize self-financing portfolio allocation strategies through a path-dependent PDE and provide explicit solutions for the portfolio value in generic markets, including price paths that are not necessarily continuous or exhibit variation of any order. As an application, we extend an aggregating algorithm of Vovk and the universal algorithm of Cover to continuous-time meta-algorithms that combine multiple strategies into a single strategy, respectively tracking the best individual and the best convex combination of strategies. This work extends Cover's theorem to continuous-time without probability.*

Volatility Models and Computational Option Pricing - Aula L

ORAL ID 78 (01)

Unpuzzling Volatility Risk Premiums through the Joint SPX/VIX Smile Calibration

João Pedro Nunes (*ISCTE-IUL and BRU-IUL, Portugal*); **Joao Pedro Ruas** (*ISCTE-IUL and BRU-IUL, Portugal*); **Jose Carlos Dias** (*ISCTE-IUL and BRU-IUL, Portugal*)

Abstract: *Several authors identify highly negative volatility risk premiums during periods of market stress. Without any assumptions on investors preferences and wealth, or on the distribution of returns, we document that no pricing kernel can justify those puzzling premiums and argue that such puzzle is a statistical flaw arising from the overdifferentiation of the volatility time-series. Alternatively, it is easy to replicate volatility risk premiums based on fractional (instead of integer) integration, but the pricing kernel only remains positive after using information from both SPX/VIX option markets. Hence, a new method for the joint SPX/VIX smile calibration is proposed.*

ORAL ID 134 (02)

From rough to multifractal multidimensional volatility: A multidimensional Log S-fBM model

Othmane Zarhali (*Université Paris Dauphine, France*); **Emmanuel Bacry** (*Université Paris Dauphine, France*); **Jean-François Muzy** (*Université de Corse, France*)

Abstract: *We introduce the multidimensional Log S-fBM (mLog S-fBM), extending the Log S-fBM model of Wu et al. to the multivariate setting. The model is built from a multidimensional stationary fractional Brownian motion with marginal S-fBM dynamics and a structured cross-covariance characterized by co-Hurst and co-intermittency matrices. The mLog S-fBM is well defined for co-Hurst parameters in $[0,1/2)[0,1/2)$, including vanishing values, bridging rough volatility and multifractal regimes. We develop a multivariate small-intermittency GMM calibration method, validated on synthetic data and applied to S&P 500 stocks. This is joint work with Emmanuel Bacry and Jean-François Muzy.*

ORAL ID 332 (03)

Quantum Speedup for PDEs Arising from Option Pricing

Jack Jacquier (*Imperial College London, United Kingdom*); **Sofia Moliner** (*Imperial College London, United Kingdom*); **Eyal Neuman** (*Imperial College London, United Kingdom*)

Abstract: *We present a novel numerical algorithm for option pricing based on quantum walks, with the aim of accelerating standard Markov chain methods. We begin by considering the discrete heat equation and its associated discrete Feynman–Kac representation via random walks with absorbing boundaries. We then introduce a quantum analogue of Markov chains by defining the corresponding quantum walk model. We prove that the quantum walk algorithm reduces the computational time required to solve the heat equation relative to classical benchmarks. Finally, we discuss applications of this approach to the pricing of exotic options under Black–Scholes dynamics and local volatility models.*

ORAL ID 158 (04)

Proxy-identification of an MGARCH model

Matthias Fengler (*University of St. Gallen, Switzerland*); **Jeannine Polivka** (*University of St. Gallen, Switzerland*)

Abstract: *We identify shocks in a structural MGARCH model of asset returns using news-based proxy instruments. Structural parameters, including an orthogonal matrix, are estimated via Riemannian optimization. We study daily returns on the S&P500, the 10-year Treasury yield, and the USD index. The proxies identify an equity valuation shock and a bond valuation shock. The dynamic impact matrix is asymmetric, and sign changes in the bond valuation shock loading drive switches between negative and positive stock–bond co-movement. A decomposition of the COVID-19 episode shows that bond valuation shocks partially offset equity market stress and explain the temporary yield surge in March.*

Time Inconsistency - Aula M

ORAL ID 56 (01)

Equilibrium investment under dynamic preference uncertainty

Luca De Gennaro Aquino (*Reykjavik University, Iceland*); **Yevhen Havrylenko** (*University of Lausanne, Switzerland*); **Sascha Desmettre** (*Johannes Kepler University Linz, Austria*); **Mogens Steffensen** (*University of Copenhagen, Denmark*)

Abstract: *We study a continuous-time portfolio choice problem for an investor whose preferences are determined by an exogenous factor evolving as an Itô diffusion process. Uncertainty about future risk aversion leads to an objective that aggregates certainty equivalents across possible terminal preference states, generating inherent time-inconsistency. We address this problem using an equilibrium approach and derive an extended Hamilton-Jacobi-Bellman system characterizing subgame-perfect investment strategies. In a tractable CRRA specification, the equilibrium portfolio admits a semi-explicit representation that decomposes into a myopic demand and a novel preference-hedging component that captures incentives to hedge against anticipated changes in risk aversion.*

ORAL ID 292 (02)

On consistency of optimal portfolio choice for state-dependent exponential utilities

Edoardo Berton (*Politecnico di Milano, Italy*); **Marco Maggis** (*Università degli Studi di Milano, Italy*); **Marzia De Donno** (*Università Cattolica del Sacro Cuore, Italy*)

Abstract: *In an arbitrage-free simple market, we demonstrate that for a class of state-dependent exponential utilities, there exists a unique prediction of the random risk aversion that ensures the consistency of optimal strategies across any time horizon. Our solution aligns with the theory of forward performances, with the added distinction of identifying, among the infinite possible solutions, the one for which the profile is the actual optimizer of the system of preferences specified a priori.*

ORAL ID 476 (03)

Competition under liability constraints and additive relative performance among (heterogeneous) agents with CRRA and Epstein-Zin utilities

Wilfried Kuissi Kamdem (*University of Freiburg, Germany*); **Olivier Menoukeu Pamen** (*University of Liverpool, United Kingdom*)

Abstract: *This paper studies the strategic interaction of finite and infinite agents under both (power) CRRA utility and Epstein-Zin utility. Unboundedness of the market coefficients, additive relative performances and heterogeneity among the investors are the three main novelties of the paper. We solve the finite- and infinite-agent games completely and find explicitly their respective equilibrium. This is possible because we are able to find an explicit solution to their associated multidimensional coupled forward backward stochastic differential equations (FBSDEs). As a by product, we compute the competition indifference capital, namely the capital making an agent indifferent between whether or not to compete.*

ORAL ID 369 (04)

Managerial turnover and time inconsistency in portfolio choice with illiquid securities

Ali Lazrak (*UBC, Canada*); **Hanxiao Wang** (*Shenzhen University, China*); **Jiongmin Yong** (*University of central Florida, United States*)

Abstract: *We study portfolio choice with managerial turnover and illiquid securities. When managers discount performance more heavily out of office than in office, turnover induces time inconsistency: rotations of control create a collective present bias even when managers are individually time-consistent. We model portfolio choice as a dynamic game between the incumbent and successors and characterize a linear stationary closed-loop equilibrium. Relative to a no-turnover benchmark, the incumbent targets an aim portfolio closer to the Markowitz benchmark but adjusts more cautiously. Higher trading costs reduce index exposure, and with turnover illiquidity acquires commitment value.*

Robo-Advisory and DeFi Risk - Aula Filopanti

ORAL ID 214 (01)

Eliciting Risk Aversion with Inverse Reinforcement Learning via Interactive Questioning

Ziteng Cheng (*The Hong Kong University of Science and Technology (Guangzhou), China*); **Anthony Coache** (*Imperial College London, United Kingdom*); **Sebastian Jaimungal** (*University of Toronto, Canada*)

Abstract: *We investigate a framework for robo-advisors to estimate non-expert clients' risk aversion using adaptive binary-choice questionnaires. We model risk aversion using cost functions and spectral risk measures in a static setting. We prove the identifiability and obtain a convergence rate of* $\sqrt{N}$*, where* N *is the number of questions. We introduce the notion of distinguishing power and demonstrate in simulation that designing questions by maximizing distinguishing power achieves satisfactory accuracy with fewer than 50 questions. We also provide a preliminary investigation of an infinite-horizon setting with an additional discount factor for dynamic risk aversion, establishing qualitative identifiability in this case.*

ORAL ID 750 (02)

Implied Impermanent Loss for Concentrated Liquidity

Luca Luigi Alberici (*Bayes Business School, United Kingdom*); **Andrew Papanicolaou** (*North Carolina State University, United States*); **Lorenzo Schönleber** (*Collegio Carlo Alberto, Italy*)

Abstract: *Providing liquidity on decentralized exchanges earns fees but exposes liquidity providers (LPs) to impermanent loss from price movements. With concentrated liquidity, LPs control this risk by choosing how narrowly to deploy capital around the price. Using option prices, we quantify the cost of liquidity provision by developing measures of implied and realized impermanent loss for concentrated liquidity and define the associated impermanent loss risk premium. Empirically, higher expected impermanent loss widens liquidity ranges, while higher risk premia re-center liquidity around the spot price, highlighting opposing effects of risk and compensation.*

ORAL ID 466 (03)

A Risk-Based Perspective on Autodeleveraging Rules

Natascha Hey (*Columbia University, United States*); **Ciamac Moallemi** (*Columbia University, United States*); **Steven Campbell** (*Columbia University, United States*); **Marcel Nutz** (*Columbia University, United States*)

Abstract: *Auto-deleveraging (ADL) mechanisms are a critical yet understudied component of risk management on leveraged cryptocurrency futures exchanges. When margin resources are insufficient under large price moves, exchanges reduce positions of solvent traders through rule-based ADL mechanisms, reallocating residual risk. We formulate deleveraging as an optimization problem minimizing the exchange's risk from future equity shortfalls. In a single-asset, isolated-margin setting, risk-optimal deleveraging reduces positions of the most highly levered accounts first and progressively equalizes leverage across affected accounts. We discuss extensions to multi-asset cross margining, where portfolio coupling breaks separability.*

ORAL ID 241 (04)

Optimal exit from Uniswap v3 and best expected return for a liquidity provider

Ankush Agarwal (*University of Western Ontario, Canada*); **Emmanuel Gobet** (*Sorbonne Université, France*)

Abstract: *We analyze the profitability of liquidity providers' (LPs) positions in Uniswap v3 by aggregating fee income and impermanent loss within an optimal stopping framework. We first show that the liquidity burn should be optimized over one range at a time, and that without discounting future swap fees, indefinite liquidity provision is optimal. In this case, we derive closed-form expressions for the value of LP positions according to different price levels of liquidity burn. With a discount factor, we introduce an equivalent rate of return and demonstrate that under a Black-Scholes model with volatility sigma, the optimal return is approximately* $0.425\sigma^2$*.*

Modeling, Prediction, and Control in Energy Markets and Climate Finance - Part 1 - Aula A

Organized by: **Chiheb Ben Hammouda** and **Antonis Papapantoleon**

MINI-SYMPOSIUM (ID 341): ID 670 (01)

Finance-informed learning and pricing of energy derivatives

Fred Espen Benth (*BI Norwegian Business School, Norway*); **Luca Galimberti** (*King's College London, United Kingdom*); **Nils Detering** (*Heinrich Heine University Düsseldorf, Germany*); **Fabian Harang** (*BI Norwegian Business School, Norway*); **Silvia Lavagnini** (*BI Norwegian Business School, Norway*)

Abstract: *We show how to use financial information along with mathematical structures to develop neural networks for pricing of energy derivatives. We pay particular attention to forward and futures prices in energy, weather and commodities, and options on these, which can be analyzed as a case of operator learning. We propose neural networks in term structure spaces, with activation functions mapping entire curves through layers.*

MINI-SYMPOSIUM (ID 341): ID 655 (02)

Data-Driven Stochastic Optimal Control for Intraday Electricity Trading by Renewable Producers

Chiheb Ben Hammouda (*Utrecht University, Netherlands*); **Michael Samet** (*RWTH Aachen University, Germany*); **Michael Samet** (*RWTH Aachen University, Germany*); **Raul Tempone** (*King Abdullah University of Science and Technology, Saudi Arabia*)

Abstract: *We develop a data-driven continuous-time stochastic optimal control framework for intraday electricity trading that maximizes expected profit net of liquidity costs and imbalance charges. Production and prices follow forecast-driven SDEs, a Jacobi diffusion for wind production and a jump-diffusion with asymmetric jumps for prices. We extend the market modeling by explicitly accounting for gate closure, lead time, and the imbalance settlement window, yielding a path-dependent imbalance penalty. Dynamic programming yields two linear Kolmogorov backward equations and a nonlinear HJB–PIDE, solved using a proposed monotone IMEX finite-difference scheme with operator splitting and Rosenbrock linearization of the Hamiltonian with Picard iterations.*

MINI-SYMPOSIUM (ID 341): ID 613 (03)

Numerical Methods for Impulse Control Problems in Swing Option Pricing

Mustapha Regragui (*Ghent University, Belgium*)

Abstract: *We study the numerical valuation of swing options in electricity markets under a two-factor mean-reverting price model that incorporates spikes and negative prices. The contract features state-dependent waiting times determined by the exercised amount, with flexible exercise opportunities subject to local and global constraints. This framework leads to a coupled system of a parabolic partial integro-differential equation and a partial differential complementarity problem. We investigate the existence of an optimal exercise strategy and develop an effective numerical scheme to solve this coupled system.*

MINI-SYMPOSIUM (ID 341): ID 598 (04)

Optimal Switching Games for Climate Green Transition

Jisu Yu (*University of California, Santa Barbara, United States*); **Mike Ludkovski** (*University of California, Santa Barbara, United States*); **René Aïd** (*Université Paris-Dauphine PSL, France*)

Abstract: *We study a non-cooperative game model of macroeconomic climate transition. We consider economic sectors that dynamically optimize when to decarbonize considering transition costs and climate damages. Agents interact through the global temperature state that is driven by aggregate emissions and in turn lowers profits of non-green sectors. The transition to a zero-emission technology is modeled as a stopping time and the sectors additionally continuously make capital investments. We characterize Markov Nash equilibrium through a system of HJB-VI equations with varying dimension. Numerical case studies illustrate the strategic switching and the impact of policy tools such as a carbon tax.*

Advances in FinTech and Financial Decision-Making - Part 2 - Aula G

Organized by: **Fay¸cal Drissi** and **Fenghui Yu**

MINI-SYMPOSIUM (ID 255): ID 742 (01)

Geometries of generative AI with applications to time series modelling

Josef Teichmann (*ETH Zurich, Switzerland*); **Fenghui Yu** (*TU Delft, Netherlands*)

Abstract: *Reversing ergodic diffusions plays an important role in generative AI for, e.g., images. We propose a more geometric framework of this well known technique and prove that the new framework preserves geometric properties of training data. This technique can be applied for time series modelling under geometric constraints, as it appears, e.g., in finance.*

MINI-SYMPOSIUM (ID 255): ID 768 (02)

Stochastic Implied Volatility, Learned

Hans Buehler (*University of Oxford, United Kingdom*); **Blanka Horvath** (*University of Oxford, United Kingdom*)

Abstract: *We present a class of stochastic implied volatility models for a full surface of option prices, trained using modern time-series AI/ML methods. We avoid static arbitrage by using our recent strictly arbitrage-free non-parametric option surfaces (SANOS).*

MINI-SYMPOSIUM (ID 255): ID 540 (03)

Deep Learning for Continuous-Time Stochastic Control with Jumps in Finance

Jean Loup Dupret (*ETH Zurich, Switzerland*); **Patrick Cheridito** (*ETH Zurich, Switzerland*); **Donatien Hainaut** (*UCLouvain, Belgium*)

Abstract: *In this paper, we introduce a model-based deep-learning approach to solve finite-horizon continuous-time stochastic control problems with jumps. We iteratively train two neural networks: one to represent the optimal policy and the other to approximate the value function. Leveraging a continuous-time version of the dynamic programming principle, we derive two different training objectives based on the Hamilton-Jacobi-Bellman equation, ensuring that the networks capture the underlying stochastic dynamics. Empirical evaluations on different problems illustrate the accuracy and scalability of our approach, demonstrating its effectiveness in solving complex, high-dimensional stochastic control tasks with an emphasis on financial problems.*

MINI-SYMPOSIUM (ID 255): ID 588 (04)

Distributionally Robust Deep Q-Learning

Julian Sester (*National University of Singapore, Singapore*); **Chung I Lu** (*National University of Singapore, Singapore*); **Aijia Zhang** (*National University of Singapore, Singapore*)

Abstract: *We propose a distributionally robust Q-learning algorithm for continuous-state Markov decision processes under model uncertainty. Uncertainty in the state transition dynamics is modeled via worst-case transitions within a Wasserstein ball around a reference probability measure. To compute the optimal policy, we reformulate the resulting non-linear Bellman equation by dualising and regularising the Bellman operator using the Sinkhorn distance, enabling a tractable approximation. The resulting operator is parameterised with deep neural networks, yielding a robust variant of the Deep Q-Network algorithm. We demonstrate the practicality and effectiveness of our approach in several applications, including portfolio optimisation based on S&P 500 data.*

Arbitrage Theory - Aula B

ORAL ID 3 (01)

No-Arbitrage in Continuous Rough Path Markets: Rigidity toward the Semimartingale Paradigm

Qijin Shi (*University of California, Santa Barbara, United States*); **Tomoyuki Ichiba** (*University of California, Santa Barbara, United States*)

Abstract: *We study no-arbitrage in continuous frictionless rough-path-based markets where gains are defined via rough integration. After proposing a No Controlled Free Lunch (NCFL) condition, we prove a rough Kreps–Yan theorem, reducing NCFL to unbiasedness of the price driver as a rough integrator under an equivalent measure. We then classify unbiased rough integrators. As admissible strategies expand from Markovian to signature-type portfolios, we obtain rigidity: viable models are forced to be infinitesimally close to (time-changed) Itô Brownian motions (as rough-path lifts), up to an equivalent measure change. In conclusion, rich-strategy frictionless rough-path markets are forced back toward the classical semimartingale paradigm.*

ORAL ID 204 (02)

Hedging American options under local viability

Miklos Rasonyi (*Alfréd Rényi Institute of Mathematics and Eötvös Lorand University, Hungary*); **Ngoc Huy Chau** (*Manchester University, United Kingdom*)

Abstract: *In this talk we present a framework where hedging of American options is studied in an infinite-dimensional functional analytic framework. Our viewpoint reduces American options to European ones in a general setting. The method is applicable even in cases where an equivalent local martingale measure fails to exist. Our main results include a new superhedging duality for American options when wealth processes can be negative and trading strategies are subject to a cone constraint.*

ORAL ID 266 (03)

Collective Arbitrage and Individual Rationality

Marco Frittelli (*Università degli Studi di Milano, Italy*); **Marco Maggis** (*Università degli Studi di Milano, Italy*); **Alessandro Doldi** (*Università degli Studi di Milano, Italy*)

Abstract: *Within a general semimartingale framework, we study the relationship between collective market efficiency and individual rationality. We derive necessary and sufficient condition for the existence of (possibly zero-sum) exchanges among agents that strictly increase their indirect utilities and characterize this condition in terms of the compatibility between agents' preferences and collective pricing measures. The framework applies to both continuous- and discrete-time models and clarifies when cooperation leads to a strict improvement in each participating agent's indirect utility.*

ORAL ID 301 (04)

Collective completeness and superhedging duality

Alessandro Doldi (*Università degli Studi di Milano, Italy*); **Marco Frittelli** (*Università degli Studi di Milano, Italy*); **Marco Maggis** (*Università degli Studi di Milano, Italy*)

Abstract: *This paper builds on* Collective Arbitrage and the Value of Cooperation *by Biagini et al.* (*2025,* Finance and Stochastics), *which introduced in discrete time the notions of collective arbitrage and super-replication in a multi-agent market framework, where agents may operate in several submarkets and collaborate through risk exchange mechanisms. Expanding on these foundations, we establish a Collective First FTAP and a collective pricing-hedging duality under different assumptions and with new techniques compared to Biagini et al.* (*2025*). *We further introduce the notion of collective replication in order to study collective market completeness and provide a Collective Second FTAP.*

Robust finance: recent developments and applications - Aula C

Organized by: **Anna Aksamit**

MINI-SYMPOSIUM (ID 291): ID 689 (01)

Hidden Dependence and Aggregate Tail Risk

Corrado De Vecchi (*University of Verona, Italy*); **Max Nendel** (*University of Waterloo, Canada*); **Steven Vanduffel** (*Vrije Universiteit Brussel, Belgium*)

Abstract: *We introduce the notion of hidden dependence for random vectors and study its role in risk aggregation problems for arbitrary non-decreasing aggregation functions and tail risk measures. We show that, starting from a tail event of the aggregate loss for an arbitrary random vector Y, one can construct a random vector with hidden dependence that dominates Y on the tail event. We then focus on the case in which model uncertainty is described by marginal-preserving perturbations of the distribution of a random vector with respect to a suitable probability distance and show that these perturbations are compatible with hidden dependence.*

MINI-SYMPOSIUM (ID 291): ID 653 (02)

Delta Upsilon Hedging

Haoyu Xie (*National University of Singapore, Singapore*); **Julian Sester** (*National University of Singapore, Singapore*); **Jan Obloj** (*University of Oxford, United Kingdom*)

Abstract: *We propose a novel hedging framework for European options motivated by quantifying model uncertainty non-parametrically via small-radius Wasserstein balls around a baseline risk-neutral distribution. This motivates a new "Greek", upsilon, and an associated bilinear co-upsilon, which together yield closed-form optimal hedging ratios when trading the underlying and one (or several) liquid options. We provide the the sensitivity formula in a one-period setting and derive optimal upsilon hedges as orthogonal projections in a space of payoff-slope factors. We conduct synthetic and market experiments to compare the performance of delta-upsilon hedging against delta and delta-vega hedging.*

MINI-SYMPOSIUM (ID 291): ID 678 (03)

An optimal transport foundation for a class of dynamically consistent risk measures

Sven Fuhrmann (*University of Konstanz, Germany*); **Michael Kupper** (*University of Konstanz, Germany*); **Max Nendel** (*University of Waterloo, Canada*)

Abstract: *We study dynamically consistent risk measures that robustify a time homogeneous Markov model under distributional uncertainty. Starting from one step penalized worst case expectations, time consistency yields a convex monotone semigroup on bounded payoffs, uniquely determined by its risk generator. Under transport type lower bounds on the penalties, we identify the generator on smooth test functions and obtain two regimes: a first order drift correction via a convex Hamiltonian for Wasserstein penalizations, and a second order correction given by a convex monotone functional of the Hessian under martingale transport constraints. We give explicit formulas via convex conjugates of transport costs.*

MINI-SYMPOSIUM (ID 291): ID 649 (04)

Partially Ordered Peacocks

Anna Aksamit (*University of Sydney, Australia*); **Ivan Guo** (*Monash University, Australia*); **Jan Obloj** (*University of Oxford, United Kingdom*)

Abstract: *The celebrated Kellerer's Theorem asserts that one can embed a peacock (PCOC, or measures in increasing convex order) in a Markovian martingale that attains the measures as marginals. This is a fundamental result with close connections to martingale optimal transport. We consider the problem of embedding a family of measures in partial increasing convex order (partially ordered peacock), and analyse when it can be done. We will also present a convex-concave decomposition of measure pairs, as well as geometric characterisations of such embeddings.*

Perspectives on stochastic control with uncertainty and frictions - Aula D

Organized by: **Marco Rodrigues**

MINI-SYMPOSIUM (ID 328): ID 528 (01)

Equilibrium prices with uncertain fundamentals

Dylan Possamaï (*ETH Zurich, Switzerland*); **Mateo Rodriguez Polo** (*ETH Zurich, Switzerland*)

Abstract: *In this project, we show how to extend price-to-dividend formula from the paper from A. David and P.Veronesi,* Option prices with uncertain fundamentals, *when the cycle of earnings growth is modelled by a regime switching model with an arbitrary number of states and when preferences are recursive as in Epstein–Zin.*

MINI-SYMPOSIUM (ID 328): ID 603 (02)

Dynamic Schrödinger bridges beyond entropy

Camilo Hernández (*University of Southern California, United States*); **Ludovic Tangpi** (*Princeton University, United States*)

Abstract: *Over the past decade, Schrödinger's problem has become central in modeling uncertainty in dynamical systems. Unlike its static counterpart, the dynamic formulation models the temporal evolution of probability flows, a feature essential in generative diffusion models. The classical Schrödinger problem relies on relative entropy, which can be restrictive: it yields diffuse trajectories and imposes a log-penalty structure unable to capture robustness or structural features. General divergence-based penalties offer flexibility similar to how L^2-regularized optimal transport induces sparsity in the transport plan. In this work, we leverage stochastic control and convex duality to extend these ideas to the dynamic path-space setting.*

MINI-SYMPOSIUM (ID 328): ID 631 (03)

Robust hedging of American options via aggregated Snell envelopes

Marco Rodrigues (*WIAS Berlin, Germany*)

Abstract: *We study the robust hedging of American options under model uncertainty in a nondominated setting. Our approach is based on the construction of a Snell envelope under a sublinear expectation. We prove a duality formula for the robust superhedging price and establish the existence of a minimal superhedging strategy. Our results encompass continuous processes or processes with jumps and non-vanishing diffusion. A key application is to financial market models, where uncertainty is quantified through the semi-martingale characteristics.*

MINI-SYMPOSIUM (ID 328): ID 722 (04)

2BSDE erratic horizon: theory and applications

Alberto Gennaro (*UC Berkeley, United States*); **Thibaut Mastrolia** (*UC Berkeley, United States*)

Abstract: *We investigate the existence and uniqueness of non-Markovian second-order backward stochastic differential equations (2BSDEs) with an uncertain terminal horizon and establish comparison principles. The terminal time is random and exogenous, and it may not be adapted to the Brownian filtration, which induces a singular jump in the 2BSDE decomposition. In a Markovian framework, we further establish a connection between this new class of 2BSDEs and fully nonlinear partial differential equations. Our theoretical findings are applied to non-Markovian stochastic control problems. As an illustration, we present an example involving volatility control under default risk in a portfolio delegation setting.*

Strategic interaction among many agents: games and control - Aula E

Organized by: **Anna De Crescenzo**

MINI-SYMPOSIUM (ID 331): ID 550 (01)

Regulation or Competition: Major-Minor Optimal Liquidation across Dark and Lit Pools

Hao Wang (*UC Berkeley, United States*); **Thibaut Mastrolia** (*UC Berkeley, United States*)

Abstract: *We study the optimal liquidation problem in both dark and lit pools. First, we design an optimal make-take fee policy for a large investor in interaction with small investors. We explicitly characterize the large investor's strategies using BSDE theory, under a compensation scheme proposed by an exchange to mitigate market impact in the lit pool. Second, we study a purely competitive model with major and minor traders. We provide explicit solutions to the associated HJB–Fokker–Planck equations. We illustrate our results through comparing market impact in a regulated market with a strategic large investor to that in a purely competitive market.*

MINI-SYMPOSIUM (ID 331): ID 563 (02)

An alpha-potential approach to games of stopping times

Mehdi Talbi (*Universite Paris-Cite, France*)

Abstract: *In this talk, we shall discuss how to approximate certain types of games of stopping times with potential games, which we prove to derive from a multi dimensional singular control problem. This approach provides a convenient way to establish the existence of approximated Nash equilibria for the game of stopping times and to compute them through reinforcement learning algorithms.*

MINI-SYMPOSIUM (ID 331): ID 640 (03)

Mean-field control of heterogeneous systems

Anna De Crescenzo (*ETH Zurich, Switzerland*)

Abstract: *We study the optimal control of mean-field systems with heterogeneous and asymmetric interactions. We consider a family of controlled Brownian diffusion processes with dynamics depending on the whole collection of marginal probability laws. We establish well-posedness, define the associated control problem and value function, and show that the value function satisfies a Bellman dynamic programming equation in a L2-set of Wasserstein space-valued functions. To illustrate the applicability of our approach, we present a linear-quadratic graphon model with analytical solutions, and apply it to a systemic risk model involving heterogeneous banks.*

MINI-SYMPOSIUM (ID 331): ID 728 (04)

Approximation of Singular-Stopping Control Driven by Hawkes Processes via Rescaled MDPs

Isabel Agostino (*UC Berkeley, United States*); **Thibaut Mastrolia** (*UC Berkeley, United States*)

Abstract: *We investigate a singular–optimal stopping stochastic control problem driven by self-exciting dynamics governed by a Hawkes process. We show that the continuous-time optimization problem reduces to solving a gradient-constrained variational partial differential equation. We then introduce a discretization, modeled as a Markov Decision Process. We prove, via rescaling, that the value function of the discrete-time problem converges to its continuous-time equivalent, implying the asymptotic optimality of the discrete time optimizers. Finally, we apply these results to an Ornstein-Uhlenbeck SDE with a Hawkes process and singular control to illustrate the theoretical findings through numerical simulations.*

Path-dependent and signature modeling in finance - Part 2 - Aula F

Organized by: **Christa Cuchiero** and **Luca Pelizzari**

MINI-SYMPOSIUM (ID 312): ID 674 (01)

Dynamic Universal Approximation via Signature Controlled Differential Equations

Tomás Carrondo (*University of Vienna, Austria*); **Christa Cuchiero** (*University of Vienna, Austria*); **Paul Peter Hager** (*University of Vienna, Austria*); **Fabian Harang** (*BI Norwegian Business School, Norway*)

Abstract: *We study signature controlled differential equations (Sig-CDEs), path-dependent controlled differential equations whose vector fields factor through the signature. Working on spaces of stopped Hölder paths, we develop an existence, uniqueness, and stability theory for general path-dependent CDEs, and translate sufficient pathwise well-posedness criteria into intrinsic conditions on the corresponding signature functionals. We then prove dynamic universality: simply parametrised Sig-CDEs approximate the solution path of any well-posed path-dependent CDE, uniformly over bounded controls and histories, with global variants via weighted spaces. Finally, we analyse lifted/truncated Sig-CDEs and obtain new sufficient criteria for global existence on homogeneous groups in intrinsic group metrics.*

MINI-SYMPOSIUM (ID 312): ID 679 (02)

Local signature-based expansions

Sara Svaluto-Ferro (*University of Verona, Italy*); **Roberto Renò** (*Essec Business School, France*); **Federico M. Bandi** (*Johns Hopkins University, United States*)

Abstract: *We study the local (in time) expansion of a continuous-time process and its conditional moments, including the process' characteristic function. The expansions are conducted by using the properties of the (time-extended) Itô signature, a tractable basis composed of iterated integrals of the driving deterministic and stochastic signals: time, multiple correlated Brownian motions and multiple correlated compound Poisson processes. We show that these properties are conducive to automated expansions to any order with explicit coefficients and, therefore, to stochastic representations in which asymptotics can be conducted for a shrinking time.*

MINI-SYMPOSIUM (ID 312): ID 699 (03)

A universal approximation theorem for norm-bounded sets of geometric rough paths.

Asma Khedher (*University of Amsterdam, Netherlands*); **Sonja Cox** (*University of Amsterdam, Netherlands*); **Thijs Maessen** (*University of Amsterdam, Netherlands*)

Abstract: *We prove a universal approximation theorem (UAT) for norm-bounded geometric rough paths. The proof relies on embedding the rough path space into a linear Hölder space and equipping it with the induced weak-* topology, together with an explicit characterization of the corresponding predual. We further show that the signature map is weak-* continuous, extending finite-dimensional results to the infinite-dimensional setting. Our motivation is to develop an approach that enables the proof of a global UAT on the entire rough path space, with applications to energy markets, in particular to volatility modeling in HJMM-type frameworks via signatures of a Q-Brownian motion.*

MINI-SYMPOSIUM (ID 312): ID 671 (04)

The Attention Signature

Fabian Harang (*BI Norwegian Business School, Norway*); **Hao Ni** (*University College London, United Kingdom*); **Paul Peter Hager** (*University of Vienna, Austria*); **Luca Pelizzari** (*University of Vienna, Austria*)

Abstract: *The* attention signature *bridges modern transformer-based neural networks with signature-based learning. By employing the Volterra signature framework governed by learnable Query-Key Attention Kernels, this approach offers a mathematically rigorous, universal feature set that enables stable and interpretable learning via simple linear readouts. We demonstrate its performance on diverse benchmark tasks.*

Optimal Control/Optimization - Aula P

ORAL ID 335 (01)

A measure-valued HJB perspective on Bayesian adaptive optimal control

Alexander Cox (*University of Bath, United Kingdom*); **Sigrid Källblad** (*KTH Royal Institute of Technology, Sweden*); **Chaorui Wang** (*University of Bath, United Kingdom*)

Abstract: *We study Bayesian adaptive stochastic control with a static hidden signal that affects the drift of noisy observations through a controllable, non-separable dependence. The objective allows for broad nonlinear costs that on the full posterior distribution. Using posterior dynamics in the observation filtration, we reformulate the problem as an infinite-dimensional control problem via measure-valued martingales, and solve it using viscosity methods and approximation. As a byproduct, we prove a new stability result for a class of measure-valued SDEs. The talk will also discuss potential applications to mathematical finance and reinforcement learning, as well as an associated deep 2BSDE-based numerical method.*

ORAL ID 219 (02)

Signature scheme to solve linear-quadratic control problems

Alif Aqsha (*University of Oxford, United Kingdom*); **Peter Bank** (*Technische Universitat Berlin, Germany*); **Leandro Sánchez-Betancourt** (*University of Oxford, United Kingdom*)

Abstract: *We study a signature-driven numerical scheme to solve stochastic control problems. In the case of multi-dimensional linear-quadratic (LQ) stochastic control problems, we show that our approach turns the original LQ problem into a convex quadratic polynomial optimisation. We prove that, in the Brownian case, the optimal value function obtained using our method converges to the true optimal value function derived from the classical Hamiltonian-Jacobi-Bellman (HJB) equation. We discuss how our methodology is suited for path-dependent problems, and in particular, we show how a number of our results extend to the fractional Brownian motion case. Keywords: signatures, stochastic control, linear-quadratic*

ORAL ID 323 (03)

Neural network approximations for stochastic control problems with degenerate dynamics

Marco Scaratti (*University of Verona, Italy*); **Olivier Bokanowski** (*Université Paris Cité - LJLL, France*); **Jean-François Chassagneux** (*CREST, ENSAE, Institut Polytechnique de Paris, France*); **Xavier Warin** (*Électricité de France (EDF), France*)

Abstract: *We consider numerical approximations of stochastic optimal control problems over a finite time horizon. We establish new explicit error bounds, together with a convergence result for the associated value function in an averaged sense. The analysis is based on neural network approximations of optimal feedback controls. Compared with existing approaches, our framework provides an improved error estimate and accommodates degenerate stochastic diffusions. Numerical simulations illustrate the relevance of the proposed approach.*

ORAL ID 113 (04)

Optimal Policy Characterization for Multi-Dimensional Ergodic Singular Stochastic Control Problems

Alessandro Calvia (*Politecnico di Milano, Italy*); **Federico Cannerozzi** (*University of Bielefeld, Germany*); **Giorgio Ferrari** (*University of Bielefeld, Germany*)

Abstract: *We characterize the optimal policy and the value for a class of multi-dimensional ergodic singular stochastic control problems, in which a decision-maker instantaneously adjusts a state variable using a control of bounded variation to minimize a long-term average cost. The dynamics involve a linearly controlled one-dimensional stochastic differential equation whose coefficients, together with the cost functional, depend on a multi-dimensional uncontrolled process. We provide novel verification theorems linking optimal controls to Skorokhod reflection at state-dependent free boundaries arising from an auxiliary Dynkin game. Two genuinely two-dimensional optimal inventory management problems are fully solved.*

Optimal Transport - Aula Q

ORAL ID 337 (01)

Bid-Ask Martingale Optimal Transport

Valentin Tissot-Daguette (*Bloomberg, United States*); **Shunan Sheng** (*Columbia University, United States*); **Marcel Nutz** (*Columbia University, United States*); **Bryan Liang** (*Bloomberg, United States*)

Abstract: *Martingale Optimal Transport (MOT) provides a robust framework for pricing and hedging illiquid derivatives. Traditionally, MOT ignores bid–ask spreads by calibrating exactly to mid-prices, which underestimates model risk. We introduce Bid–Ask Martingale Optimal Transport (BAMOT), where model marginals are constrained by bid and ask distributions via convex order. We establish strong duality and prove convergence to the MOT limit as spreads vanish, quantifying the rate using a novel "bid–ask distance" between probability measures. Our empirical findings expose critical risks in mid-price calibration and demonstrate that BAMOT better aligns with industry practices.*

ORAL ID 418 (02)

Entropic Optimal Transport Problem with Convex Functional Cost

Xiaozhen Wang (*Université Paris-Dauphine PSL, France*); **Anna Kazeykina** (*Université Paris-Saclay, France*); **Zhenjie Ren** (*Université Evry Paris-Saclay, France*); **Yufei Zhang** (*Imperial College London, United Kingdom*)

Abstract: *We study an entropic optimal transport problem with an additional nonlinear convex penalty on the coupling. We prove existence, uniqueness, and uniform a priori bounds for the minimizer, which satisfies a fixed-point first-order optimality system via an exponentially tilted reference measure. Leveraging this variational structure, we propose a Sinkhorn–Frank–Wolfe flow, establish global well-posedness, and derive an energy–dissipation inequality implying exponential convergence to the unique optimum. We apply the resulting SFW algorithm to UAV routing with congestion aversion. Joint work with Anna Kazeykina, Zhenjie Ren, and Yufei Zhang.*

ORAL ID 371 (03)

Low-dimensional adapted optimal transport and its Schrödinger equations

Linn Engström (*KTH Royal Institute of Technology, Sweden*); **Sigrid Källblad** (*KTH Royal Institute of Technology, Sweden*)

Abstract: *During the last decade there has been a rapid development of methods for computationally addressing optimal transport problems; motivated by applications within robust finance and machine learning, effort has also been made to generalize these techniques to problems equipped with additional causality constraints. Solving such adapted optimal transport (AOT) problems computationally remains a challenging task though for problems formulated over many periods. In this talk we will present an efficient framework for solving a class of AOT problems computationally. Our method leverages on sparse structures and allows for deriving a low-dimensional version of the adapted Schrödinger equations.*

ORAL ID 470 (04)

Information-Based Martingale Optimal Transport

Georges Kassis (*Department of Mathematics, University College London, United Kingdom*); **Andrea Macrina** (*Department of Mathematics, University College London, United Kingdom*)

Abstract: *Filtered-arcade-martingales (FAMs) are continuous-time processes that interpolate random variables of a discrete-time martingale. We relax the FAM setting to the interpolation between probability measures and treat the problem of selecting the worst martingale coupling for given, convexly ordered, probability measures contingent on the paths of FAMs. We examine this optimisation problem, termed information-based martingale optimal transport(IB-MOT), if it is understood as a model-free construction of FAMs, where the coupling is not determined a priori, and from the viewpoint of optimal transport(OT), where a noise factor is introduced in martingale optimal transport, similar to how entropic regularisation introduces noise in OT.*

Energy Finance - Aula H

ORAL ID 137 (01)

Deep Learning for Energy Market Contracts: Dynkin Game with Doubly RBSDEs

Ihsan Arharas (*Linnaeus University, Sweden*); **Nacira Agram** (*KTH Royal Institute of Technology, Sweden*); **Nacira Agram** (*KTH Royal Institute of Technology, Sweden*); **Giulia Pucci** (*KTH Royal Institute of Technology, Sweden*); **Jan Rems** (*University of Ljubljana, Slovenia*)

Abstract: *We formulate a Contract for Difference (CfD) with early exit options as a two-player zero-sum Dynkin game, reflecting the strategic interaction between an electricity producer and a regulatory entity. The game value is characterized through a doubly reflected backward SDE. To compute the contract value and optimal stopping strategies, we develop a neural solver that approximates the DRBSDE solution using a sequence of neural networks trained on simulated trajectories. We establish a convergence result and test the method on two scenarios: a benchmark symmetric game in 20 dimensions, and a CfD model with 24-dimensional electricity prices representing multiple European zones.*

ORAL ID 504 (02)

Natural Gas Storage Valuation Using Deep Reinforcement Learning

Masood Tadi (*Prague University of Economics and Business, Czechia*); **Milan Fičura** (*Prague University of Economics and Business, Czechia*); **Jiří Witzany** (*Prague University of Economics and Business, Czechia*)

Abstract: *We study the natural gas storage valuation problem under a stochastic futures term structure using deep reinforcement learning. The storage operator maximizes profit through optimal injection and withdrawal decisions subject to physical constraints. The problem is formulated as a continuous-state, continuous-action Markov Decision Process and solved using the DDPG algorithm with PER and a constraint-aware policy network trained on simulated data. We benchmark the approach against intrinsic and rolling intrinsic strategies. Results show that the DRL method consistently outperforms intrinsic valuation and performs competitively with rolling intrinsic, capturing additional extrinsic value under stochastic dynamics with jumps, seasonality, and operational constraints.*

ORAL ID 440 (03)

Seasonality and Spikes in the Natural Gas Market

Francesco Rotondi (*Università Commerciale L. Bocconi, Italy*)

Abstract: *In this paper we propose an arbitrage-free model for the natural gas spot price and its convenience yield. An empirical analysis of European markets shows that log spot prices are non-stationary, weakly seasonal, and nearly continuous, whereas the implied convenience yield is stationary, strongly seasonal, and characterized by frequent spikes. Motivated by these features, we model the convenience yield as the sum of a deterministic seasonal component and a mean–reverting jump process. Closed-form futures prices are derived under suitable jump specifications, and empirical results show an excellent fit before and after the COVID–19 pandemic and the Russia-Ukraine war.*

ORAL ID 273 (04)

A hybrid Hidden Markov–LSTM Modell for adaptive forecasting in Electricity Spot Markets

Christina Erlwein-Sayer (*HTW Berlin, Department of Business Mathematics, Germany*); **Tilman Sayer** (*Department of Data and Analytics, mobile de, Germany*)

Abstract: *Electricity spot prices are prone to volatile periods. We propose a hybrid approach that combines Long Short-Term Memory (LSTM) networks with Hidden Markov Models (HMMs) to capture regime shifts. We enhance the LSTM by incorporating an underlying HMM to detect market regimes. The regimes are filtered, enabling the model to find regime segments in the observation process. The LSTM is trained for each time series, probabilities are integrated as weights into the prediction. The integration of HMM enhances the accuracy and interpretability of the model. It is applied to German spot prices and outperforms single state methods in predictive accuracy.*

Market Microstructure, Insider Trading and Auctions - Aula I

ORAL ID 74 (01)

The Private Enforcer: Algorithmic Deterrence and the Shadow Tax on Insider Trading

Tingyi Lin (*Central University of Finance and Economics, China*); **Ruoran Lai** (*Sun Yat-sen University, China*)

Abstract: *Can code deter insider trading more effectively than law? In decentralized markets lacking public enforcement, we identify a novel mechanism of "privatized regulation": predatory algorithms (MEV bots) that impose an immediate, state-dependent penalty on toxic order flow. By solving a coupled HJB-QVI equilibrium between a risk-averse insider and a strategic predator, we demonstrate that the threat of "sandwich attacks" functions as an endogenous "shadow tax" on information. This tax generates a structural "Liquidity Trap"—a safe-harbor region where algorithmic deterrence compels insiders into inaction, effectively replicating a regulatory blackout period without legal intervention.*

ORAL ID 457 (02)

Decentralized Simulation of Automated Trading in Intelligent Markets: Risk-Averse Agent Optimization

Tommi Vuorenmaa (*Rayleigh Research, Finland*)

Abstract: *This paper explains the basic principles of a decentralized simulation framework called Simulation of Automated Trading. The system extends a centralized agent-based modeling framework into a decentralized one, where a portion of the agents are programmed to act in a stylized manner by certain simple rules in combination with high-frequency market makers to produce a realistic limit-order book feed. Decentralized AI Agents are incentivized to compete in the same setting. This system allows for statistically more precise simulation of trading algorithms for risk management and more generally for the optimization of market microstructure and regulations to improve market quality.*

ORAL ID 385 (03)

Price Manipulation in equity auctions

Salma Elomari (*Université Paris-Saclay, Centrale-Supélec, France*); **Ioane Muni Toke** (*Université Paris-Saclay, Centrale-Supélec, France*); **Damien Challet** (*Université Paris-Saclay, Centrale-Supélec, France*)

Abstract: *Equity auctions account for a substantial share of daily trading volume and determine reference prices. During auction call periods, orders accumulate without execution, and the indicative clearing price can be mechanically influenced through order submissions, revisions, and cancellations. We propose two order-level, sequence-based statistical diagnostics to identify atypical order-revision behaviour. The first targets asymmetries in immediate price impact between volume increases and decreases within a single order ("min–max impact"). The second targets counter-economic revisions, in which traders adjust displayed volume against recent indicative price changes ("self-harming"). Both diagnostics are model-free and operational, ranking individual order sequences by statistical atypicality.*

ORAL ID 198 (04)

Risk aversion of insider and dynamic asymmetric information.

Albina Danilova (*LSE, United Kingdom*); **Valentin Lizhdvoj** (*HSE, Russian Federation*)

Abstract: *We study a Kyle-Back model with a risk-averse insider possessing exponential utility and a dynamic signal about the asset's terminal value. While existing literature considers either risk-neutral insiders with dynamic signals or risk-averse insiders with static signals, we establish equilibrium when both features are present, imposing no restrictions on the risk aversion parameter. We derive necessary conditions showing the optimal insider strategy must be continuous with bounded variation and characterize the equilibrium pricing rule and strategy. Explicit closed-form solutions are obtained for deterministic signal volatility and static signal cases, demonstrating tractability.*

Derivative Pricing, Calibration and Event Risk - Aula L

ORAL ID 48 (01)

Effective Markovian Projection Using Coefficient Matching: Application to Forward Starting Options

Kefentse Freddy Dipudi (*University of Cape Town, South Africa*); **Jörg Kienitz** (*University of Cape Town, Germany*); **Thomas Mcwalter** (*University of Cape Town, South Africa*)

Abstract: *We investigate a framework that reconciles stochastic local volatility (SLV) and stochastic volatility (SV) models while maintaining tractability and market consistency. At its core is an Effective Coefficient Matching technique, which projects complex models onto simpler counterparts with semi-analytic accuracy of order $O(\varepsilon^2)$. We also derive a semi-analytic pricing formula for forward starting options within a broad class of stochastic volatility models. The representation characterizes the forward implied volatility surface in closed form, enhances pricing accuracy, and allows forward dynamics to be embedded into calibration. Keywords: Stochastic Volatility, Local Volatility, Effective Coefficient Matching, Forward implied volatility, Option pricing*

ORAL ID 89 (02)

A Copula-Based Approach for the Pricing of Energy Quanto Options

Amia Santini (*Università di Bologna, Italy*); **Silvia Romagnoli** (*Università di Bologna, Italy*); **Diego Cisbani** (*Intesa Sanpaolo, Italy*)

Abstract: *This work proposes a novel pricing methodology for Energy Quanto Options (EQOs), derivative instruments which aim to mitigate the joint risk from temperature and electricity price fluctuations. We employ a copula-based approach, ensuring maximum flexibility in the modeling of codependence and the ability to capture tail risk. This pricing methodology leads to an explicit, closed-form solution, independent of Monte Carlo methods.*

ORAL ID 183 (03)

A Wiener–Chaos Approach to Martingale Modelling and Implied Volatility Calibration

Pere Diaz Lozano (*University of Oslo, Norway*); **Thomas Kloster** (*University of Aarhus, Denmark*)

Abstract: *Calibration to a surface of option prices requires specifying a suitably flexible martingale model for the discounted asset price under a risk-neutral measure. Assuming Brownian noise and mean-square integrability, we construct an over-parameterized model by approximating the terminal value of the martingale via a truncated Wiener–chaos expansion and recover the intermediate dynamics by computing the corresponding conditional expectations. Using the Hermite-polynomial formulation of Wiener chaos, we obtain easily implementable expressions that enable fast calibration to a target implied-volatility surface. We illustrate the flexibility and expressive power of the resulting model through numerical experiments on both simulated and real market data.*

ORAL ID 284 (04)

A Framework for Event Risk Pricing with Stochastic Event Outcome Probabilities

Michael Hanke (*University of Liechtenstein, Liechtenstein*); **Wolfgang Schadner** (*University of Liechtenstein, Liechtenstein*); **Sebastian Stöckl** (*University of Liechtenstein, Liechtenstein*); **Alex Weissensteiner** (*University of Bolzano, Italy*)

Abstract: *We provide a flexible framework for the pricing of event risk, which allows for analyzing event risk premia and pricing of options on underlyings that are affected by event risk. In contrast to previous literature, the framework incorporates stochastic event outcome probabilities. It nests a number of pricing models from the literature and accomodates stylized facts such as non-convex volatility smiles and bi-modal risk-neutral densities. We show that in addition to an increase in implied volatility caused by the event payoff distributions, options expiring before the event are affected by the event risk via the uncertainty in event outcome probabilities.*

Statistical and Numerical Perspectives on Diffusion-Based Models: From Data to Dynamics - Aula M

Organized by: **Yating Liu**

MINI-SYMPOSIUM (ID 271): ID 575 (01)

Recent advances on the simulation of McKean-Vlasov type equations

Armand Bernou (*Université Claude Bernard Lyon 1, France*); **Yating Liu** (*Université Paris Dauphine, France*)

Abstract: *This talk will focus on some recent results regarding the simulation of non-linear diffusions of McKean-Vlasov type. We will mostly present a recently established bound on the strong error, in Wasserstein distance, of the particle method for the simulation of the path-dependent McKean-Vlasov equation, illustrated with numerical simulations. If time allows, we will also discuss some recent advances on the description of the weak error of propagation of chaos for those mean-field models, in the spirit of Chassagneux-Szpruch-Tse (2022), including the kinetic Langevin system. This analysis grounds the use of Romberg's interpolation to accelerate numerical schemes.*

MINI-SYMPOSIUM (ID 271): ID 534 (02)

Learning drift functions in diffusion processes: from estimation to classification via neural networks

Yuzhen Zhao (*Université Paris Dauphine PSL, France*); **Jiarong Fan** (*Université Paris-Saclay, France*); **Yating Liu** (*Université Paris Dauphine PSL, France*); **Marc Hoffmann** (*Université Paris Dauphine PSL, France*)

Abstract: *We study learning problems for time-homogeneous diffusion processes observed at discrete times, focusing on drift estimation and supervised classification. We propose a neural network–based nonparametric drift estimator using high-frequency trajectories and derive non-asymptotic convergence rates. For compositional drift structures, the rates show only weak dependence on the dimension. Numerical results demonstrate clear improvements over classical B-spline methods, especially in high dimensions. Building on this framework, we introduce a neural plug-in classifier for multiclass diffusion models and establish convergence rates for the excess risk, demonstrating improved performance over direct end-to-end neural network classifiers by exploiting the diffusion structure.*

MINI-SYMPOSIUM (ID 271): ID 577 (03)

Kernel-Smoothed Scores for Denoising Diffusion: A Bias-Variance Study

Franck Gabriel (*Université Claude Bernard Lyon 1, France*); **François Ged** (*University of Vienna, Austria*); **Maria Han Veiga** (*Ohio State University, United States*); **Emmanuel Schertzer** (*University of Vienna, Austria*)

Abstract: *Diffusion models generate realistic samples but may memorize training examples. Since the smooth implicit bias of learning can partially mitigate memorization, we study a simplified setting where the empirical score is mollified. This reveals a two-stage regularization mechanism: (i) isotropic diffusion that removes details and (ii) smoothing along the data manifold. We show that the LED-KDE, a new density estimator, guides the diffusion. In the short-time, large-sample regime, we analyze bias-variance for both scores and bound the gap between the noised data distribution and that generated by diffusions driven by either score, quantifying how smoothing improves generalization and reduces memorization.*

MINI-SYMPOSIUM (ID 271): ID 599 (04)

On Forgetting and Stability of Score-based Generative models

Stanislas Strasman (*Sorbonne Université, France*); **Sylvain Le Corff** (*Sorbonne Université, France*); **Vincent Lemaire** (*Sorbonne Université, France*); **Gabriel Victorino Cardoso** (*Mines Paris, France*); **Antonio Ocello** (*ENSAE Paris, France*)

Abstract: *Understanding the stability and long-time behavior of generative models is a fundamental problem in modern machine learning. This talk provides bounds on the sampling error of score-based generative models by leveraging stability and forgetting properties of the Markov chain associated with the reverse-time dynamics. Under weak assumptions, we provide the two structural properties to ensure the propagation of initialization and discretization errors of the backward process: a Lyapunov drift condition and a Doeblin-type minorization condition. A practical consequence is quantitative stability of the sampling procedure, as the reverse diffusion dynamics induces a contraction mechanism along the sampling trajectory.*

Hedging - Aula Filopanti

ORAL ID 494 (01)

Explicit Characterization and Backward Construction of Superhedging Prices with Transaction Costs

Amal Omrani (*Université Paris Dauphine PSL, France*); **Emmanuel Lepinette** (*Université Paris-Dauphine PSL, France*)

Abstract: *We study the superhedging problem in a discrete-time financial market with proportional transaction costs and deterministic conditional support of asset returns. Payoffs are allowed to depend on the previous portfolio position, capturing a broad class of contingent claims arising in frictional markets. We provide an explicit characterization of one-step superhedging strategies and derive closed-form expressions for the set of feasible portfolios and the minimal superhedging price. This leads to an exact backward construction of superhedging prices and strategies. Numerical experiments illustrate the efficiency and stability of the proposed approach.*

ORAL ID 243 (02)

Model Risk Static-Hedging a Constrained Distributionally Robust Optimization approach

Nathan Sauldubois (*New York University, United States*)

Abstract: *We study sensitivity analysis for distributionally robust optimization under martingale coupling constraints. Building on Touzi & Sauldubois (2024), we address the previously open case of static hedging with second-maturity vanilla options and strategies involving a vanilla payoff. We also extend existing sensitivity results to model classes constrained by martingale couplings. Our results include estimates for the adapted Wasserstein distance between the pushforward of a martingale coupling under progressively measurable maps and the set of feasible martingale couplings, as well as a computation of the "Riesz" projection via a weak implicit-function argument. We obtain closed-form sensitivities and characterize hedging strategies.*

ORAL ID 310 (03)

Limit theorems for the hedging error of contingent claims under integer constraints

Florian Ostendorf (*FAM @ TU Wien, Vienna, Austria, Austria*); **Stefan Gerhold** (*FAM @ TU Wien, Vienna, Austria, Austria*); **Paul Eisenberg** (*WU Vienna, Austria*)

Abstract: *The classical theory of dynamic trading and hedging relies on the simplifying assumption that financial assets can be traded in arbitrary quantities, however, the implications of discrete trading constraints have received limited attention in the literature. We establish a CLT for the integerization error that arises when continuous trading strategies are approximated by integer-valued positions in a standard diffusion model. We use the diffusion's local time and expected occupation measure to describe the limiting distribution - a scale mixture of normal distributions with variance equal to the limit of the error's quadratic variation - and the expected squared error.*

ORAL ID 32 (04)

Monotone mean-variance investment-reinsurance under the Cramer-Lundberg model

Zuoquan Xu (*The Hong Kong Polytechnic University, Hong Kong*)

Abstract: *We study an optimal investment-reinsurance problem under the Cramer-Lundberg model with monotone mean-variance (MMV) criterion. The insurer can purchase reinsurance or acquire new business and invest in a security market with random return and volatility rates. Trading strategies face a general convex cone constraint, encompassing no-shorting constraint as a special case. Explicit optimal investment-reinsurance strategy is derived via backward stochastic differential equations with jumps. Similar to the continuous case, we show MMV and classical mean-variance criteria yield identical results even with Poisson jumps and random market coefficients.*

Modeling, Prediction, and Control in Energy Markets and Climate Finance - Part 2 - Aula A

Organized by: **Chiheb Ben Hammouda** and **Antonis Papapantoleon**

MINI-SYMPOSIUM (ID 341): ID 721 (01)

Prediction of energy production from wind farms using SDEs

Antonis Papapantoleon (*TU Delft, Netherlands*); **Michail Loulakis** (*NTU Athens, Greece*); **Christos Nakos** (*PPC Greece, Greece*); **Alexandros Saplaouras** (*U Aegean, Greece*)

Abstract: *We propose, estimate and test a stochastic model for the prediction of energy production from a renewable asset (wind park), based on the available numerical weather prediction and historical data of energy production. The stochastic model for the wind speed is based on a suitable transformation of the CIR process. Motivated by the statistical analysis of realized production, we consider different power curves for translating the wind speed in produced power, depending on the direction of the wind. The empirical analysis shows that the model performs well and showcases the advantages of this approach.*

MINI-SYMPOSIUM (ID 341): ID 618 (02)

Italian Market Signals for Hybrid Wind-Battery Dispatch: from Price-Agnostic to Price-Driven Control

Nicolò Filippas (*University of Genoa, Italy*); **Giorgia Callegaro** (*University of Padova, Italy*); **Emanuela Sasso** (*University of Genoa, Italy*); **Sadion Xhuveli** (*University of Genoa, Italy*)

Abstract: *We implement and extend the optimal intraday dispatch algorithm for hybrid wind–battery assets developed by Aung and Ludkovski (2025), adapting it to the Italian electricity market and boosting its profitability. The method combines dynamic programming with Gaussian-process emulators for value and control maps, making the Dynamic Programming Principle computationally tractable. It delivers an optimal battery schedule that minimizes firming deviations between realized and target generation. We calibrate the model on Italian wind production and imbalance-price data, replacing the U.S. price-agnostic setting with signals from the Mercato del Giorno Prima and the real-time Prezzo di Sbilanciamento, including asymmetric upward/downward imbalance penalties.*

MINI-SYMPOSIUM (ID 341): ID 658 (03)

Semi-static hedging of volumetric risk in energy markets

Sven Karbach (*University of Amsterdam, Netherlands*); **Konstantinos Chatziandreou** (*University of Amsterdam, Netherlands*)

Abstract: *In this talk, we develop quantitative methods for pricing and hedging Power Purchase Agreements (PPAs), whose value depends on the joint dynamics of future renewable production and forward electricity prices. We propose a coupled HJM framework for forward power prices and renewable production indices, driven by a Wishart-type stochastic covariance model that captures their complex dependence structure. Within this setting, we derive semi-closed-form solutions for the variance-optimal hedge and assess its effectiveness in mitigating intrinsic volume and price risks. Our integrated approach is benchmarked against Delta hedging and a fully static strategy based on portfolios of power and weather derivatives.*

MINI-SYMPOSIUM (ID 341): ID 739 (04)

Predicting DART Spread Spikes in ISO Electricity Markets

Ronnie Sircar (*Princeton University, United States*); **Emma Hubert** (*Université Paris Dauphine, France*); **Dimitrios Lolas** (*Princeton University, United States*)

Abstract: *We study the problem of forecasting and optimally trading day-ahead versus real-time (DART) price spreads in U.S. wholesale electricity markets. Building on the framework of Galarneau-Vincent et al., we extend spike prediction from a single zone to a multi-zone setting and treat both positive and negative DART spikes within a unified statistical model. To translate directional signals into economically meaningful positions, we develop a structural and market-consistent price impact model based on day-ahead bid stacks. When applied to NYISO, the resulting impact-aware strategy significantly improves the risk–return profile relative to unit-size trading and highlights substantial heterogeneity across markets and seasons.*

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Recent Advances on Mean-Field Control and Mean-Field Games - Part 1 - Aula G

Organized by: **Dena Firoozi**

MINI-SYMPOSIUM (ID 357): ID 568 (01)

Optimal Execution Games with Transient Price Impact: Existence, Uniqueness, and the Limits of Randomization

Steven Campbell (*Columbia University, United States*); **Marcel Nutz** (*Columbia University, United States*)

Abstract: *We analyze an N-player execution game in the Obizhaeva–Wang price-impact model and identify a striking pathology: seemingly natural game formulations may admit no equilibrium. We propose simple regularizations that recover existence and deliver closed-form equilibrium strategies and prices, clarifying exactly why equilibrium breaks down as the regularization vanishes. We then ask whether allowing randomization fixes the problem. It does not: under mild conditions, equilibrium outcomes are essentially unique, and mixed strategies do not expand the equilibrium set. If time permits, I will discuss consequences for the mean-field limit. Based on joint work with Marcel Nutz.*

MINI-SYMPOSIUM (ID 357): ID 589 (02)

Mean Field Control with Poissonian Common Noise: A Pathwise Compactification Approach

Xiang Yu (*The Hong Kong Polytechnic University, Hong Kong*)

Abstract: *This paper contributes to the compactification approach to study mean-field control problems with Poissonian common noise. We propose a pathwise formulation in a two-step procedure by freezing a sample path of the common noise. In the first step, we establish the existence of the optimal relaxed control in the pathwise formulation as if common noise is absent. The second step plays the key role in our approach, which is to aggregate the optimal solutions in the pathwise formulation over all sample paths of common noise and show that it yields an optimal solution in the original model.*

MINI-SYMPOSIUM (ID 357): ID 630 (03)

Deep Signature Approach for McKean-Vlasov FBSDEs in a Random Environment

Ruimeng Hu (*University of California, Santa Barbara, United States*); **Botao Jin** (*University of California, Santa Barbara, United States*); **Mathieu Laurière** (*NYU Shanghai, China*); **Jiacheng Zhang** (*Chinese University of Hong Kong (Shenzhen), Hong Kong*)

Abstract: *Mean-field games with common noise model large populations affected by shared randomness and can be formulated as McKean–Vlasov forward-backward SDEs whose coefficients depend on conditional state distributions. Existing numerical methods typically handle only moment-based interactions, not full distributional dependence. This work proposes a deep learning algorithm combining fictitious play and supervised learning to solve such general MV-FBSDEs. Conditional laws are represented via signatures, and neural networks approximate both the FBSDE solutions and distribution-dependent coefficients, enabling high-dimensional scalability. Convergence of the fictitious play scheme is established under suitable assumptions, with errors driven by supervised learning. Numerical experiments confirm the method's effectiveness.*

MINI-SYMPOSIUM (ID 357): ID 676 (04)

An □-Potential Game Framework for □-Player Dynamic Games

Xin Guo (*UC Berkeley, United States*); **Xinyu Li** (*University of Oxford, United Kingdom*); **Yufei Zhang** (*Imperial College London, United Kingdom*)

Abstract: *We propose and study a general form of dynamic N-player non-cooperative games called α-potential games. The α-potential game framework reduces the task of finding α-Nash equilibria to minimizing an α-potential function. An analytical characterization of α-potential functions is established, with α represented in terms of the asymmetry of value functions' second-order derivatives. For stochastic differential games, α is characterized in terms of the number of players, the choice of admissible strategies, and the level of heterogeneity among players. To analyze the α-NE, the associated optimization problem is embedded into a conditional McKean-Vlasov control problem, and a verification theorem is established.*

FX Market Making, Price Impact and Arbitrage - Aula B

ORAL ID 197 (01)

Duality theory for utility maximization in Volterra kernel models for transient price impact

Jun Cheng (*London School of Economics and Political Sciences, United Kingdom*); **Christoph Czichowsky** (*London School of Economics and Political Sciences, United Kingdom*)

Abstract: *We study exponential utility maximization under linear price impact featuring temporary and transient Volterra components. Using convex duality, we identify the dual domain and establish a novel superhedging theorem for this non-Markovian problem. We prove a duality theorem guaranteeing the existence of optimizers. To demonstrate tractability, we apply our framework to continuous Gaussian price processes. We derive semi-explicit optimal trading strategies for these non-semimartingale models, demonstrating how shadow prices render such rough dynamics tractable by embedding them into a fictitious frictionless market. Our results extend previous duality theory to settings with memory-dependent price impact.*

ORAL ID 253 (02)

FX Market Making with Internal Liquidity

Alexander Barzykin (*HSBC, United Kingdom*); **Robert Boyce** (*Imperial College London, United Kingdom*); **Eyal Neuman** (*Imperial College London, United Kingdom*)

Abstract: *As the FX markets evolve, many institutions have started offering passive access to their internal liquidity pools. Market makers act as principal and can fill those orders as part of risk management, or adjust pricing to their OTC franchise to facilitate the matching flow. It is, a priori, unclear how strategies managing internal liquidity should depend on market conditions, the market maker's risk appetite, and the algorithms deployed by clients. In this work, we investigate the optimal strategy of a market maker with an option to take liquidity on an internal exchange, and draw insights for real-world trading.*

ORAL ID 484 (03)

Triangular Arbitrage in FX Markets: Evidence from High-Frequency Data

Erhan Uluceviz (*Gebze Technical University, Türkiye*)

Abstract: *We investigate triangular arbitrage in major FX markets using high-frequency bid–ask quotes at millisecond resolution from 2023 to 2025, constructing triangular rate products for the EUR/USD, USD/CHF, and EUR/CHF pairs and analyzing deviations from the no-arbitrage condition implied by exchange-rate consistency. The results show that potential arbitrage opportunities are predominantly small—mostly below one basis point—and extremely short-lived, typically lasting tens of milliseconds. Larger and more persistent deviations are rare and likely reflect transient quote dislocations or synchronization artifacts. Despite relying on a free-tier indicative dataset, the empirical patterns align with prior findings and indicate improvements in FX market efficiency.*

ORAL ID 430 (04)

Market segmentation and arbitrage

Umut Cetin (*London School of Economics and Political Sciences, United Kingdom*); **Eduardo Ferioli Gomes** (*Universidade Federal Fluminense, Brazil*)

Abstract: *We study the optimal strategies for a high frequency arbitrageur who takes advantage of his superior trading speed to create arbitrage opportunities by investing in a stock traded in two venues. Arbitrage opportunities arise due to a combination of liquidity shocks and asynchronous price adjustment to news. We study the problem in a variant of the Kyle model. In a striking deviation from the Kyle mode, it is the market makers, as opposed to the strategic arbitrageur, that drive the prices to the fundamental value to limit the speculations of the arbitrageur towards the end of the trading period.*

Stochastic Volatility - Aula C

ORAL ID 76 (01)

Calibration Geometry for Volatility: Detecting Model Stress via Curvature-Gradient Instability

David Ramirez (*N/A, United States*); **Zachary Dasilva** (*N/A, United States*)

Abstract: *We develop dynamic calibration geometry for volatility-model validation. Rolling calibration on a likelihood-derivative Riemannian metric generates a geometry-only state G_t and curvature-gradient instability $I_{g,t} = |\nabla R(\hat{\theta}_t)|_g$. A log-normal/GBM negative control defines numerical floors and audit checks; Shape Risk and Process Risk probes verify mechanism sensitivity. Because G_t is generated by estimation, metric regularization, finite differences, and first-stage choices, audit admission precedes empirical use. We test audit-admitted high Ig, tinside high-IV/RV states against adverse Heston QLIKE review outcomes and realized metric-normalized calibration-state displacement.*

ORAL ID 441 (02)

Asset Pricing with Regime-Sensitive Volatility and Jumps

Marco Patacca (*University of Perugia, Italy*); **Gianna Figà-Talamanca** (*University of Perugia, Italy*); **Alessandra Cretarola** (*University of Chieti-Pescara, Italy*)

Abstract: *We introduce a two-factor stochastic volatility model extending the classical Bates framework by introducing a regime-dependent structure; the asset volatility is decomposed into a latent base component and a state-sensitive bias. Other key model parameters are also drivenby the underlying Markov process allowing the model to adapt to market conditions. The model is specified under the real-world probability measure and requires a careful investigation of the conditions under which an equivalent martingale measure exists. We derive a closed-form solution for European-style derivative prices, enabling efficient calibration of model parameters to observed market data. Finally, we provide an extensive empirical evaluation.*

ORAL ID 389 (03)

When is Volatility Fair? Holder Regularity and Financial Risk

Daniele Angelini (*University of Rome - La Sapienza, Italy*); **Sergio Bianchi** (*University of Rome - La Sapienza, Italy*)

Abstract: *We argue that financial risk is driven by unpredictability rather than variability and propose a risk measure based on the local regularity of log-returns. This perspective motivates the notion of* fair volatility*, defined as the volatility level consistent with efficient markets and martingale dynamics, which does not necessarily coincide with high volatility. Within the class of Multifractional Processes with Random Exponent (MPRE), we derive an analytical link between regularity and increment scale. Using standard estimators, we compare MPRE-implied and realized volatility across fourteen equity indices, identifying coherent patterns and transient inefficiencies corrected by opposite behavioural regimes.*

ORAL ID 141 (04)

A Reappraisal of Volatility Bursts in Two-Factor Stochastic Volatility Models with Autoregressive Gamma Dynamics

Simon Fabian Ernst Feistle (*University of St. Gallen, Switzerland*)

Abstract: *We propose a new filtering-based approximate maximum likelihood estimator for two-factor stochastic volatility (SV) models with latent autoregressive gamma (ARG) variance processes, based solely on return observations. Building on Bates (2006, 2012), our approach models the joint conditional transition law of the latent variance components to address the extreme volatility dynamics seen in estimations of two-factor ARGSV models. Empirically, our method implies a more plausible two-factor ARGSV structure and outperforms a recent two-factor GARCH benchmark in forecasting realized variance. These findings suggest that multi-factor ARGSV models estimated from returns alone can provide both econometric tractability and improved forecasting performance.*

Mean-field games in Economics II - Aula D

Organized by: **Roxana Dumitrescu** and **Peter Tankov**

MINI-SYMPOSIUM (ID 455): ID 659 (01)

Optimal Maritime Transport through Mean Field Games and inference of its parameters

Charles-Albert Lehalle (*Ecole Polytechnique, France*); **Giulia Livieri** (*London School of Economics and Political Sciences, United Kingdom*)

Abstract: *Our paper present a Mean Field Game (MFG) model for maritime traffic flow, treating the navigation of ships between seaports as a large-scale stochastic control problem with key factors: transportation costs, expected profit margins and a congestion term that reflects the costs associated with accessing the destination port. We derive an explicit solution for the stationary version of the model. Furthermore, we introduce a statistical methodology to infer the parameters of the game from real-world data. To validate our model, we use the ShipFix dataset of daily ''Dry Coal'' shipments worldwide from 2015 to 2025.*

MINI-SYMPOSIUM (ID 455): ID 767 (02)

Growth model with externalities for energetic transition via MFG with common external variable

Quentin Petit (*Électricité de France (EDF), France*)

Abstract: *We develop a mean-field game model for multi-sector economic growth with a dynamic externality driven by countries' collective actions and subject to common noise. Using a Forward–Backward Stochastic Differential Equation formulation, we prove existence and uniqueness of equilibrium under various assumptions and monotonicity conditions. A numerical solution is obtained through a fixed-point algorithm combined with neural network approximations.*

MINI-SYMPOSIUM (ID 455): ID 710 (03)

Continuous-time mean field games: a primal-dual characterization

Xin Guo (*UC Berkeley, United States*); **Anran Hu** (*Columbia University, United States*); **Jiacheng Zhang** (*The Chinese University of Hong Kong, Hong Kong*); **Yufei Zhang** (*Imperial College London, United Kingdom*)

Abstract: *This paper develops a primal–dual framework to characterize all Nash equilibria in continuous-time mean field games. For any given mean field flow, the representative player's control problem is reformulated as a linear program over occupation measures, with a dual formulation as a maximization over smooth subsolutions of the associated Hamilton–Jacobi–Bellman equation. Strong duality between the primal and dual problems yields a complete characterization of equilibria. Unlike existing approaches, this framework does not require Hamiltonian convexity or uniqueness of optimizers, and remains valid even when the HJB equation lacks classical solutions. Extensions to mean field optimal stopping games are discussed.*

MINI-SYMPOSIUM (ID 455): ID 717 (04)

A new probabilistic approach for optimal stopping mean-field games

Roxana Dumitrescu (*CREST, ENSAE, Institut Polytechnique de Paris, France*); **Andrea Cosso** (*Universita di Milano, Italy*); **Laura D'andolfi** (*CREST, ENSAE, Institut Polytechnique de Paris, France*)

Abstract: *We propose a novel probabilistic formulation for mean-field games of optimal stopping (OS-MFGs) based on a new class of McKean–Vlasov reflected BSDEs that incorporates two novel Skorokhod-type conditions to characterize the optimality of the stopping strategy. We establish the well-posedness of the system under various alternative assumptions, and uniqueness is proved under specific conditions. We also show that the solution of our system induces an approximate Nash equilibrium for the associated N-player stopping game. Finally, we connect our probabilistic formulation to the analytical approach.*

Stochastic Control and Optimization in Finance and Insurance - Part 2 - Aula E

Organized by: **Gu Wang, Dan Ren** and **Bin Zou**

MINI-SYMPOSIUM (ID 87): ID 608 (01)

Existence of equilibria for time-inconsistent games in discrete time

Zhou Zhou (*University of Sydney, Australia*)

Abstract: *We investigate time-inconsistent stochastic games in discrete time with uncountable state spaces. Our objective is to establish the existence of time-consistent Markov relaxed equilibrium strategies. The primary challenges stem from the non-compactness of the control spaces and the discontinuity of the associated best response strategies. We provide sufficient conditions under which the existence of such equilibria can be guaranteed.*

MINI-SYMPOSIUM (ID 87): ID 623 (02)

Optimal Investment to Reach a Financial Goal: A Stochastic Control Framework

Gechun Liang (*University of Warwick, United Kingdom*); **Moris Strub** (*University of Warwick, United Kingdom*); **Yuwei Wang** (*Shanghai University of Finance and Economics, China*); **Zhaojun Yang** (*Southern University of Science and Technology, China*)

Abstract: *We develop a framework for an investor who trades until she either reaches a financial goal or a deadline. Satisfaction with the timing of goal attainment is captured by a discount function. In a continuous-time market with a stochastic factor affecting stock prices and goals, the investor maximizes the expected discount at the goal-reaching time and the expected utility of the funding ratio at the deadline if the goal is unmet, leading to a new class of stochastic control problems. We establish Bellman's principle, characterize the value function, analyze special cases, and develop numerical solutions using Howard's algorithm.*

MINI-SYMPOSIUM (ID 87): ID 625 (03)

Optimal consumption under loss-averse multiplicative habit-formation

Bahman Angoshtari (*University of Miami, United States*); **Xiang Yu** (*The Hong Kong Polytechnic University, Hong Kong*); **Fengyi Yuan** (*Chinese University of Hong Kong (Shenzhen), China*)

Abstract: *This talk studies optimal investment and consumption under a loss-averse multiplicative habit-formation preference. Preferences are modeled by a general S-shaped utility function of the consumption-to-habit ratio, capturing reference dependence and asymmetric attitudes toward gains and losses. After concavifying the utility, we analyze the associated HJB equation via a nonlinear free-boundary problem and characterize its solution. This yields optimal consumption and portfolio policies in feedback form, together with verification arguments that apply to a broad class of S-shaped utilities. Numerical examples illustrate the qualitative features and financial implications of the optimal strategies. Joint work with Xiang Yu and Fengyi Yuan.*

MINI-SYMPOSIUM (ID 87): ID 681 (04)

From optimal dividend payments to optimal carbon emission patterns

Hansjoerg Albrecher (*University of Lausanne, Switzerland*)

Abstract: *In this talk the optimal policy for using an allocated carbon emission budget over time is investigated, with the objective to maximize profit under additional considerations of sustainability aspects. Under diffusion assumptions of the underlying budget process, we formulate and solve associated stochastic control problems, explicitly look into the effects of present-biased preferences of decision-makers, and consider a constraint on abatement of consumption. We extend stochastic control techniques developed for optimal dividend strategies in insurance risk theory for the present purpose. The approach also allows to study the efficiency of carbon taxation to steer emission patterns towards a certain target.*

Stochastic Volatility - Aula F

ORAL ID 276 (01)

Martingale property and moment explosions in signature volatility models

Eduardo Abi Jaber (*Ecole Polytechnique, France*); **Paul Gassiat** (*Université Paris Dauphine, France*); **Dimitri Sotnikov** (*Ecole Polytechnique, France*)

Abstract: *We study the martingale property and moment explosions of a signature volatility model, where the volatility process of the log-price is given by a linear form of the signature of a time-extended Brownian motion. Excluding trivial cases, we demonstrate that the price process is a true martingale if and only if the order of the linear form is odd and a correlation parameter is negative. Once martingality is established, we characterize the existence of higher moments of the price process in terms of a condition on a correlation parameter. This is joint work with Eduardo Abi Jaber and Paul Gassiat.*

ORAL ID 278 (02)

Surjectivity of the conditional expectation operator

Thibault Jeannin (*Ecole des Ponts ParisTech - CERMICS, France*); **Julien Guyon** (*Ecole des Ponts ParisTech - CERMICS, France*); **Benjamin Jourdain** (*Ecole des Ponts ParisTech - CERMICS, France*)

Abstract: *Motivated by the calibration of path-dependent volatility model to the implied volatility surface, we investigate the distributions of random couples (X, Y) with X real-valued such that any non-negative integrable random variable $f(X)$ can be represented as a conditional expectation, $f(X) = \mathbb{E}[g(Y) \mid X]$, for some non-negative measurable function g. We give a sufficient condition for the representation property and check that it is also necessary under some additional mild assumptions. We also exhibit an involved example where the representation property holds but the sufficient condition does not.*

ORAL ID 439 (03)

The Guyon–Lekeufack Volatility Model in Discrete Time: Reconciling Calibration under P and Q

Léo Parent (*Ecole des Ponts ParisTech - CERMICS, France*); **Julien Guyon** (*Ecole des Ponts ParisTech - CERMICS, France*)

Abstract: *This talk introduces a modelling and calibration framework based on a discrete-time version of the Guyon–Lekeufack model aiming to be jointly consistent with P and Q market data. We first illustrate the model's ability to fit option data across multiple dimensions, including VIX time series and joint SPX/VIX smiles. We then turn to estimation of the model under the historical measure and show that this model, estimated under P, is consistent with option market data. Building on these results, we introduce new estimation and calibration approaches that combine P and Q time series, which we assess through a trading game.*

ORAL ID 449 (04)

Bergomi models with volatility memory

Jules Delemotte (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Stefano De Marco** (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Julien Guyon** (*Ecole des Ponts ParisTech - CERMICS, France*)

Abstract: *A family of stochastic volatility models with volatility memory is presented as an extension of Bergomi models. The volatility feedback accounts for two important features of equity markets that the classical time-homogeneous Bergomi models fail to capture: (a) the time-asymmetry of large positive VIX spikes, and (b) the positive VIX skews. An expansion in small volatility of volatility, along the lines of the Bergomi-Guyon expansion, provides an approximation of the smile. Numerical experiments illustrate the properties of the models, compared to classical Bergomi models and the quintic OU model, and assess the accuracy of the smile expansion for market-calibrated parameters.*

Computational Methods for Pricing, Hedging and Portfolio Choice - Aula P

ORAL ID 225 (01)

Machine Learning Strategies for Pricing Options in Financial Markets

Sajid Ali (*ISCTE-IUL and BRU-IUL, Portugal*); **Luciana Barbosa** (*ISCTE-IUL and BRU-IUL, Portugal*); **Anderea Meireles** (*ISCTE-IUL and BRU-IUL, Portugal*); **Alberto Sardinha** (*Pontifícia Universidade Católica do Rio de Janeiro, Brazil*)

Abstract: *This study provides an extensive analysis of European call option pricing on the S&P 500 (SPX) index over 2017–2022, covering both low- and high-volatility regimes. A comprehensive set of models is considered, including the classical Black–Scholes framework and a wide range of machine learning approaches, such as Random Forest, XGBoost, AdaBoost, Support Vector Regression, K-Nearest Neighbours, Linear Regression, and a Neural Network. The study evaluates model performance in terms of pricing accuracy across different market conditions, demonstrating the robustness of ensemble tree-based methods. We also employ explainable AI (XAI) techniques, to analyze contributions of input features in option pricing models.*

ORAL ID 264 (02)

Deep Hedging of Autocallable Products

Junior Parfait Ngalamo (*Università degli studi di Verona, Italy*); **Kristoffer Andersson** (*Università degli studi di Verona, Italy*); **Alessandro Gnoatto** (*Università degli studi di Verona, Italy*); **Andrea Pallavicini** (*Intesa Sanpaolo, Italy*); **Stefano Scoleri** (*Intesa Sanpaolo, Italy*)

Abstract: *This work focuses on the hedging of autocallables under an average daily trading volume (ADTV) constraint. These products present significant hedging challenges due to their path-dependency and discontinuous payoff, especially in a multiple-asset setting. The hedging problem is formulated as a stochastic impulse control problem, in which the impulses represent daily trading decisions and are parametrized by a feed-forward neural network. The objective is to optimize the neural network parameters so as to minimize the mean-squared hedging error.*

ORAL ID 296 (03)

Deep Duality Methods for Constrained Optimal Portfolios

Christoph Knochenhauer (*Technische Universität München, Germany*); **Alexander Schütt** (*Technische Universität München, Germany*)

Abstract: *We present a deep learning approach for solving constrained optimal portfolio problems in high-dimensional markets. Our approach combines the duality framework of Cvitanić and Karatzas with Physics-Informed Neural Networks (PINNs). The objective is to maximize the expected utility of terminal wealth, subject to convex constraints. We solve the primal and corresponding dual problem using PINNs to obtain an approximate optimal trading strategy and an upper bound on the optimal performance under constraints. Comparing the performance of the learned trading strategy to this upper bound leads to an explicit and interpretable error estimate of its maximal deviation from the optimal strategy.*

ORAL ID 511 (04)

A hedged Monte-Carlo approach to bitcoin mining farm investment decisions

Jorge Zubelli (*Khalifa University of Science and Technology, United Arab Emirates*); **Yerkin Kitapbayev** (*Khalifa University of Science and Technology, United Arab Emirates*); **Alvaro Macias** (*International Bank, Chile*)

Abstract: *The decision to invest in a Bitcoin mining facility involves uncertainties, primarily driven by the high volatility of Bitcoin prices and fluctuating energy costs. We analyze the optimal timing for such investments within a real options framework as an optimal-stopping problem, considering both the option to defer the investment and the operational flexibility to temporarily suspend mining activities when unprofitable. We employ the Hedged Monte Carlo method, which enhances the accuracy of the estimate by incorporating hedge sensitivities as control variables. This approach allows for robust valuation under the real-world probability measure, accommodating complex dynamics for the underlying stochastic factors.*

Corporate Finance/Capital Structure/Liquidity Management - Aula Q

ORAL ID 73 (01)

Debt-Equity Spread under Jumps and Trading Strategy for Global Corporate Bonds

Kaname Imagawa (*Nomura Asset Management Co., Ltd / Hitotsubashi University Business School, Japan*); **Kaname Imagawa** (*Nomura Asset Management Co., Ltd / Hitotsubashi University Business School, Japan*); **Hidetoshi Nakagawa** (*Hitotsubashi University Business School, Japan*)

Abstract: *This paper tests whether capital structure arbitrage exploiting bond–equity mispricing works globally. Relative to Chen et al. (2023), we extend the sample beyond the USD to USD, EUR, GBP, CAD, and JPY markets, model firm value with jump diffusion to address the credit spread puzzle, and calibrate a key parameter. Quantile portfolios sorted by the debt–equity spread perform extremely well in USD, reasonably well in EUR, GBP, and CAD, and poorly in JPY. With jumps, DES portfolios show a smaller carry imbalance across quantiles, smaller drawdowns in risk off periods, and more stable profits over time.*

ORAL ID 297 (02)

Warrants and Their Agency Issues: Investment Timing, Financing, and Default Effects

Thomas Mcwalter (*University of Cape Town, South Africa*); **Peter Ritchken** (*Case Western, United States*)

Abstract: *Equity, contingent equity, and debt are jointly determined as claims on the assets of the firm. Contingent equity, in the form of warrants, impacts the dynamics of shareholder equity, alters the timing of bankruptcy, the timing of exercising growth options, and the financing of new investments. Warrants are provided with certain protections that only partially mitigate agency conflicts. The purpose of our research is to investigate these agency issues in a full-information setting. As the magnitude of the warrant issue increases, default thresholds increase, growth options are exercised earlier, and less debt is used for financing.*

ORAL ID 509 (03)

Valuation of Corporate Securities with Environmental Investment and Sustainability-Linked Bonds

Jerome Detemple (*Boston University, United States*); **Yerkin Kitapbayev** (*Khalifa University of Science and Technology, United Arab Emirates*)

Abstract: *We study the valuation of sustainability-linked bonds (SLBs) and equity in a model with sustainability-sensitive consumers, endogenous environmental investment, endogenous default time, and fixed operating cost. We show that the standard step-up SLB contract is ineffective in spurring investment, even when incentives for issuance are adequate. We propose an amended SLB with smooth payoff that incentivizes sustained investment and examine its properties. We solve for the optimal contract design and the capital structure of the firm.*

ORAL ID 434 (04)

The trilemma of American options with liquidation penalties

Anna Battauz (*Università Commerciale L. Bocconi, Italy*); **Marzia De Donno** (*Università Cattolica del Sacro Cuore, Italy*); **Alessandro Sbuelz** (*Università Cattolica del Sacro Cuore, Italy*)

Abstract: *In an arbitrage-free, complete market, we study optimal exercise policies for American options subject to liquidation penalties. American equity options often incur significant liquidation costs, as documented in the literature. Battauz et al. (2025) analyze optimal exercise by comparing available cash flows. We extend this framework by allowing a triple decision: the holder may exercise, sell at a discounted price, or wait until the next period. The continuation value incorporates individual risk preferences over future risky cash flows. We examine how varying levels of risk aversion affect the investor's optimal policy.*
Keywords: Optimal stopping; American options; Real options; Bellman equation

Credit Risk/Credit Portfolios - Aula H

ORAL ID 33 (01)

Robust Bernoulli mixture models for credit portfolio risk

Jonathan Ansari (*University of Salzburg, Austria*); **Eva Lütkebohmert** (*University of Freiburg, Germany*)

Abstract: *We establish comparison results and determine risk bounds for credit portfolios within classes of Bernoulli mixture models. We provide simple and interpretable conditions on conditional default probabilities that imply a comparison of credit portfolio losses in convex order. In the case of threshold models, the ranking of portfolio losses is based on a pointwise comparison of the underlying copulas. Our results accommodate general tail dependencies and extend the classical parameterized models, such as the industry models CreditMetrics and KMV Portfolio Manager, towards a robust setting where individual parameters or the copula modeling the dependence structure can be ambiguous.*

ORAL ID 35 (02)

Sector Concentration Risk in Credit Portfolios

John Jarratt (*University of Technology Sydney, Australia*); **Erik Schlögl** (*University of Technology Sydney, Australia*)

Abstract: *We develop a framework for quantifying sector concentration risk in credit portfolios, with a focus on deriving a set of explainable formulae that could be used in a regulatory context. We first derive a formula based on the standard deviation of portfolio loss which uses the Herfindahl-Hirschman Index (HHI). We then extend this to consider skewness and the capital multiplier, leading to the introduction of a third order HHI which gives information on portfolio composition which influences the multiplier that is not contained in H2. The paper includes an evaluation of the PRA approach to concentration risk within Pillar 2.*

ORAL ID 195 (03)

Statistical Learning of Value-at-Risk and Expected Shortfall

Juan David Barrera Cano (*Universidad de los Andes, Colombia*); **Stephane Crepey** (*Universite Paris-Cite, France*); **Emmanuel Gobet** (*Université Paris Cité - LPSM, France*); **Hoang-Dung Nguyen** (*Université Paris Cité - LPSM, France*); **Bouazza Saadeddine** (*Quantitative research GMD, Credit Agricole, France*)

Abstract: *We propose a two-step approach to learn a conditional value-at-risk (VaR) and a conditional expected shortfall (ES), and a finite-sample convergence analysis using Rademacher and VC bounds in a non-parametric setup allowing for heavy-tails on the loss. Our approach for the VaR is extended to the problem of learning multiple VaRs corresponding to different quantile levels. An a posteriori Monte Carlo procedure is also introduced to estimate distances to the ground-truth VaR and ES. This is illustrated by numerical experiments in a Student-toy model and a financial case study where the objective is to learn a dynamic initial margin.*

ORAL ID 71 (04)

Multi-Layer Deep xVA Solver: Structural Credit Models and Convergence Analysis

Alessandro Gnoatto (*Università degli studi di Verona, Italy*); **Kristoffer Andersson** (*Università degli studi di Verona, Italy*)

Abstract: *We propose a structural default model for portfolio-wide valuation adjustments (xVAs) and represent it as a system of coupled backward stochastic differential equations. The framework is divided into four layers. We use an iterative deep BSDE approach, handling each layer sequentially so that earlier outputs serve as inputs to the subsequent layers. We further extend Han and Long's (2020) a posteriori error analysis to BSDEs on bounded domains. Numerical experiments illustrate that this method drastically reduces computational demands and successfully scales to high-dimensional, non-symmetric portfolios.*

Interest Rates, Term Structures and Monetary Policy - Aula I

ORAL ID 124 (01)

Regime-switching affine term structure models

Mansa Aidoo (*University of Cape Town, South Africa*)

Abstract: *Economic shifts, including changes in business cycles and monetary policy regimes, create regime-dependent dynamics in interest rate behavior, underscoring the need for their integration into term structure models. Regime-switching models offer a compelling framework for capturing such changes in the stochastic behavior of interest rates. This study contributes to affine term structure modeling by developing a regime-switching model where both the pricing factors and the market price of risk are influenced by regime shifts. The pricing factors follow a Gaussian vector autoregression process, while regime transitions are governed by a discrete-time Markov process with regime-dependent transition probabilities.*

ORAL ID 517 (02)

Pricing and Hedging of SOFR Derivatives

Yining Ding (*The University of Sydney, Australia*); **Marek Rutkowski** (*University of Sydney, Australia*); **Matthew Bickersteth** (*The University of Sydney, Australia*)

Abstract: *LIBOR has served since the 1970s as a benchmark for floating term rates across currencies and maturities. Following the Financial Conduct Authority's 2017 announcement of LIBOR's cessation after end-2021 and the New York Fed's selection of the Secured Overnight Financing Rate (SOFR) as the U.S. dollar risk-free reference, we study arbitrage-free pricing and hedging of SOFR-referencing interest rate swaps, with and without collateralization. Hedging is implemented using SOFR futures together with idiosyncratic funding rates for hedge and margin accounts. For tractability, we adopt a one-factor Vasicek framework to model the joint dynamics of SOFR and an unsecured funding rate.*

ORAL ID 436 (03)

Ample Reserves and Deposit Pass-Through

Guido Spanò (*University College London, United Kingdom*)

Abstract: *This paper studies how the Euro Area transition from a scarce-reserves operating framework to an ample-reserves regime with fixed-rate full allotment altered the pass-through from policy-controlled short rates to household current-account (overnight) deposit rates. The empirical evidence relies on an IV local-projections design identified with high-frequency monetary policy surprises and documents a large decline in deposit-rate pass-through in the ample-reserves era, together with a negative interaction between pass-through and country-level reserve abundance. A simple model of the banking systems shows how relaxing liquidity constraints can affect the dependence of deposit rates on the policy rate.*

ORAL ID 324 (04)

Finite-Dimensional HJM Models with Unconstrained Tangential Diffusion

Andreas Celary (*WU Vienna, Austria*); **Paul Eisenberg** (*WU Vienna, Austria*)

Abstract: *The Heath–Jarrow–Morton (HJM) framework models the evolution of forward rate curves and is arbitrage-free exactly when the HJM drift condition holds. We study finite-dimensional HJM models whose dynamics remain on a fixed finite-dimensional manifold of curves, so the term structure is described by a parameter process. From a statistical viewpoint, it is desirable that the diffusion of this process be unrestricted within the tangent space. We characterize those manifolds where this is possible while maintaining the HJM drift condition, and show that they are nowhere locally affine and not affinely foliated.*

Asset Allocation/Optimal Investment/Portfolio Theory - Aula L

ORAL ID 477 (01)

Calculus of Variations and Portfolio Choice

Emmet Lawless (*University of Michigan, United States*); **Paolo Guasoni** (*Dublin City University, Ireland*); **Ho Man Tai** (*University of Sydney, Australia*); **Erhan Bayraktar** (*University of Michigan, United States*)

Abstract: *In this presentation we consider a calculus of variations approach to the infinite horizon optimal consumption problem. We illustrate how leveraging variational methods acts as a powerful tool to analyse semilinear HJB equations. This yields rigorous verification and an easy-to-implement numerical scheme in non-linear market models wherein classical approaches fail, overcoming typical difficulties such as the absence of boundary conditions and the need to verify that local martingales are true martingales. We focus primarily on agents with isoelastic preferences and illustrate the potential of the method by exploring extensions to stochastic differential utility of Epstein–Zin type.*

ORAL ID 151 (02)

Stochastic factors can matter: improving robust growth under ergodicity

Paul Mangers Bastian (*London School of Economics and Political Sciences, United Kingdom*); **Josef Teichmann** (*ETH Zurich, Switzerland*); **David Itkin** (*London School of Economics and Political Sciences, United Kingdom*); **Balint Binkert** (*ETH Zurich, Switzerland*)

Abstract: *We study robust growth-optimization in an incomplete market under drift uncertainty of the asset price process X and an additional ergodicity assumption, constraining the drift in X. The class of admissible models allows X to depend on a stochastic factor Y and fixes (a) their joint volatility structure, (b) their long-term joint ergodic density and (c) the dynamics of Y. We determine the robust optimal growth rate, construct a worst-case admissible model and characterize the robust growth-optimal strategy via solving a partial differential equation. We demonstrate that utilizing the stochastic factor leads to improvement in robust growth.*

ORAL ID 410 (03)

A Novel Factor Construction Framework Based on Itô Signatures

Lidia Brailovskaia (*ETH Zurich, Switzerland*)

Abstract: *Factor models play a central role in asset pricing and portfolio management. We introduce a new class of factors constructed from Itô signatures that effectively capture nonlinear and path-dependent features of stock returns. Using a reproducing kernel framework, we provide conditions for robustness of the oracle model.*

ORAL ID 59 (04)

On local utility maximization

Ales Cerny (*Bayes Business School, United Kingdom*); **Jozef Skokan** (*London School of Economics and Political Sciences, United Kingdom*)

Abstract: *In optimal control theory, one typically seeks an optimizer of some local criterion (dynamic programming value function) generated by some global criterion (e.g., expected utility). The local optimizer typically acts as a stochastic integrand with respect to some underlying stochastic process. Since the existence of the local optimizer can be established under very mild conditions, the main aim is to understand under what circumstances the local optimizer has good integrability properties. It is shown that the reasonable asymptotic elasticity condition (Kramkov and Schachermayer, 1999; Schchermayer, 2003) applied to the local utility function plays a key role in this context.*

BSDEs, Dynamic Risk Measures and Control - Aula M

ORAL ID 83 (01)

A Strict Comparison Principle for Integro-Differential Hamilton-Jacobi-Bellman Equations on Domains with Boundary

Fabian Fuchs (*Luiss University Rome, Italy*); **Serena Della Corte** (*TU Delft, Netherlands*); **Richard Kraaij** (*TU Delft, Netherlands*); **Max Nendel** (*University of Waterloo, Canada*)

Abstract: *This work provides a comparison principle for viscosity solutions to boundary value problems on (partially) bounded, cylindrical spaces. The comparison principle is based on a test function framework, that allows for the simultaneous treatment of diffusive as well as jump terms. Estimates in the proof of the comparison principle incorporate the use of Lyapunov functions that act as growth bounds for the solutions, effectively yielding a theory for unbounded viscosity solutions. We apply the results to a wide class of parabolic equations and elliptic problems on a space with corners.*

ORAL ID 515 (02)

Uncertainties in risk evaluation for long term horizons and computational aspects

Giulia Di Nunno (*University of Oslo, Norway*)

Abstract: *Long and short-horizons must be treated differently in monetary risk-evaluations. Horizon-risk and h-longevity are identified to capture this. We clarify that classical dynamic risk measures are subject to horizon-risk exposure, and propose to work with fully-dynamic risk-measures. In long horizons, also interest rate uncertainty cannot be underestimated. We combine these aspect working with cash non-additive dynamic risk-measures via BSDEs and generalised shortfalls. We take steps in the numerical quantification relying on a novel use of Wiener-Ito chaos expansions and proposing DeepO BSDEs schemes. Presentation based on different works with Emanuela Rosazza Gianin (U. Milano Bicocca) and Pere Diaz Lozano (U. Oslo).*

ORAL ID 763 (03)

Risk Aware Stochastic Control via Dynamic Risk Measures

Nacira Agram (*KTH Royal Institute of Technology, Sweden*); **Nacira Agram** (*KTH Royal Institute of Technology, Sweden*)

Abstract: *This paper studies stochastic control problems in which future losses are evaluated by dynamic risk measures generated by backward stochastic differential equations. The framework is motivated by financial decision problems, such as portfolio allocation, hedging, and risk management, where optimizing expected performance alone may lead to excessive exposure to volatility, tail losses, and model uncertainty. We formulate a controlled forward–backward stochastic system, discuss the associated dynamic programming viewpoint, and emphasize both the entropic driver and a nonquadratic Lipschitz driver as benchmark risk aggregators.*

ORAL ID 510 (04)

A stability result for quadratic BSDEs with BMO growth at the origin

Nikolaos Constantinou (*University of Stuttgart, Germany*); **Martin Herdegen** (*Universität Stuttgart, Germany*); **Christoph Czichowsky** (*London School of Economics and Political Sciences, United Kingdom*); **David Martins** (*ETH Zürich, Department of Mathematics, Switzerland*)

Abstract: *The goal of this paper is to establish stability of solutions to backward stochastic differential equations (BSDEs) in a continuous filtration, where the drivers are of quadratic growth in Z and have BMO growth (as opposed to being bounded) at the origin. We consider this question within the class of bounded solutions. This problem is motivated by the study of existence of CAPM equilibria in continuous time.*

Risk Measures, Stress Testing and Resilience - Aula Filopanti

ORAL ID 491 (01)

When interest rate shock defies expectations: A precise methodology of stress testing for bond portfolios

Alexandra Matyunina (*El Banco de España, Spain*); **Andrey Pankratov** (*Université Laval, Canada*); **Federico Severino** (*Université Laval, Canada*)

Abstract: *Large interest rate changes pose a solvency risk to financial institutions (the failure of Silicon Valley Bank). Conventional stress-testing methodologies for bonds typically rely on polynomial price approximations, whose accuracy deteriorates markedly under large rate movements. We introduce a simple yet accurate approach to approximate bond prices: we construct a fictitious two-cash-flow bond that matches the duration and convexity of the original bond. This method yields precise bond price estimates under extreme scenarios. Additionally, our method allows us to confine the bond price in a narrow interval and enhances the portfolio losses estimation under changes in the yield curve shape.*

ORAL ID 209 (02)

Star-Shaped Risk Measures: Representations and Cash-Additive Hulls

Foivos Xanthos (*Toronto Metropolitan University, Canada*)

Abstract: *In this talk, we present representation results for star-shaped risk measures defined on general model spaces. We further investigate the cash-additive hulls of star-shaped risk measures and establish conditions under which these hulls preserve key continuity properties. The results provide new insights into the structure of Optimized Certainty Equivalents and Haezendonck–Goovaerts risk measures. The talk is based on joint work with Niushan Gao and Denny Leung*

ORAL ID 170 (03)

Measuring financial resilience using BSDEs

Roger Laeven (*University of Amsterdam, Netherlands*); **Matteo Ferrari** (*University of Amsterdam, Netherlands*); **Emanuela Rosazza Gianin** (*University of Milano-Bicocca, Italy*); **Marco Zullino** (*University of Milano-Bicocca, Italy*)

Abstract: *We propose the resilience rate as a measure of financial resilience that captures the rate at which a dynamic risk measure recovers after the risk-acceptance set is breached. We develop the associated stochastic calculus by establishing representation theorems of a suitable time-derivative of solutions to BSDEs evaluated at stopping times. These results reveal that our resilience rate can be represented as an expectation of the BSDE's generator. We also introduce resilience-acceptance sets and study their properties in relation to the resilience rate and the dynamic risk measure. The definition of the resilience rate is also generalized to the jumps' case.*

ORAL ID 391 (04)

Financial resilience evaluation: From conditional expectation to dynamic risk measures

Matteo Ferrari (*University of Amsterdam, Netherlands*); **Roger Laeven** (*University of Amsterdam, Netherlands*); **Emanuela Rosazza Gianin** (*University of Milano-Bicocca, Italy*); **Marco Zullino** (*University of Milano-Bicocca, Italy*)

Abstract: *Financial resilience - the speed of recovery after adverse events - depends not only on expected price changes but also on dispersion and risk revaluation. We define a first-order response of a (dynamic) risk measure ρ to an infinitesimal increment of a price/risk process π as the L^1 limit of $\varepsilon^{-1}\rho(\pi_{t+\varepsilon} - \pi_t)$ as $\varepsilon \to 0^+$. For Itô-modelled π we establish well-posedness for conditional expectation, entropic risk measure, and coherent BSDE-induced risk measures with possibly non-differentiable drivers, and express the limit in terms of the drift and volatility of π. We further apply the theory to define resilient capital allocation rules.*

Recent Advances on Mean-Field Control and Mean-Field Games - Part 2 - Aula A

Organized by: **Dena Firoozi**

MINI-SYMPOSIUM (ID 357): ID 736 (01)

Major-Minor Mean Field Game of Stopping: An Entropy Regularization Approach

Jiacheng Zhang (*The Chinese University of Hong Kong, Hong Kong*); **Xiang Yu** (*The Hong Kong Polytechnic University, Hong Kong*); **Zhou Zhou** (*University of Sydney, Australia*); **Keyu Zhang** (*Tsinghua University, China*)

Abstract: *This paper explores a discrete-time major-minor mean field game of stopping, where the major player can choose an optimal control or stopping time. We establish a relaxed equilibrium as a randomized stopping policy, using entropy regularization for the major player's strategy and framing minor players' problems as linear programming over occupation measures. We show that as the regularization parameter approaches 0, regularized equilibria converge to a fixed point of the original operator, confirming the existence of a relaxed equilibrium.*

MINI-SYMPOSIUM (ID 357): ID 741 (02)

Deterministic Policy Gradient for Reinforcement Learning with Continuous Time and State

Ziheng Cheng (*UC Berkeley, United States*); **Xin Guo** (*UC Berkeley, United States*); **Yufei Zhang** (*Imperial College London, United Kingdom*)

Abstract: *Continuous-time reinforcement learning (RL) has advanced rapidly, but most existing methods rely on stochastic policies, which require high-frequency action sampling and costly expectations over continuous action spaces, leading to high-variance gradients and slow convergence. In this paper, we develop deterministic policy gradient methods for continuous-time RL. We derive a policy gradient formula based on an advantage rate function and establish martingale characterizations of the value function and advantage rate. Building on this theory, we propose CT-DDPG, a model-free algorithm that achieves greater stability and faster convergence than existing stochastic-policy methods across diverse tasks, discretizations, and noise levels.*

MINI-SYMPOSIUM (ID 357): ID 765 (03)

Self-fictitious-play for Potential Monotone Ergodic Mean-field Games

Yupeng Bai (*ENSIIE - LaMME Paris-Saclay, France*)

Abstract: *We study long-time learning in ergodic, potential, monotone mean-field games (MFG) via a self–fictitious-play (SFP) dynamics that couples an optimally controlled diffusion with a slowly updated belief. At each time, the state follows the optimal feedback for the current belief; that tracks the running occupation measure. For monotone potential MFGs on the torus, we show that the SFP system is contractive and admits a unique stationary law. We prove that this stationary distribution is quantitatively close to the MFG Nash equilibrium: after an exponentially fast transient, the gap scales on the order of the square root of the belief-update rate.*

MINI-SYMPOSIUM (ID 357): ID 423 (04)

Randomized Impulse Control and Reinforcement Learning

Haoyang Cao (*Johns Hopkins University, United States*); **Yuchao Dong** (*Tongji University, China*); **Zhouhao Yang** (*Johns Hopkins University, United States*)

Abstract: *We propose a randomization scheme for impulse control problems via a compound operator which consists of a regularized nonlocal operator and a regularized stopping operator. We establish the existence and uniqueness of the fixed-point, ensuring that the randomized framework is well-defined. We then demonstrate the convergence to the classical problem as the randomization parameter vanishes, confirming that our framework provides a robust approximation. Under this framework, we propose an offline reinforcement learning (RL) algorithm. We implement a model-free version of the algorithm and numerically demonstrate its effectiveness using a widely-studied example. A sensitivity analysis effectively demonstrates the exploration-exploitation tradeoff.*

Stochastic Analysis - Aula G

ORAL ID 259 (01)

Maximum-Likelihood estimation in stochastic Volterra equations

Martin Friesen (*Dublin City University, Ireland*); **Mohamed Ben Alaya** (*University of Rouen Normandy, France*); **Jonas Kremer** (*Modelling & Quant. Analytics, E.ON Energy Markets, Germany*)

Abstract: *Stochastic Volterra processes have become essential for modelling rough volatility and path-dependence in finance, yet their non-Markovian nature and lack of semimartingale structure pose significant challenges. We present a rigorous framework for the Maximum Likelihood Estimation (MLE) of drift parameters in these systems. By introducing a novel transformation of the Volterra process into an explicitly path-dependent process, we derive its likelihood ratio and study consistency and asymptotic normality of the MLE in the ergodic regime. The latter is based on the Law of Large Numbers, which is established via infinite-dimensional Markovian lifts for a large class of stochastic Volterra processes.*

ORAL ID 403 (02)

On McKean-Vlasov SDEs with polynomial drifts for SIS epidemic models

Alexander Kalinin (*University of Munich, Germany*); **Thilo Meyer-Brandis** (*Ludwigs Maximilian University Munich, Germany*); **Annika Steibel** (*Ludwigs Maximilian University Munich, Germany*)

Abstract: *We present a tractable class of one-dimensional McKean-Vlasov equations that allow for unique strong solutions and extend the dynamics of several SIS epidemic models that are well-established in the literature. While the distribution-dependent drift coefficients are of polynomial type, the diffusion coefficients may involve sums of power functions. Our analysis includes various scenarios of extinction or persistence of the disease and an effective Euler-Maruyama scheme, for which we derive an explicit strong error estimate inpth moment forp* ≥ 2.

ORAL ID 445 (03)

Stochastic Volterra equations with random functional coefficients in Banach spaces

Alexander Kalinin (*University of Munich, Germany*)

Abstract: *We derive unique Banach-valued solutions to stochastic Volterra equations with random coefficients that may depend on pure chance and involve singular kernels. In particular, for controlled and distribution-dependent coefficients these solutions become strong, as a measurability analysis of the Wasserstein metric confirms. The presented novel approach is based on the verification that a stochastic Volterra integral admits a progressively measurable modification in a weak sense and on sharp moment estimates for non-negative product measurable processes.*

ORAL ID 753 (04)

Path-dependent Affine Processes

Boris Günther (*Justus-Liebig-University Gießen, Germany, Germany*); **Thomas Kruse** (*University of Wuppertal, Germany*); **Ludger Overbeck** (*Justus Liebig University, Germany*); **Thorsten Schmidt** (*University of Freiburg, Germany*)

Abstract: *We extend the classical theory of affine processes to a path-dependent setting by introducing path-dependent coefficients and provide analytic formulas for their Fourier–Laplace transform via generalized Riccati equations. We define path-dependent affine processes through an exponential-affine Fourier–Laplace transform on the path space and establish a characterization theorem. In particular, we show the equivalence between affine path-dependent coefficients and the exponential-affine structure of the conditional Fourier–Laplace transform given the past trajectory. We further derive conditions ensuring non-negativity of the path-dependent diffusion coefficient and hence well-posedness. Applications include a path-dependent volatility model and a path-dependent extension of the Heston model.*

Stochastic Models for Energy, Trading and Volatility - Aula B

ORAL ID 405 (01)

Synthetic LNG competitiveness under carbon pricing with scenario based operational dispatch

Ezio Lauro (*University College London, United Kingdom*); **Andrea Macrina** (*Department of Mathematics, University College London, United Kingdom*); **Helyette Geman** (*Johns Hopkins University, United States*)

Abstract: *We quantify when synthetic liquefied natural gas produced from renewable electricity via electrolysis, carbon dioxide methanation, and liquefaction reaches carbon adjusted cost parity with fossil liquefied natural gas. German electricity and Title Transfer Facility gas prices are simulated using a correlated mean reverting two factor model calibrated to futures, feeding a daily mixed integer dispatch with ramping, storage, binary operating states, parasitic loads, and carbon screened grid purchases. Carbon pricing raises the fossil benchmark and discourages high emission imports. Parity is conditional at 84.6 and 105.5 euros per tonne carbon dioxide, and robust near 150.*

ORAL ID 52 (02)

Continuous Time Trading with Multiple Insiders and Price Impact

Scott Robertson (*Boston University, United States*); **Boyi Li** (*Boston University, United States*)

Abstract: *We revisit the price impact model of Kyle and Back in continuous time, allowing for insiders entering at various times. In the main application there is one insider who receives a private signal at time zero, while a second insider receives a private signal at a later time. Our goal is to see how the first insider adjusts her trading policy prior to the second insider's arrival, versus when the second insider is entirely absent. For insiders with CARA preferences, we explicitly identify a linear equilibrium, and show the first insider's welfare is increasing with the second insider's entry time.*

ORAL ID 171 (03)

Ultra-short-term volatility surfaces

Federico M. Bandi (*Johns Hopkins University, United States*); **Nicola Fusari** (*Johns Hopkins University, United States*); **Guido Gazzani** (*Università degli studi di Verona, Italy*); **Roberto Renò** (*Essec Business School, France*)

Abstract: *Options with maturities below one week, hereafter ultra-short-term options, have seen a sharp increase in trading activity recently. Yet, these instruments are difficult to price jointly using classical models due to the oscillations observed in the ATM implied-volatility term structure across ultra-short-term tenors. We propose Edgeworth++, a parsimonious jump–diffusion model featuring a nonparametric stochastic volatility component, with flexibility in capturing implied-volatility smiles, combining a deterministic shift extension, which allows the model to fit at-the-money implied-volatility shapes across tenors. A local (in tenor) expansion of the process characteristic function is derived and we discuss the benefits of Edgeworth++ relative to benchmarks.*

ORAL ID 263 (04)

Stochastic optimal control with randomly arriving control moments

Josha Dekker (*University of Amsterdam, Netherlands*); **Roger Laeven** (*University of Amsterdam, Netherlands*); **Michel Vellekoop** (*University of Amsterdam, Netherlands*); **John Schoenmakers** (*WIAS Berlin, Germany*)

Abstract: *Control problems with randomly arriving control moments occur naturally in finance. We develop methods and algorithms to analyze such problems in a continuous-time finite-horizon setting, under mild conditions on the arrival process of control moments. Operating on the random timescale implied by the control moments, we obtain a discrete-time, infinite-horizon problem. We develop a stochastic primal-dual simulation-and-regression algorithm that does not require knowledge of the transition probabilities and discuss how this algorithm may be implemented feasibly. We apply our methods to a stylised optimal liquidation example and explore the effect of randomly arriving control moments on the optimal control policies.*

Neural Methods for Pricing and Model Estimation - Aula C

ORAL ID 120 (01)

Spanning Multi-Asset Payoffs with ReLUs

Sebastien Bossu (*University of North Carolina, United States*); **Stephane Crepey** (*Universite Paris-Cite, France*); **Hoang-Dung Nguyen** (*Universite Paris-Cite, France*)

Abstract: *We propose a distributional formulation of the spanning problem of a multi-asset payoff by vanilla basket options. This problem has a unique solution iff the payoff is absolutely homogeneous, and we establish a Fourier-based formula to calculate it. Financial payoffs are typically piecewise linear, resulting in a solution that may be derived explicitly, yet may also be hard to exploit numerically. One-hidden-layer feedforward neural networks instead provide a natural and efficient numerical alternative for discrete spanning. We test this approach for a selection of archetypal payoffs and obtain better hedging results than some industry-favored approaches.* Mathematical Finance, *open access: https://onlinelibrary.wiley.com/doi/10.1111/mafi.12454*

ORAL ID 269 (02)

Bridging Physical and Risk-Neutral Worlds with Neural SDEs

Vedant Choudhary (*University of Toronto, Canada*); **Sebastian Jaimungal** (*University of Toronto, Canada*)

Abstract: *We present a novel generative framework for financial modeling that contributes a data-driven method for learning the measure change between physical(P) and risk-neutral(Q) worlds via Neural SDEs. Unlike traditional approaches relying on rigid parametric assumptions, we model the Radon-Nikodym derivative process using a flexible Neural SDE that captures path-dependent market prices of risk. We apply this methodology to the challenging problem of jointly simulating SPX-VIX markets free of dynamic arbitrage. By maximizing the log-likelihood of historical data for physical dynamics and calibrating the change to risk-neutral measure against observed option prices, our approach ensures both statistical fidelity and pricing accuracy.*

ORAL ID 442 (03)

Neural operator methods for the inverse double phase problem

Philipp Schmocker (*ETH Zurich, Switzerland*)

Abstract: *We use neural operators to learn both the coefficient-to-solution map and the associated inverse problem of non-uniformly elliptic double phase equations. By extending generative equilibrium operators (GEOs) from Hilbert spaces to reflexive, strictly convex, and smooth Banach spaces, we derive a universal approximation theorem for the coefficient-to-solution map. Moreover, we establish universal approximation results for the inverse map by using neural operators trained on synthetic data generated by GEOs. Further applications of GEOs are presented in the context of portfolio optimization and quadratic hedging. This talk is based on joint work with Anastasis Kratsios, Gunther Uhlmann, and Philipp Zimmermann.*

ORAL ID 502 (04)

A Comparison of Neural Networks and Bayesian Approaches for the Heston Model Estimation

Jiri Witzany (*Prague University of Economics and Business, Czechia*); **Milan Fičura** (*Prague University of Economics and Business, Czechia*)

Abstract: *The main goal of this paper is to compare the classical Markov Chain Monte Carlo (MCMC) Bayesian estimation method with a universal Neural Network (NN) approach to estimate unknown parameters of the Heston stochastic volatility model given a series of observable asset returns. Our empirical study implements the MCMC estimation algorithm and demonstrates that the trained NN provides more precise and substantially faster estimations of the Heston model parameters. We hypothesize that the universal NN approach can in general give better results compared to the classical statistical estimation methods for a wide class of models.*

Stochastic Control and Optimization in Finance and Insurance - Part 1 - Aula D

Organized by: **Gu Wang, Dan Ren** and **Bin Zou**

MINI-SYMPOSIUM (ID 87): ID 529 (01)

Optimal dividend, reinsurance, and capital injection strategies for an insurer with two collaborating business lines

Tim Boonen (*University of Hong Kong, Hong Kong*); **Engel Dela Vega** (*University of Hong Kong, Hong Kong*); **Bin Zou** (*University of Connecticut, United States*)

Abstract: *This paper considers an insurer with two collaborating business lines, and the risk exposure of each line follows a diffusion risk model. The manager of the insurer makes three decisions for each line: (i) dividend payout, (ii) (proportional) reinsurance coverage, and (iii) capital injection (from one line into the other). The manager seeks an optimal dividend, reinsurance, and capital injection strategy to maximize the expected weighted sum of the total dividend payments until the first ruin. We completely solve this problem and obtain the value function and optimal strategies in closed form.*

MINI-SYMPOSIUM (ID 87): ID 531 (02)

Leveraged Firms: Growth or Value, Constraints or Frictions?

Gu Wang (*Worcester Polytechnic Institute, United States*); **Paolo Guasoni** (*Dublin City University, Italy*)

Abstract: *This paper develops a continuous-time model of a leveraged firm with constant returns to scale that chooses risky exposure, costly deleveraging, and dividends. We compare two objectives: maximizing long-run return on equity versus maximizing the discounted present value of dividends. Under long-run ROE maximization the firm endogenously regulates leverage within an interior band and avoids bankruptcy, so sufficiently loose leverage caps are redundant. Under dividend-value maximization the firm pays dividends at a leverage barrier and rationally accepts a positive probability of liquidation; regulation is binding when effective. We also establish a one-for-one equivalence between costly asset sales and equity issuance.*

MINI-SYMPOSIUM (ID 87): ID 592 (03)

Minimizing the Ruin Probability with Irreversible Reinsurance and Investment

Dan Ren (*University of Dayton, United States*); **Gu Wang** (*Worcester Polytechnic Institute, United States*); **Bin Zou** (*University of Connecticut, United States*)

Abstract: *We study an insurer whose surplus follows a diffusion process and who can manage risk through irreversible proportional reinsurance and investment. The ceded proportion is non-decreasing and incurs both continuous premium payments under the expected value principle and proportional transaction costs. Ruin is defined as the first time the controlled surplus becomes non-positive. Given initial surplus and reinsurance level, the insurer seeks optimal investment and reinsurance strategies to minimize the probability of ultimate ruin.*

MINI-SYMPOSIUM (ID 87): ID 602 (04)

Active Portfolio Management with Market Diversity and Dispersion

Xiaofei Shi (*University of Toronto, Canada*); **Brian Ceco** (*University of Toronto, Canada*); **Ting-Kam Leonard Wong** (*University of Toronto, Canada*)

Abstract: *Equal-weighted portfolios have historically delivered substantial outperformance relative to capitalization-weighted benchmarks. Motivated by stochastic portfolio theory, we show that dynamic allocations between equal-weighted and capitalization-weighted portfolios can be described through market diversity and dispersion. We introduce stochastic diversity–dispersion models, formulate an active mean–variance problem for the allocation process, and penalize active risk and trading costs. The optimal strategy is characterized by a linear forward–backward SDE and admits an "aiming in front of a moving target" representation. We calibrate the model to S&P 500 data and evaluate the strategy under trading costs.*

Risk Measures and Financial Risk Assessment - Aula E

ORAL ID 199 (01)

Some results on general Λ-quantiles

Fabio Bellini (*University of Milano-Bicocca, Italy*); **Felix Liebrich** (*University of Amsterdam, Netherlands*)

Abstract: *Lambda-quantiles are a generalisation of the usual quantiles introduced in the financial literature by Frittelli et al. (2014) by replacing in the usual definition of quantile the probability level $\lambda \in [0,1]$ with a functional parameter $\Lambda : \mathbb{R} \to [0,1]$. In the case of a decreasing Λ, it is known that the properties of Λ-quantiles are similar to those of the usual quantiles. We study here the general non-monotonic case, with a focus on bounded variation Λ, discussing properties such as weak continuity, mixture representations, generalised ordinal covariance, and convexity of the level sets of the resulting Λ-quantiles.*

ORAL ID 352 (02)

Convex Expectations on Path Space: Dual Representations and their Applications

David Criens (*University of Freiburg, Germany*); **Michael Kupper** (*University of Konstanz, Germany*)

Abstract: *Convex expectations on path space (CE) are canonical models in insurance mathematics—representing dynamic convex risk measures—and in robust finance, with Peng's G-expectation as a prominent example. In this talk, we demonstrate that CEs admit dual representations via dynamic penalty functions. Building on this, we establish that CEs are uniquely determined by their finite-dimensional distributions. This insight implies that two seemingly distinct approaches in robust finance are equivalent: the Hu-Peng and the Neufeld-Nutz definitions of G-Lévy processes. Finally, we prove that Markovian CEs are determined by their one-dimensional distributions and we apply this to a large deviation analysis for random G-expectations.*

ORAL ID 388 (03)

Correlating Discrete Events: A Scalable Approach for Financial Risk Assessment

Andrea Monaco (*University College Dublin, Ireland*); **Antonio Scala** (*Institute for Complex Systems, CNR, Rome, Italy, Italy*)

Abstract: *This paper presents a novel method for modeling correlated discrete events for financial risk assessment. Traditional approaches, such as copulas, face scalability and computational limitations. We introduce a probabilistic framework based on Markov-Chain Monte Carlo (MCMC), whose main advantage is enabling efficient greedy strategies to generate configurations with a prescribed correlation. Two constructive procedures, relaxation and aggregation, enable fast scenario generation at a target correlation level. The approach improves scalability and efficiency compared to copulas and aligns with regulatory practice, in which probability of default is defined as a constant one-year measure. Its effectiveness is demonstrated through simulations and comparisons.*

ORAL ID 443 (04)

Shaping volatility surfaces with optimal transport: arbitrage repair, stress-testing, and scenario generation

Marius Chevallier (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Stefano De Marco** (*Centre de Mathématiques Appliquées, Ecole Polytechnique, France*); **Pierre-Emmanuel Lévy-Dit-Vehel** (*Société Générale, France*)

Abstract: *We propose a framework based on optimal transport for performing risk management tasks on volatility surfaces. It addresses arbitrage removal, arbitrage-free stress testing, and generation of surfaces. Starting from volatilities on a discrete grid, we construct a vector of marginals consistent with the data. It is then transformed by minimizing a functional involving Monge–Kantorovich value functions. The feasible set consists of vectors of probabilities increasing in the convex order, ensuring that the data generated by the solution is arbitrage-free. Depending on the application, we motivate how cost functions of Monge-Kantorovich problems can be chosen. We illustrate the method with examples.*

Climate Finance and Transition Risk - Aula F

ORAL ID 91 (01)

Credit portfolio losses with climate change factors

Oriol Tubella-Domingo (*University of Barcelona, Spain*); **Luis Ortiz Gracia** (*University of Barcelona, Spain*)

Abstract: *In this work, we consider the problem of computing risk measures of a credit portfolio via the evaluation of the characteristic function of the loss variable. We propose a new methodology to obtain the characteristic function of the loss distribution when the dependence structure is driven by either the Gaussian or t-copula model. This new approach relies on a quadrature method based on Shannon wavelets and the cardinal sine function. We conclude our work with a real portfolio where the exposures are taken from the European Investment Bank, and we incorporate climate change-related factors into the analysis.*

ORAL ID 60 (02)

Climate options pricing based on cumulative indexes

Chiara Guardasoni (*University of Parma, Italy*); **Luca Vincenzo Ballestra** (*Università di Bologna, Italy*); **Carlos Allué Buesa** (*University of Barcelona, Spain*); **Ivan Gallo** (*Università di Bologna, Italy*); **Maria Letizia Guerra** (*Università di Bologna, Italy*); **Luis Ortiz Gracia** (*University of Barcelona, Spain*)

Abstract: *The impact of climate change is now macroscopically evident. The damage caused by floods occurred in Emilia Romagna (Italy) in May 2023 was over €8.5 billion and, in October 2024 and December 2025, exceptional precipitations again occurred in the area with exceptional frequency. With the purpose of mitigating climate-related financial risks, some strategies to forecast cumulative climate indexes related to temperatures and rainfall are suggested and compared, starting from historical databases of meteorological stations in Emilia Romagna. Then, some examples of climate derivative valuation based on these indexes follow.*

ORAL ID 437 (03)

Market-Implied Time to Transition to a Low-Carbon Economy from the Greenium Term Structure

Lorenzo Mercuri (*University of Milan, Italy*); **Andrea Perchiazzo** (*Eastern Piedmont University (UPO), Italy*); **Edit Rroji** (*University of Milano-Bicocca, Italy*); **Ilaria Stefani** (*University of Parma, Italy*)

Abstract: *In the transition to a low- or zero-carbon economy, we expect the difference in greenium between twin bonds with different maturities to disappear or, at least, to reduce in both level and volatility. This calls for a model that imposes a terminal condition on the dynamics of the process representing the difference in nodes within the greenium term structure. Empirical evidence shows that these differences are mean-reverting motivating ad-hoc models that allow for a transition at a specific future date. We discuss two models. The first extends the classical Vasicek model. Then this model is integrated into a regime-switching framework.*

ORAL ID 318 (04)

Pricing Climate Transition Risk via Behavioural Cash-Flow Dynamics in Incomplete Markets

Tal Morgenstern (*University of Sydney, Australia*)

Abstract: *We develop a continuous-time valuation framework for climate transition risk in incomplete markets, modelling transition uncertainty through a family of transition-consistent equivalent martingale measures indexed by behavioural and policy regimes. Valuation is obtained via selection of the minimal-entropy pricing measure, yielding a dynamically consistent and robust valuation functional, rather than dependent on a single transition scenario. The proposed approach links entropy penalties to observable economic behaviour, generating then an endogenous transition risk premia. This framework admits tractable valuation, stability under regime shifts, and natural applications to climate stress testing and sustainability-linked financial instruments.*

Asset Allocation/Optimal Investment/Portfolio Theory - Aula P

ORAL ID 42 (01)

Do Low Internal Carbon Prices Signal Climate Inaction? A Financed-Emissions Perspective

Haibo Liu (*Purdue University, United States*); **Zhongyi Yuan** (*The Pennsylvania State University, United States*)

Abstract: *Most firms in the financial services and insurance industries adopt low internal carbon prices (ICPs). We rationalize these low ICPs by focusing on financed emissions, which account for the majority of their total emissions. We develop and solve an extended mean–variance model with a constraint on portfolio emissions. The model identifies an emissions-efficient frontier (EEF) for environmentally conscious investors. Using data from the London Stock Exchange Group, we empirically estimate the EEF. According to our model, to maximize a firm's carbon-adjusted Sharpe ratio, the ICP should not exceed \$4.7 per tonne, supporting the use of low ICPs for financed emissions.*

ORAL ID 144 (02)

Income-Based Optimal Portfolio Choice: A New Approach

Seyoung Park (*University of Nottingham, United Kingdom*); **Alain Bensoussan** (*University of Texas at Dallas, United States*)

Abstract: *We develop a new income-based optimal portfolio choice framework. We introduce the new state variable and the new risk control representing, respectively, total wealth (financial wealth plus human capital) and the total risk exposure of total wealth to both the stock and labor markets. In particular, total wealth plays an important direct input variable in the agent's optimal risk control. We find a certain threshold of wealth below which the agent's risk taking decreases as unspanned income risk increases and above which the risk taking rises as the unspanned risk increases.*

ORAL ID 251 (03)

Outperforming a Benchmark with α-Bregman Wasserstein divergence

Silvana Pesenti (*University of Toronto, Canada*); **Thai Nguyen** (*Université Laval, Canada*)

Abstract: *We consider an investor who seeks the portfolio with maximal expected utility of the difference between the terminal wealth of their strategy and a proportion of the benchmark's, subject to a budget, and a deviation constraint. The investor chooses theα-Bregman-Wasserstein divergence, that asymmetrically penalises gains and losses as well as penalises underperforming the benchmark more than outperforming it. We prove existence and uniqueness, characterise the optimal portfolio strategy, and give explicit criteria when the divergence constraints and the budget constraints are binding. We illustration of the optimal quantile function in a geometric Brownian motion market model.*

ORAL ID 411 (04)

Optimal investment under capital gains taxes

Alexander Dimitrov (*Goethe University Frankfurt, Germany*); **Christoph Kühn** (*Goethe University Frankfurt, Germany*)

Abstract: *We generalize classical results on the existence of optimal portfolios in discrete time frictionless market models to models with capital gains taxes. We consider the realistic but mathematically challenging rule that losses do not trigger negative taxes but can only be offset against potential gains in the future. Central to the analysis is a well-known phenomenon from arbitrage-free markets with proportional transaction costs that does not exist in arbitrage-free frictionless markets: an investment in specific quantities of stocks that is completely riskless but may provide an advantage over holding money in the bank account.*

Robust Preferences and Incentive-Constrained Decisions - Aula Q

ORAL ID 277 (01)

Preference robust distortion risk measures

Carole Bernard (*Vrije Universiteit Brussel, Belgium*); **Silvana Pesenti** (*University of Toronto, Canada*)

Abstract: *We introduce a framework for preference-robust decision making when preferences over risk are modelled through generalized distortion risk measures. Unlike distributional robustness, our approach addresses ambiguity in the risk functional itself. We construct ambiguity sets on distortion (weight) functions using the Wasserstein distance and Bregman divergences, and derive closed-form expressions for the worst- and best-case distortion risk measures. We further extend the framework to Rank-Dependent Expected Utility (RDEU), yielding preference-robust behavioural models. For instance we construct models that are consistent with Allais paradox.*

ORAL ID 295 (02)

Bayesian multi-objective stochastic control

Gabriela Kovacova (*Reykjavik University, Iceland*); **Igor Cialenco** (*Illinois Institute of Technology, United States*)

Abstract: *Consider the motivating example of mean-risk portfolio selection. In the last decade, the problem has been successfully handled as a multi-objective control problem. However, the existing results were derived under an (unrealistic) assumption of the distribution of stochastic factor (asset returns) being known. This motivates the need for combining multi-objective control with model uncertainty approaches. In this work, we explore the Bayesian approach to model uncertainty in the context of multi-objective control problem. We build on the existing results for single-objective Bayesian control and aim to establish validity of dynamic programming results for Bayesian multi-objective control.*

ORAL ID 336 (03)

A model-based selling propensity: Prospect theory, multiple agents and the disposition effect

Salvatore Ciano (*University of Warwick, United Kingdom*); **Vicky Henderson** (*University of Warwick, United Kingdom*)

Abstract: *We develop a model-based, state-dependent selling propensity,$D(x)$, in an optimal asset sale framework where the price$X$follows a time-homogeneous diffusion.$D(x)$depends upon the optimal target distribution. We extend to a multi-agent framework. We specialise to an agent with PT and give examples which aim to match empirical hazard rates from the literature which exhibit the disposition effect. Using a particular embedding,$D(x)$is interpreted as a stopping intensity. If the agent sells at a level-dependent rate per unit time,$D(x)$, the optimal distribution is attained.*

ORAL ID 771 (04)

Interim Incentive Efficiency in Pure-Exchange Economies with Hidden Types: A Negishi Characterization

Mario Ghossoub (*University of Waterloo, Canada*)

Abstract: *We study interim incentive efficiency in a one-period pure-exchange economy with privately observed types. Agents enter the economy with type-dependent state-contingent endowments and can trade risks and deterministic monetary transfers through Bayesian mechanisms. We formulate both indirect mechanisms with general message spaces and direct mechanisms in which agents report their types. We provide a Bayesian revelation principle that shows that every interim utility profile generated by a Bayesian equilibrium of an indirect mechanism can be replicated by a Bayesian incentive-compatible direct mechanism. We introduce several notions of interim efficiency and develop Negishi-type characterization thereof, through a social welfare maximization representation of incentive Pareto optima.*

Optimal Stopping - Aula H

ORAL ID 58 (01)

A potential-theoretic approach to optimal stopping in a spectrally negative Lévy Model

Masahiko Egami (*Kyoto University, Japan*); **Tomohiro Koike** (*Kyoto University, Japan*)

Abstract: *We establish a systematic solution method for optimal stopping problems of spectrally negative Lévy processes. Our approach relies essentially on the potential theory, in particular the Riesz decomposition and the maximum principle. Using these mathematical results, we not only derive necessary and sufficient conditions of optimality for a broad class of reward functions, but also develop a method to tackle general problems in a direct and constructive way (without pre-specifying the solution form). To reinforce the latter point, we provide a step-by-step solution procedure applicable to complex solution structures, including continuation regions with multiple connected components.*

ORAL ID 200 (02)

Existence of Strong Randomized Equilibria in Mean-Field Games of Optimal Stopping with Common Noise

Anna Pajola (*University of Bielefeld, Germany*); **Giorgio Ferrari** (*University of Bielefeld, Germany*)

Abstract: *We study a mean-field game of optimal stopping with common noise and investigate the existence of strong solutions, through the connection between optimal stopping problems and Bank-El Karoui's representation problem. We show that, under some continuity assumptions, there exists a strong randomized mean-field equilibrium, where the mean-field interaction term is adapted to the common noise, while the stopping time is randomized in the Baxter-Chacon sense. Moreover, under some monotonicity assumptions, we provide a result of existence of strong mean-field equilibria and run a comparative statics analysis. The talk will be based on a joint work with Giorgio Ferrari (Bielefeld University).*

Artificial Intelligence in Finance - Aula I

ORAL ID 456 (01)

Scalable Signature-Based Distribution Regression via Reference Sets

Blanka Horvath (*University of Oxford, United Kingdom*); **Andrew Alden** (*King's College London, United Kingdom*); **Carmine Ventre** (*King's College London, United Kingdom*)

Abstract: *Distribution Regression (DR) on stochastic processes describes the learning task of regression on collections of time series. Path signatures, a technique prevalent in stochastic analysis, have been used to solve the DR problem. State of the art DR solutions are memory intensive and incur a high computation cost, leading to a trade-off between path length and the number of paths considered. We present a methodology for addressing the above issues; resolving estimation uncertainties whilst also proposing a pipeline that enables us to use DR for a wide variety of learning tasks. Integral to our approach is our novel distance approximator.*

ORAL ID 261 (02)

Solving Optimal Execution Problems via In-Context Operator Networks

Tingwei Meng (*University of California, Los Angeles, United States*); **Moritz Voss** (*University of California, Los Angeles, United States*); **Nils Detering** (*Heinrich Heine University Düsseldorf, Germany*); **Giulio Farolfi** (*University of California, Los Angeles, United States*); **Stan Osher** (*University of California, Los Angeles, United States*); **Georg Menz** (*University of California, Los Angeles, United States*)

Abstract: *We propose a novel transformer-based neural network architecture (ICON-OCnet) for solving optimal order execution problems in the presence of unknown price impact. Our architecture facilitates data-driven in-context operator learning for the incurred price impact by merging offline pre-training with online few-shot prompting inference. First, the operator learning component (ICON) learns the prevailing price impact environment from only a few executed trade and price impact trajectories provided as context. Second, we employ ICON as a surrogate operator to train a neural network policy (OCnet) for the optimal order execution strategy for the price impact regime inferred from the in-context examples.*

ORAL ID 340 (03)

Differentiable GAN-Based Modeling for Financial Distributions and Sensitivity-Aware Pricing

Lokmane Abbas Turki (*Sorbonne Université, France*); **Aurélien Grenard** (*Sorbonne Université, France*)

Abstract: *We propose a differentiable generative framework for financial models based on smooth conditional GANs that learn parametric marginal distributions directly. Unlike traditional simulation schemes, the resulting generators are fully compatible with automatic adjoint differentiation, enabling fixed-cost simulation and stable access to prices and sensitivities via automatic differentiation. This property allows gradient-aware training of neural pricers without relying on costly or unstable sensitivity data. Applications to subordinated Lévy, Heston, and rough volatility models demonstrate improved accuracy, robustness, and very reduced static arbitrage violations.*

ORAL ID 399 (04)

Data-Driven Duration Management: Term Structure Forecasting Using Machine Learning

Tobias Lausser (*Technische Universität München, Germany*)

Abstract: *Predicting movements of the term structure of zero rates is a central task in fixed-income portfolio management: small perturbations of any of the key yield-curve factors (level, slope and curvature) may have a significant impact on portfolio valuation, risk metrics and relative performance. In our contribution, we propose several forecasting procedures that combine classical methods and machine learning, and develop an evaluation framework based on statistical metrics and economic performance in duration management. The forecasting methods connect dimension reduction techniques and time-series forecasting in the latent space, also allowing the inclusion of macroeconomic factors.*

Mean Field Control/Mean Field Games - Aula L

ORAL ID 490 (01)

Long Time Average of Mean Field Game Systems with Common White Noise and Long Time Behavior of Second Order Master Equations

Wenbin Yan (*Université Paris Dauphine PSL, China*); **Pierre Cardaliaguet** (*Université Paris Dauphine PSL, France*); **Raphaël Maillet** (*Capital Fund Management, France*)

Abstract: *We investigate the long-time behavior of mean field game systems with common noise. Unlike deterministic MFGs, where convergence to stationary solutions follows from monotonicity and compactness, common white noise rules out such arguments. For an MFG with infinitely many players subject to both idiosyncratic and common noise, we introduce quantitative techniques to study the infinite-horizon limit. We construct stationary random processes capturing the turnpike behavior, prove exponential convergence toward them, and identify a deterministic ergodic constant. Almost sure convergence is obtained via a refined analysis of the ergodic master equation, based on new BSPDE estimates*

ORAL ID 108 (02)

Mean field game of mutual holding with major and minor players

Shuoqing Deng (*The Hong Kong University of Science and Technology, Hong Kong*)

Abstract: *We study the problem of mean field game of mutual holding with major and minor players. In a market where major can hold minor and minor can only hold between themselves, we show that the optimal strategy for the major is the mean-variance trade-off and the optimal strategy for the minor is bang-bang. We then consider a specific model to give a more explicit result.*

ORAL ID 69 (03)

Quantitative convergence rates for extended mean field games with volatility control

Hiroaki Horikawa (*University of Michigan, United States*); **Erhan Bayraktar** (*University of Michigan, United States*)

Abstract: *We investigate the convergence of symmetric stochastic differential games with interactions via control, where the volatility terms of both idiosyncratic and common noises are controlled. We apply the stochastic maximum principle, following the approach of Laurière and Tangpi, to reduce the convergence analysis to the study of forward-backward propagation of chaos. Under the standard monotonicity conditions, we derive quantitative convergence rates for open-loop Nash equilibria of N-player stochastic differential games toward the corresponding mean field equilibrium. As a prerequisite, we also establish the well-posedness of the conditional McKean–Vlasov forward-backward stochastic differential equations by the method of continuation.*

ORAL ID 348 (04)

Conditional McKean-Vlasov Control

Kaiwen Zhang (*Princeton University, United States*); **René Carmona** (*Princeton University, United States*); **Ludovic Tangpi** (*Princeton University, United States*)

Abstract: *Conditional McKean-Vlasov control problems involve controlling McKean-Vlasov diffusions where the interaction occurs through the law of the state process conditionally on it staying in a domain. Introduced by Lions in his 2016 lectures at the Collège de France, these problems have notable applications, particularly in systemic risk. We establish well-posedness and provide a general characterization of optimal controls using a new Pontryagin maximum principle in the probabilistic weak formulation. Unlike the classical approach based on forward-backward systems, our results connect the control problem to a generalized McKean-Vlasov backward stochastic differential equation.*

Optimal Control/Optimization - Aula M

ORAL ID 38 (01)

A stochastic Gordon-Loeb model for optimal cybersecurity investment under clustered attacks

Giorgia Callegaro (*University of Padova, Italy*); **Claudio Fontana** (*University of Padova, Italy*); **Caroline Hillairet** (*ENSAE, France*); **Beatrice Ongarato** (*TU Dresden, Germany*); **Beatrice Ongarato** (*TU Dresden, Germany*)

Abstract: *We develop a continuous-time stochastic model for optimal cybersecurity investment under the threat of cyberattacks. The arrival of attacks is modeled using a Hawkes process, capturing clustering in cyberattacks. Extending the Gordon-Loeb model, each attack may result in a breach, with breach probability depending on the system's vulnerability. We aim at determining the optimal cybersecurity investment to reduce vulnerability. The problem is cast as a stochastic optimal control problem and solved using dynamic programming methods. Numerical results illustrate how accounting for attack clustering leads to more responsive and effective investment policies, offering significant improvements over static and Poisson-based benchmark strategies.*

ORAL ID 138 (02)

Liquid–Illiquid Conversion via Singular Control: Staking and Partial Commitment

Kyoung Jin Choi (*Haskayne School of Business, University of Calgary, Canada*); **Junkee Jeon** (*Kyung Hee University, Korea, Republic of*); **Minsuk Kwak** (*Hankuk University of Foreign Studies, Korea, Republic of*); **Byung Hwa Lim** (*Sungkyunkwan University, Korea, Republic of*)

Abstract: *Optimal commitment of liquid resources to illiquid, reward-generating states is a fundamental problem in stochastic control. We study this setting as a continuous-time singular control problem with costly reversibility, featuring interacting controls and endogenous inaction regions. Despite state-dependent rewards and asymmetric adjustment frictions, we derive a fully explicit solution for the value function and the optimal boundaries. The solution reveals systematic responses to reward–cost trade-offs and a sign reversal in hedging behavior depending on risk preferences. We illustrate the framework using Proof-of-Stake staking, providing closed-form value-equivalent wedges and shadow costs induced by lock-up constraints.*

ORAL ID 275 (03)

Habit Formation, Labor Supply, and the Dynamics of Retirement and Annuitization

Criscent Birungi (*Concordia University, Canada*); **Cody Hyndman** (*Concordia University, Canada*)

Abstract: *We analyze a continuous-time lifecycle model with habit formation, endogenous labor supply, and an irreversible annuitization option under age-dependent mortality. Utility depends on consumption relative to an internal habit, leading to a coupled stochastic control and optimal stopping problem. Using dynamic programming, we characterize the solution via a Hamilton–Jacobi–Bellman variational inequality and exploit homotheticity to reduce the state space to a single wealth-to-habit ratio. The resulting optimal policies exhibit regime switching in labor supply, portfolio choice, and annuitization, with discontinuous de-risking at retirement and belief-driven variation in annuity demand, supported by semi-analytical solutions and explicit policy characterization.*

ORAL ID 306 (04)

The Impact of Preventive Effort on Loss Reduction in a CIR Risk Model

Gaia Pescosolido (*Sapienza Università di Roma, Italy*); **Claudia Ceci** (*Sapienza Università di Roma, Italy*)

Abstract: *In this paper, we propose a Markovian model for a self-protection problem in which the stochastic claim arrival intensity follows a Cox–Ingersoll–Ross (CIR) process. Self-protection strategies are actions undertaken by an individual facing potential losses to reduce the probability that a loss occurs. The agent aims to maximize the expected exponential utility of the terminal wealth. The value function is characterized as the unique classical solution of the associated Hamilton–Jacobi–Bellman equation. Quasi-explicit expressions for the value function and the optimal self-protection strategy are derived. Finally, we conduct a sensitivity analysis of the optimal strategy with respect to key model parameters.*

Stochastic Control, Equilibrium and Computational Finance - Aula Filopanti

ORAL ID 109 (01)

Climate Transition as Structural Change: A Computable Time-Varying-Parameter ABM for Macro-Finance

Yongyeon Oh (*Bank of Korea, Korea, Republic of*)

Abstract: *Climate transition is structural change: persistent increases in energy costs shift macro-financial behavior and constraints over time. We propose a time-varying agent-based macro-finance model in which key behavioral and financial parameters evolve with endogenous states. Following Kulish (2017), transition is modeled as predictable parameter evolution rather than an exogenous regime switch, yielding a non-stationary ABM that requires an explicit solution strategy. Our methodological contribution is a stable computational approach to compute transition paths in this setting, using bounded updates, adaptive step sizing, and damping. We validate computed paths using sign, persistence, and state-dependence diagnostics for FX volatility and risk premia.*

ORAL ID 77 (02)

Self-Consistent Transport in Heterogeneous-Agent Models

Andrew Lyasoff (*Independent, France*)

Abstract: *Heterogeneous-agent models are studied from the beyond of stationary recursive equilibria. A novel mathematical tool, called time-interlaced backward induction, is introduced. It parallels Pontryagin's maximum principle, but differs in the way in which state and costate variables are sequenced in time and are connected across the population. It also differs in the way in which their forward and backward dynamics, which become endogenous and give rise to a special form of transport, are resolved. The new method does not involve the notion of representative agent and is benchmarked against existing techniques. Some old, yet still open, problems are resolved.*

ORAL ID 196 (03)

Reverse Mortgages, Housing, and Consumption: An Equilibrium Approach

Jialu Shen (*Fudan University, China*)

Abstract: *Reverse Mortgages (RMs) enable eligible homeowners aged 62 and older to access home liquidity without moving out or repaying before loan termination, which occurs when borrowers die or move to long-term care. We incorporate RMs into a quantitative equilibrium life-cycle model to assess their impacts on household decisions, mortgages, and the housing market. We show that the volatility of consumption growth decreases for RM borrowers. Additionally, introducing RMs enhances the house's perceived value, making homeownership a more financially attractive option and stimulating housing demand. These effects increase overall household welfare in our model, highlighting the positive impact of RMs.*

Advances in Market Microstructure, Market Making, and Competition - Aula A

Organized by: **Thibaut Mastrolia** and **Leandro Sánchez-Betancourt**

MINI-SYMPOSIUM (ID 79): ID 731 (01)

Optimal Dynamic Fees in Automated Market Makers

Martin Herdegen (*Universität Stuttgart, Germany*); **Leonardo Baggiani** (*University of Warwick, United Kingdom*); **Leandro Sánchez Betancourt** (*University of Oxford, United Kingdom*)

Abstract: *Automated Market Makers (AMMs) are emerging as a popular decentralised trading platform. In this work, we determine the optimal dynamic fees in a constant function market maker. We find approximate closed-form solutions to the control problem and study the optimal fee structure. We find that there are two distinct fee regimes: one in which the AMM imposes higher fees to deter arbitrageurs, and another where fees are lowered to increase volatility and attract noise traders.*

MINI-SYMPOSIUM (ID 79): ID 669 (02)

Optimal Exit Time for Liquidity Providers in Automated Market Makers

Philippe Bergault (*Université Paris Dauphine, France*); **Sébastien Bieber** (*Université Paris Dauphine, France*); **Leandro Sánchez-Betancourt** (*University of Oxford, United Kingdom*)

Abstract: *We study optimal liquidity withdrawal for a liquidity provider (LP) in an automated market maker (AMM). LPs earn fees but face impermanent loss (IL) from price fluctuations. We model the exit decision as an optimal stopping problem and characterise the value function as the unique viscosity solution of an HJB quasi-variational inequality. Using calibrated simulations, we show how the optimal policy depends on volatility, fees, and the activity of arbitrageurs and noise traders. The LP exits when pool-oracle misalignments become large, since expected fees no longer offset the IL realised when arbitrageurs realign prices.*

MINI-SYMPOSIUM (ID 79): ID 536 (03)

Learning Market Making with Closing Auctions

Julius Graf (*UC Berkeley, United States*); **Thibaut Mastrolia** (*UC Berkeley, United States*)

Abstract: *We investigate the market-making problem on a trading session where a continuous phase is followed by a closing auction. Whereas standard models rely on terminal inventory penalties and ignore closing auction liquidity, we propose a Deep Q-Learning framework that explicitly incorporates this mechanism by anticipating the auction and continuously refining the projected clearing price. We develop a generative stochastic market model to simulate the trading session. We apply our method in two settings: (1) where the mid price follows a rough Heston model; and (2) using historical S&P 500 data, comparing performance of our algorithm against classical optimal market-making benchmarks.*

MINI-SYMPOSIUM (ID 79): ID 548 (04)

Market Making, Informed Trading, and the Price of Information

Adrien Mathieu (*University of Oxford, United Kingdom*); **Alvaro Cartea** (*University of Oxford, United Kingdom*); **Leandro Sánchez-Betancourt** (*University of Oxford, United Kingdom*)

Abstract: *We characterize the leader-follower equilibrium between a market maker (leader) and an informed trader (follower) in a market with price-sensitive uninformed traders. The informed trader observes the asset's stochastic drift, which the market maker can also observe at a cost. We first solve the informed trader's optimization problem for any given liquidity schedule, then derive the market maker's optimal strategy accounting for the trader's best response. At equilibrium, we determine the maximum amount of money the market maker will pay to observe the drift and how it varies with model parameters.*

Energy, Green Investment and Environmental Risk - Aula G

ORAL ID 458 (01)

Cap and Trade on water with seasonal forecasts: a theoretical model

Fabio Ehrenhofer (*University of Bologna, Italy*); **Silvia Romagnoli** (*Università di Bologna, Italy*)

Abstract: *Climate change will increase interannual hydrologic variability and water scarcity. Two adaptation tools are water markets, reallocating supplies, and seasonal forecasts, informing ex-ante choices in farmers land-use decisions. Prior work treats them separately, missing interactions between expected availability and trading opportunities. We build a competitive equilibrium model linking realized water, forecast distributions, and heterogeneous producers. Simulations show: (i) under scarcity, trade yields the largest efficiency gains by moving water to higher-value uses; (ii) forecasts add value when skill is moderate-high and variability is pronounced; (iii) combined use can be synergistic, especially for risk-averse producers. Results motivate joint policy evaluation.*

ORAL ID 486 (02)

Sovereign bond yields, pollution and natural disasters

Emilio Barucci (*Politecnico di Milano, Italy*); **Daniele Marazzina** (*Politecnico di Milano, Italy*); **Aldo Nassigh** (*Politecnico di Milano, Italy*)

Abstract: *We explore the interplay between sovereign bond yields, pollution and natural disasters. Physical pollution contributes to the likelihood of natural disasters and influences economic growth. As pollution undermines productive capacity, it shapes the government's ability to service its debt. In this context, the country can decide at any time whether to default on its obligations and whether to invest in pollution abatement. The framework provides insights into the relationship between credit spreads of sovereign bonds and country's climate vulnerability. Through calibration, we show that bond spreads of developing and low-income countries are strongly sensitive to climate vulnerability.*

ORAL ID 463 (03)

Solar Energy Risks: Spatial Stochastic Radiation Modeling and Optimal Hedging Strategies

Silvia Romagnoli (*Università di Bologna, Italy*); **Beniamino Sartini** (*University of Bologna, Italy*)

Abstract: *We develop a new spatial stochastic model for daily solar radiation that integrates local dynamics with a coherent cross-sectional dependence structure. Marginally, each location follows a seasonal ARMA-GARCH specification with regime-switching Gaussian-mixture innovations, while spatial dependence is introduced through correlated Bernoulli regimes and Gaussian residuals. To extend the model over a continuous geographical domain, we estimate local parameters and spatial correlations on a grid using Universal Kriging. This framework allows us to quantify joint tail risk across arbitrary sets of locations, evaluate risks faced by solar farms or regional portfolios and offers a flexible foundation for solar-risk and derivative design.*

ORAL ID 208 (04)

Strategic Focus or Technological Neutrality? On the Optimal Mix of Green Investment and Carbon Capture and Storage Research in a Budget-Constraint World

Rüdiger Frey (*Vienna University of Economics and Business, Austria*); **Katia Colaneri** (*University of Rome - Tor Vergata, Italy*); **Alessio D'amato** (*University of Naples Parthenope, Italy*)

Abstract: *Major pathways for carbon abatement include renewable energy sources (RES) and carbon capture and storage (CCS) technologies. While RES offer clean, sustainable energy, significantly expanding their share in the energy mix necessitates heavy infrastructure investment. On the other hand, CCS allows to decarbonize existing fossil fuel-based infrastructure. However, significant research is required to make CCS viable at scale. It may be infeasible for societies to simultaneously invest in RES infrastructure and fund foundational CCS research. We explore this trade-off by modeling the problem as a dynamic control problem which is studied using theoretical and numerical methods.*

Adapted Transport and Calibration in Finance - Aula B

Organized by: **Ibrahim Ekren**

MINI-SYMPOSIUM (ID 145): ID 580 (01)

Computing the adapted Wasserstein distance between the laws of stochastic processes

Yifan Jiang (*Imperial College London, United Kingdom*); **Fang Rui Lim** (*University of Michigan, United States*)

Abstract: *Recently, the adapted Wasserstein distance has emerged as an attractive alternative to the usual distances between laws of stochastic processes due to its application to dynamic optimization problems, such as optimal stopping, for example. However, the exact value of this distance between the laws of continuous time stochastic processes is difficult to determine in general. In this talk, we discuss two methods — a transfer principle, and a discretisation approach — to compute, either explicitly or numerically, the AW distance between the laws of certain stochastic processes, such as mean-square continuous Gaussian processes and stochastic differential equations.*

MINI-SYMPOSIUM (ID 145): ID 605 (02)

Analytical Approach To Continuous-Time Causal Optimal Transport

Julio Backhoff (*University of Vienna, Austria*); **Erhan Bayraktar** (*University of Michigan, United States*); **Ibrahim Ekren** (*University of Michigan, United States*); **Antonios Zitridis** (*University of Michigan, United States*)

Abstract: *We study causal optimal transport problems with Markovian cost and prescribed Markovian marginal laws. We show that the associated value function solves a fully nonlinear parabolic PDE, for which we establish a comparison principle and, consequently, the uniqueness of its viscosity solution. This PDE characterization allows us to identify the value with that of a constrained version of the control problem for the Kushner–Stratonovich equation. We also obtain a third equivalent optimal control formulation with a state constraint, which leads to implementable numerical schemes for causal optimal transport. This is joint work with Julio Backhoff, Erhan Bayraktar, and Antonios Zitridis.*

MINI-SYMPOSIUM (ID 145): ID 643 (03)

On Schrödinger and Bass Martingales

Julio Backhoff (*University of Vienna, Austria*); **Mathias Beiglböck** (*University of Vienna, Austria*); **Giorgia Bifronte** (*University of Vienna, Austria*); **Armand Ley** (*University of Vienna, Austria*)

Abstract: *A Bass martingale attempts to be as Gaussian as possible, as measured by an adapted Wasserstein distance, while interpolating prescribed initial and terminal marginals. A martingale Schrödinger bridge attempts the same, but measured in the relative entropy sense. Beyond their theoretical interest, these martingales have been proposed for the purpose of model calibration in finance. In this talk we present new findings on martingale Schrödinger bridges, including a discrete- to continuous-time correspondence, a fixed-point algorithm for their computation, and a connection to the celebrated Föllmer processes. We also discuss some of the similarities / differences, between Bass and Schrödinger martingales.*

ORAL ID 121 (04)

A high-order recombination algorithm for weak approximation of stochastic differential equations

Yuji Shinozaki (*Hitotsubashi University Business School, Japan*); **Syoiti Ninomiya** (*Institute of Science Tokyo, Japan*)

Abstract: *A high-order recombination algorithm for weak approximation of stochastic differential equations is discussed, building on the original work of Litterer and Lyons (2012). The approach mitigates the support explosion inherent in cubature-based weak approximation by replacing intermediate discrete measures with reduced ones while preserving prescribed moment conditions. A refined error analysis is established, yielding a computationally feasible recursive partitioning algorithm. The scheme is applicable to practical problems in mathematical finance, and numerical evidence demonstrates effective avoidance of explosive growth in support cardinality. This presentation is mainly based on Ninomiya and Shinozaki (2025, arXiv:2504.19717) and also reports several recent results.*

Systemic Risk, Default and Financial Resilience - Aula C

ORAL ID 394 (01)

Can Nash inform capital requirements? Allocating systemic risk measures

Cagin Ararat (*University of Leeds, United Kingdom*); **Zachary Feinstein** (*Stevens Institute of Technology, United States*)

Abstract: *Systemic risk measures aggregate the risks from multiple financial institutions to find system-wide capital requirements. Though much attention has been given to assessing the level of systemic risk, less has been given to allocating that risk to the institutions. We propose a Nash allocation rule inspired by game theory. To construct these capital allocations, the banks compete in a game to reduce their own capital requirements while maintaining system-level acceptability. We provide sufficient conditions for the existence and uniqueness of Nash allocation rules, and apply our results to the prominent structures used for systemic risk measures in the literature.*

ORAL ID 377 (02)

A new measure of distance-to-default for the financial sector

Raffaele Corvino (*Neoma Business School, France*); **Federico Maglione** (*University of Florence, Italy*); **Berardino Palazzo** (*Federal Reserve Board, United States*)

Abstract: *Building on the structural model of default proposed by Nagel and Purnanandam (2020) [Banks' Risk Dynamics and Distance to Default. Review of Financial Studies, 2020, 33, 2421-2467], we develop a semi-analytical, market-based framework to estimate default risk for a wide range of financial institutions – including banks, insurance companies, and broker-dealers – whose business models involve leverage and maturity transformation. Our approach accounts for the compound option nature of financial firms' equity and the staggered maturity of asset portfolios, enabling the construction of a novel, multi-dimensional distance-to-default measure.*

ORAL ID 379 (03)

Robust Optimal Strategies for Two-Period Liquidation in Financial Systems

Dohyun Ahn (*The Chinese University of Hong Kong, Hong Kong*); **Hongyi Jiang** (*The Chinese University of Hong Kong, Hong Kong*)

Abstract: *Asset liquidation is often inevitable during financial distress, yet simultaneous sales of illiquid assets can lead to severe price depressions. To tackle this challenge, we develop a two-period model that allows for preemptive liquidation before clearing and propose a worst-case approach to the associated liquidation problem. To address analytical intractability, we introduce a relaxed formulation and establish its validity as a surrogate, which yields a tractable* robust optimal strategy. *This framework accommodates settings with permanent price impact or interbank liabilities. Our findings provide both theoretical insights and implementable guidance for robust liquidation decisions.*

ORAL ID 267 (04)

The Skorokhod Reflection Problem Driven by Jump Processes and an Application to Reinsurance

Graeme Baker (*Columbia University, United States*); **Ankita Chatterjee** (*Barnard College, United States*)

Abstract: *We consider reflected processes in the positive orthant driven by jump processes. For a given input, we show that there exists a unique minimal strong solution to the particle system up until a maximal stopping time, stated explicitly in terms of a certain linear program. We apply this model to the ruin time of interconnected insurance firms, where the stopping time can be interpreted as the failure time of a reinsurance agreement. Our work extends the analysis of Baker, Hambly, and Jettkant (2025) to the case of jump driving processes, and the existence result of Reiman (1984) beyond sub-stochastic matrices.*

Insurance and Actuarial Sciences - Aula D

ORAL ID 218 (01)

Pricing of Guaranteed Minimum Withdrawal Benefit in Variable Annuities within a Principal-Agent Framework

Min Dai (*The Hong Kong Polytechnic University, Hong Kong*); **Zhichao Lu** (*The Hong Kong Polytechnic University, Hong Kong*); **Weijia Zeng** (*The Hong Kong Polytechnic University, Hong Kong*)

Abstract: *We propose a risk-sharing (RS) pricing framework for guaranteed minimum withdrawal benefits, formulating the pricing problem as a principal–agent Stackelberg game. Unlike risk-neutral pricing, the RS approach captures asymmetric risk preferences and hedging capabilities, producing insurance fees that are largely consistent with market behavior. We develop two numerical schemes: a finite difference method (FDM) serving as a model-driven benchmark, and a reinforcement learning (RL) algorithm based on an entropy-regularized actor-critic architecture that learns optimal withdrawal strategies. Numerical results demonstrate that the RL method closely replicates the FDM benchmarks and remains effective even in unknown environments with jumps.*

ORAL ID 202 (02)

The effect of policy cancellation on the risk of an insurance portfolio

Manuel Schranzhofer (*FAM @ TU Wien, Vienna, Austria, Austria*); **Stefan Gerhold** (*FAM @ TU Wien, Vienna, Austria, Austria*); **Friedrich Hubalek** (*FAM @ TU Wien, Vienna, Austria, Austria*)

Abstract: *For an insurance portfolio modelled by a large number of i.i.d. losses, the average loss converges to the expected loss by the law of large numbers (LLN). Shrinking the portfolio hampers application of the LLN. We quantify this effect by applying a risk measure to the average loss before and after cancellation. For a portfolio of size* n*, the impact of cancelling either a single or a fixed proportion of contracts is shown to be of order* $n^{-3/2}$ *and* $n^{-1/2}$*, respectively. As regards technical tools, we revisit Edgeworth expansion and its inverse, the Cornish-Fisher expansion, as well as Kantorovich–Rubinstein duality.*

ORAL ID 154 (03)

Multivariate subexponentiality and interplay of insurance and financial risks in a renewal risk model

Charalampos Passalidis (*University of the Aegean, Greece*); **Dimitrios Konstantinides** (*University of the Aegean, Greece*)

Abstract: *We consider a multivariate risk model with common renewal process, and the logarithmic returns of investment-portfolio, are described by a Lévy process. In main results are established an asymptotic expression for the entrance probability of the discounted aggregate claims in some rare-sets. In first result, we are restricted in the case where the insurer makes risk-free investments, and the claim-vectors have distribution from a class negligibly smaller than multivariate subexponential distributions. We consider that the insurance and financial risks, satisfy a weak dependence structure. In the second result, we allow arbitrarily dependence between two risks, and we also permit risky-investment.*

ORAL ID 63 (04)

Asymptotics for aggregated interdependent multivariate subexponential claims with general investment returns

Dimitrios Konstantinides (*University of the Aegean, Greece*); **Zhangting Chen** (*Soochow University, China*); **Charalampos Passalidis** (*University of the Aegean, Greece*)

Abstract: *This paper investigates asymptotic estimates for the entrance probability of the discounted aggregate claim vector from a multivariate renewal risk model into some rare set. We provide asymptotic results for the entrance probability on both finite and infinite time horizons under various assumptions regarding the stochastic price process of the investment portfolio, the distribution class of claim vectors, and the dependence structure among the claim vectors. We introduce two dependence structures to model the dependence among the claim vectors. The immediate consequence of the main results is the asymptotic estimates of the ruin probabilities on finite and infinite time horizons.*

Learning and Optimization for Trading and Portfolios - Aula E

ORAL ID 55 (01)

LSTM-ARIMA as a hybrid approach in algorithmic investment strategies

Kamil Kashif (*Quantitative Finance Research Group, Department of Quantitative Finance and Machine Learning, Faculty of Economic Sciences, University of Warsaw, Poland*); **Robert Ślepaczuk** (*Quantitative Finance Research Group, Department of Quantitative Finance and Machine Learning, Faculty of Economic Sciences, University of Warsaw, Poland*)

Abstract: *This study presents an algorithmic investment strategy based on a hybrid forecasting framework combining Long Short-Term Memory (LSTM) and ARIMA models. The LSTM–ARIMA approach integrates linear dynamics captured by ARIMA with nonlinear temporal dependencies learned by LSTM by incorporating ARIMA residuals as additional inputs. The strategy is evaluated on daily data for major equity indices from 2000–2023 using walk-forward optimization. Results for Long-Only and Long-Short strategies show that LSTM–ARIMA consistently outperforms benchmark approaches in terms of risk-adjusted performance (Modified Information Ratio). Keywords: Deep learning; Recurrent neural networks; Algorithmic investment strategy; LSTM; Random forest; ARIMA; Hybrid/ensemble models; Walk-forward process*

ORAL ID 487 (02)

Portfolio Optimization with Sentiment Weighted Policy Gradients

Kemal Kirtac (*University College London, United Kingdom*)

Abstract: *Proximal policy optimization (PPO) for portfolio optimization typically relies on prices and underuses unstructured signals such as investor sentiment. We propose Sentiment-Augmented PPO (SAPPO), which injects daily asset-level sentiment into the state and into learning via a sentimentweighted advantage that scales policy gradients. Unlike prior sentiment-aware RL that adds sentiment only to the state or reward, this update rule yields more stable adaptation under nonstationarity. On Refinitiv news and NASDAQ-100 stocks, SAPPO outperforms PPO and sentimentin-state/reward baselines, increasing Sharpe from 1.67 to 2.07 and annualized return from 57% to 83% with a modest drawdown increase.*

ORAL ID 396 (03)

Mirror Descent Algorithms for Risk Budgeting Portfolios

Martin Arnaiz (*Paris 1 Panthéon-Sorbonne, France*); **Noufel Frikha** (*Paris 1 Panthéon-Sorbonne, France*); **Adil Rengim Cetingoz** (*Paris 1 Panthéon-Sorbonne, France*)

Abstract: *This paper introduces and examines numerical approximation schemes for computing risk budgeting portfolios associated to positive homogeneous and sub-additive risk measures. We employ Mirror Descent algorithms to determine the optimal risk budgeting weights in both deterministic and stochastic settings, establishing convergence along with an explicit non-asymptotic quantitative rate for the averaged algorithm. A comprehensive numerical analysis follows, illustrating our theoretical findings across various risk measures – including standard deviation, expected shortfall, deviation measures, and variantiles – and comparing the performance with that of the standard stochastic gradient descent method recently proposed in the literature.*

ORAL ID 268 (04)

Multi-scale numerical methods for control problems in continuous-time with application to optimal execution problem

Arash Fahim (*Florida State University, United States*); **Md. Arafatur Rahman** (*Citibank, United States*)

Abstract: *Optimal execution is often formulated as a simple stochastic control problem. At high trade frequencies, continuous-time modeling becomes essential. When price impact or order book resilience exhibit high-frequency oscillations, discrete-time approximations fail to capture these structures, and fine discretizations impose significant computational challenges. This work introduces a method to adaptively adjust time discretization while solving continuous-time control problems. Furthermore, we modify the approach to one that requires no time discretization. This allows for capturing oscillatory structures efficiently without the burdens of traditional fine-scale discretization.*

Reinforcement Learning and Stress-Testing in Finance - Aula F

ORAL ID 44 (01)

Robust Exploratory Stopping under Ambiguity in Reinforcement Learning

Junyan Ye (*The Chinese University of Hong Kong, Hong Kong*); **Hoi Ying Wong** (*The Chinese University of Hong Kong, Hong Kong*); **Kyunghyun Park** (*Nanyang Technological University, Singapore*)

Abstract: *We develop a continuous-time robust reinforcement learning framework for optimal stopping under ambiguity, balancing robustness and learning in an unknown environment. Ambiguity is modeled by probability measures dominated by a reference measure, allowing for misspecification of learned beliefs. Using the g-expectation framework, we recast the problem as entropy-regularized ambiguous optimal control and use Bernoulli controls to encode exploration in stopping. The optimal control is characterized by BSDEs. We prove a policy iteration theorem, implement an RL algorithm, and numerically demonstrate convergence and robustness across ambiguity and exploration levels.*

ORAL ID 49 (02)

Reinforcement Learning in Queue-Reactive Models: Application to Optimal Execution

Tomas Espana (*Princeton University, United States*); **Yadh Hafsi** (*Ecole Polytechnique, France*); **Fabrizio Lillo** (*Scuola Normale Superiore di Pisa, Italy*); **Edoardo Vittori** (*Intesa Sanpaolo, Italy*)

Abstract: *We investigate the use of RL for the optimal execution of meta-orders. Departing from traditional parametric approaches, we adopt a model-free, data-driven framework. Since policy optimization requires counterfactual feedback that historical data cannot provide, we employ the Queue-Reactive Model to generate realistic and tractable limit order book simulations. We train a Double Deep Q-Network agent on a state space comprising time, inventory, price, and depth variables, and evaluate its performance against established benchmarks. Numerical simulation results show that the agent learns a policy that is both strategic and tactical, adapting effectively to order book conditions and outperforming standard approaches.*

ORAL ID 344 (03)

One Permutation Is All You Need: Fast, Reliable Variable Importance and Model Stress-Testing

Albert Dorador (*Independent, Spain*)

Abstract: *We introduce a deterministic alternative to classical permutation-based feature importance for machine learning models in finance. By replacing repeated random permutations with a single optimal permutation, the proposed method is faster, non-random, and more stable, while preserving the core interpretation of permutation importance. Experiments across nearly 200 scenarios, including credit risk applications, show improved bias–variance tradeoffs in small samples and high-dimensional settings. We also propose Systemic Variable Importance, a stress-testing extension that models how shocks propagate through correlated features, revealing hidden dependencies and enabling transparent auditing of fairness and systemic risk.*

ORAL ID 262 (04)

Deep reinforcement learning for optimal trading with partial information

Andrea Macrì (*Scuola Normale Superiore di Pisa, Italy*); **Andrea Macrì** (*Scuola Normale Superiore di Pisa, Italy*); **Sebastian Jaimungal** (*University of Toronto, Canada*); **Fabrizio Lillo** (*Scuola Normale Superiore di Pisa, Italy*)

Abstract: *Reinforcement Learning (RL) has attracted growing interest in financial applications, yet its use for optimal trading strategies exploiting latent market information remains limited. We study an optimal trading problem in which the trading signal follows an Ornstein–Uhlenbeck process with regime-switching dynamics. We combine RL and Recurrent Neural Networks to extract latent information and derive trading strategies. We propose three DDPG-based algorithms integrating GRU networks: a one-step approach using hidden states, and two two-step methods based on regime probabilities and signal forecasts. Simulations and an empirical pair-trading application show that probabilistic regime information yields superior performance and interpretability.*

Portfolio Choice, Risk Budgeting and Marginal Utility Games - Aula P

ORAL ID 187 (01)

Risk-Budgeted Mean-Variance Portfolio

Rodrigo Targino (*Fundação Getulio Vargas (FGV), Brazil*); **Bernardo Costa** (*Fundação Getulio Vargas (FGV), Brazil*); **Raul Riva** (*Fundação Getulio Vargas (FGV), Brazil*)

Abstract: *We introduce the Risk-Budgeted Mean-Variance (RBMV) portfolio, a framework linking classical Markowitz mean-variance optimization and risk budgeting. By modifying the risk budgeting problem to incorporate constraints on expected return and volatility, RBMV provides a disciplined mechanism to balance risk concentration and return maximization. Investors can continuously tune the portfolio's proximity to either paradigm according to preferences. We show the resulting optimization problem is convex and efficiently solvable. In long-only settings, RBMV typically achieves competitive returns with lower risk concentration. An empirical study using U.S. equity returns shows effective volatility control and Sharpe ratios consistently exceeding those of mean-variance portfolios.*

ORAL ID 419 (02)

Exponential investments when prices are mean reverting

Balazs Hoffmann (*Eötvös Lorand University, Hungary*)

Abstract: *Temporary price fluctuations with sublinear mean reversion lead highly risk-averse investors to adopt horizon-dependent market-timing exposures, but the underlying diffusion becomes technically delicate when the mean-reverting drift is only Hölder continuous. In a market where the risky asset satisfies* $dS_t = \mu dt + dX_t$ *and* $dX_t = -\alpha \mathrm{sgn}(X_t)|X_t|^\beta dt + dB_t$ *with* $0 < \beta < 1$*, we show that no admissible strategy can achieve a certainty equivalent with order exceeding* $T^{2\beta+1}$ *when* $\mu \neq 0$*. We also construct a smoothed feedback strategy that attains this optimal order, with risk-taking declining over time as a power of the remaining horizon determined by* β*.*

ORAL ID 333 (03)

Optimal Portfolio Choice with a Cumulative Financed-Emissions Penalty: A Carbon-Intensity Factor Model

Olivier Féron (*Électricité de France (EDF), France*); **Ruben Haalebos** (*CREST, ENSAE, Institut Polytechnique de Paris, France*); **Ruben Haalebos** (*CREST, ENSAE, Institut Polytechnique de Paris, France*)

Abstract: *We study a continuous-time portfolio choice for an investor who aims to reduce portfolio financed greenhouse-gas emissions. Instead of hard constraints, terminal wealth is penalized by cumulative financed emissions over the horizon. With carbon intensities following mean-reverting Ornstein–Uhlenbeck dynamics, the problem becomes a tractable intensity factor model. Solving the HJB yields optimal weights in closed form up to a Riccati ODE. The policy is Merton-like, featuring an intensity-based drift discount and, under return–intensity correlation, an intertemporal hedging demand. We calibrate the penalty to meet a cumulative-emissions budget, interpreting it as an investor-specific internal carbon price.*

ORAL ID 505 (04)

The Game of Marginal Utilities

Isaac Sonin (*UNC at Charlotte, NC, United States*); **Yaakov Malinovsky** (*University of Maryland, Baltimore County, Baltimore, MD 21250, United States*); **Georgy Gaitsgori** (*Department of Mathematics, Columbia University, New York, NY 10027, United States*)

Abstract: *We describe a noncooperative, nonzero-sum game of* m *players, holding resources* $r_j, j = 1, 2, \dots, m$*. Player* j *allocates her resources according to the vector* $x^j = (x_i^j$*, among* n *projects characterized by parameters* $a_i, a_1 > \cdots > a_n > 0$*. The goal of player* j *is to maximize her return (profit), defined by*

$$\sum_{i=1}^{n} f_i^j(x^1, \dots, x^m) = \sum_{i=1}^{n} \frac{a_i x_i^j}{1 + \sum_{k=1}^{m} x_i^k}.$$

The key to solving this problem is the use of one of the most fundamental principles in economics, the so-called Equimarginal principle. We prove that the game has a unique Nash equilibrium and describe its structure.

Blockchain, Robo-Advisory and DeFi Markets - Aula Q

ORAL ID 237 (01)

Mempool: The Antechamber to the Blockchain

Josiah Baker (*Bitcoin Core, United States*); **Paolo Guasoni** (*Dublin City University, Italy*); **Gur Huberman** (*Columbia University, Israel*); **Clara Shikhelman** (*ChainCode Labs, Israel*); **Brian Timoney** (*Dublin City University, Ireland*)

Abstract: *Exploring a novel dataset that records the arrival of bitcoin transactions to nodes' mempools, this paper examines the statistical properties of blocks and transactions. Blocks are mined according to a Poisson process, as per protocol's design. Transaction sizes vary considerably, with a standard deviation several times its mean. Transaction arrivals exhibit significant daily and weekly seasonality, with peaks at UTC noon and midweek and troughs at UTC night and during weekends. Aggregating mempool flows in eight hour periods, a five-parameter seasonal ARIMA model explains over 60% of the variance in next-period flows, highlighting the high autocorrelation of flows over time.*

ORAL ID 281 (02)

PreFER: Interactive Robo-Advisor with Scoring Mechanism

Yuwei Wang (*Shanghai University of Finance and Economics, China*); **Hoi Ying Wong** (*The Chinese University of Hong Kong, Hong Kong*)

Abstract: *We propose an inverse reinforcement learning (IRL) framework that learns personalized investment advice using client-provided scores. At each interaction, the robo-advisor generates investment advice from the optimal policy distribution derived from an inferred personalized risk preference (PRP), receives a score, and updates the PRP dynamically. This motivates the study of discrete-time Predictable Forward Exploratory Reward (PreFER) processes and associated exploratory policies. Interpreting scores as acceptance probabilities, our IRL algorithm learns the client's exploratory policy via von Neumann's acceptance–rejection method. We show that the client's risk aversion can be consistently identified despite noisy feedback, and characterize its evolution through PreFER processes.*

ORAL ID 478 (03)

Economics of Decentralization and Resilience: Hydra and Connectivity Tradeoffs

Nazem Khan (*University of Oxford, United Kingdom*); **Paolo Guasoni** (*Dublin City University, Italy*); **Yufei Zhang** (*Imperial College London, United Kingdom*)

Abstract: *We study the cost of maintaining decentralized connectivity in large networks when links are costly and nodes may fail. Requiring that every pair of nodes is connected by* d *short, internally disjoint paths, and node degrees are nearly balanced, we give an explicit construction (Hydra) which minimizes the maximum degree up to a small additive gap and achieves the minimal asymptotic number of links. The resulting edge count scales on the order of* $\mathrm{n}\log\mathrm{n}$*, quantifying how decentralization raises connectivity costs relative to hub-based designs.*

ORAL ID 412 (04)

Liquid Staking: When Does It Help?

Sylvain Carré (*Université Paris 1 Panthéon-Sorbonne, France*); **Franck Gabriel** (*Université Claude Bernard Lyon 1, France*)

Abstract: *Liquid staking allows to redeploy traditionally locked capital and is thus promoted for its "capital efficiency". In the context of DeFi lending, we use a tractable general equilibrium model to determine whether liquid staking is, indeed, desirable. While in the no-friction case, the capital efficiency story holds, two natural frictions can revert this result. First, when security is endogenous, liquid staking can worsen welfare; only if the pool's interest rate mechanism is optimally adjusted can one back up the capital efficiency story. Second, even at the optimally adjusted rate, liquid staking can worsen welfare at low levels of investor competition.*

Numerical and Analytical Methods for Stochastic Finance - Aula H

ORAL ID 414 (01)

On Iterated Lorenz Curves with Applications: The Multivariate Case

Vilimir Yordanov (*FAM @ TU Wien, Vienna, Austria, Austria*)

Abstract: *A Lorenz curve, derived from the distribution function of a random variable, can itself be viewed as a distribution function. Our previous work demonstrated that, regardless of the initial variable, iterating this map leads to non-corner case convergence toward a power-law distribution. This paper generalizes the result to the multivariate setting. We establish that under reasonable restrictions, the marginals converge uniformly to independent power-law distributions with an exponent equal to the golden section. The map can be interpreted as a probability mass redistribution process. Finally, we provide relevant applications in quantitative finance to demonstrate the practical utility of the findings.*

ORAL ID 397 (02)

Time integrals under the Black-Scholes-Merton and Margrabe economies

José Carlos Dias (*ISCTE-IUL and BRU-IUL, Portugal*); **Mark Shackleton** (*Lancaster University, United Kingdom*); **Fernando Silva** (*ISCTE-IUL and BRU-IUL, Portugal*); **Rafal Wojakowski** (*University of Surrey, United Kingdom*)

Abstract: *Integrating the Black and Scholes (1973) and Merton (1973) (BSM) formula with respect to time is central in economics. Inspired by real options theory, Shackleton and Wojakowski (2007) derive analytic formulae for valuing finite-maturity caps and floors contingent on continuous lognormal flows. Equivalent closed-form solutions are proposed in Dias et al. (2024b) using a direct approach that bypasses real options intuition. This paper further extends and simplifies time-integration under BSM and provides a new closed-form solution for the Margrabe (1978) economy, enabling broader analytical applications.*

ORAL ID 294 (03)

Weak Error Rates for Local Stochastic Volatility Models

Peter K. Friz (*Technische Universitat Berlin, Germany*); **Benjamin Jourdain** (*Ecole des Ponts ParisTech - CERMICS, France*); **Thomas Wagenhofer** (*Technische Universitat Berlin, Germany*); **Alexandre Zhou** (*Qube Research and Technologies, Singapore*)

Abstract: *Local stochastic volatility refers to a popular model class in applied mathematical finance that allows for "calibration-on-the-fly", typically via a particle method. While well-posedness of the equation remains a largely open problem, our take is to start with a well-defined Euler approximation. We then establish a novel half-step-scheme that allows for good approximations of conditional expectations. After introducing a regularisation parameter, we formulate an interacting particle system. Assuming a solution to the original problem exists, by a mimicking argument we then quantify the weak error rate of the particle system with respect to all parameters used.*

ORAL ID 217 (04)

Polynomial approximation of discounted moments

Peter Spreij (*University of Amsterdam, Netherlands*); **Chenyu Zhao** (*Blackrock, United States*); **Misha Van Beek** (*Bayesline, United States*); **Makhtar Ba** (*Blackrock, United States*)

Abstract: *We introduce an approximation method for the discounted moments of a stochastic process that can approximate the true moments for a large class of problems in pricing formulas of financial products such as bonds and credit derivatives. The approximation relies on a high-order power series expansion of theinfinitesimal generator. In applications that allow an analytical solution, the approximation error decreases to around 10 to 100 times machine precision for higher orders. When no analytical solution exists, we numerically compare the approximation with existing numerical techniques. Joint work with Chenyu Zhao, Misha van Beek, and Makhtar Ba.*

Credit Risk, Climate Transition and Decentralized Finance - Aula I

ORAL ID 15 (01)

Modeling Credit Cycle Index for Loan Loss Forecasting

Steven Zhu (*Fordham University, United States*)

Abstract: *The estimation of future loan losses is not only important for the financial institutions to effectively control the credit risk of commercial loan portfolio, but also an essential component in the capital plan submitted for regulatory approval in the annual stress testing3. This paper describes a methodology of modeling the credit cycle index and estimating the point-in-time (PIT) default and rating migration probabilities based on credit cycle index under macro-economic scenarios. The modeling approach is designed to capture the credit risk concentration at the region and industry sector levels for effective stress testing and risk management of credit portfolios.*

ORAL ID 161 (02)

Clients, employees and institutional owners: Determinants of corporate decarbonisation commitments?

Ifigeneia Paliampelou (*University of Bamberg, Germany*); **Frank Schiemann** (*University of Bamberg, Germany*); **Andreas Hoepner** (*University College Dublin, Ireland*)

Abstract: *Decarbonisation commitments are an important communication tool for companies to explain how and in which period they plan to reduce carbon emissions. At the same time, such commitments might be costly because firms can be held accountable if the targets are not achieved. This raises the question: who or what motivates firms to make decarbonisation commitments? We examine the determinants of corporate decarbonisation commitments, focusing on stakeholder pressures from institutional owners, employees and clients. Using survival analysis with Weibull and Cox models, the findings highlight that institutional ownership (IO) has the strongest relation to decarbonisation commitments, followed by employees.*

ORAL ID 469 (03)

Cournot Games and the Economics of Blockchain Transaction Validation

Sveinn Olafsson (*Stevens Institute of Technology, United States*)

Abstract: *Validation of blockchain transactions takes the form of a* Cournot game, *characterized by an* aggregator, *determining how agents are incentivized based on aggregate effort. By employing a novel limiting approach, we establish existence and uniqueness of equilibrium in Cournot games with unbounded payoff functions, which are standard in blockchain economics, but not covered by any of the classical results in game theory. Furthermore, we show how our results apply to Cournot games arising in other emerging areas of decentralized finance, such as the design of decentralized exchanges, and cutting-edge proposals to support decentralization in the blockchain transaction pipeline.*

ORAL ID 367 (04)

When defaults cannot be hedged: an actuarial approach to xVA calculations via local risk-minimization

Francesca Biagini (*University of Munich, Germany*); **Alessandro Gnoatto** (*Università degli studi di Verona, Italy*); **Katharina Oberpriller** (*University of Munich, Germany*)

Abstract: *We consider the pricing and hedging of counterparty credit risk and funding when there is no possibility to hedge the jump to default of either the bank or the counterparty. This represents the situation which is most often encountered in practice, due to the absence of quoted corporate bonds or CDS contracts written on the counterparty and the difficulty for the bank to buy/sell protection on her own default. We apply local risk-minimization to find the optimal strategy and compute it via a BSDE.*

Poster Abstracts

Pricing Model for Path-Dependent American Options Using Tensors

Kensuke Kato (*SMBC, Japan*)

Abstract: *We propose a tensor-based pricing framework for path-dependent American options with a single underlying asset. Such options combine path dependence and early exercise features, making analytical valuation difficult and conventional numerical methods inefficient. The key idea is to represent path-dependent state variables as tensor objects defined on a binomial lattice. By associating each possible path with tensor elements and applying backward induction over the tensor structure, the proposed framework enables systematic valuation of general path-dependent American options. Numerical experiments on American lookback put options demonstrate stable pricing performance and improved computational efficiency, enhanced by control variates.*

Time-Dependent Mean Reversion in Hawkes-Based Heston Models

Maren Dück (*Justus Liebig University, Germany*); **Ludger Overbeck** (*Justus Liebig University, Germany*)

Abstract: *Hawkes processes provide a microstructural foundation for stochastic volatility models such as the Heston model and its rough extensions. We study how exogenous market changes can be incorporated at the microscopic level and how they affect macroscopic volatility dynamics. Starting from nearly unstable Hawkes processes with a time-dependent exogenous intensity $\mu(t)$, we show that the rescaled intensity converges to a Heston-type stochastic volatility model with a time-dependent mean reversion level, while the diffusion structure is preserved. This yields a structural explanation for non-stationary long-run variance, and extends naturally to the rough Heston setting.*

Tackling estimation risk in Kelly investing using options

Fabrizio Lillo (*Scuola Normale Superiore di Pisa, Italy*); **Piero Mazzarisi** (*University of Siena, Italy*); **Ioanna-Yvonni Tsaknaki** (*Scuola Normale Superiore di Pisa, Italy*)

Abstract: *The Kelly criterion provides a general framework for optimizing the growth rate of an investment portfolio over time by maximizing the expected logarithmic utility of wealth. However, the optimality condition of the Kelly criterion is highly sensitive to accurate estimates of the probabilities and investment payoffs. Estimation risk can lead to greatly suboptimal portfolios. In a simple binomial model, we show that the introduction of a European option in the Kelly framework can be used to construct a class of growth optimal portfolios that are robust to estimation risk.*

Time-Consistent Optimized Certainty Equivalent: Primal–Dual Theory, Properties, and Explicit Solutions

Hideki Iwaki (*Tokyo University of Science, Japan*)

Abstract: *We study a time-consistent extension of the Optimized Certainty Equivalent (OCE) of Ben-Tal and Teboulle (2007) that allows different discounting of certain and uncertain components. We develop a primal variational formulation and derive a robust dual representation via Fenchel conjugacy. Fundamental properties—monotonicity, concavity, law invariance, continuity, and primal–dual consistency—are established. Closed-form solutions are provided for exponential, logarithmic, and power utilities. The framework integrates time preferences into risk measurement, capturing economically relevant situations where certainty and risk are discounted differently over time.*

Decomposing synchronous and noisy components in market of Green and Sustainable Stocks

Stanisław Drozdz (*Polish Academy of Sciences, Poland*); **Milena Kojic** (*Florida International University, United States*); **Jarosław Kwapien** (*Polish Academy of Sciences, Poland*); **Marcin Wątorek** (*Cracow University of Technology, Poland*)

Abstract: *Understanding correlation structures in green and sustainable equity markets is essential for assessing diversification potential and systemic risk. Random Matrix Theory is applied to daily returns of 58 U.S. green and sustainable stocks over 2022–2025 to decompose empirical correlations into collective and noise components. A dominant eigenvalue captures 25–40% of total variance, reflecting market-wide synchronization, while two additional eigenvalues identify sector-specific dynamics in Utilities/Energy and High-Tech stocks. The remaining spectrum follows random matrix predictions. Overall, green stocks form a coherent complex system with limited effective degrees of freedom, implying constrained diversification and pronounced co-movement during stress periods.*

Closed-Form Solutions for Partial Double Barrier Options

Yeji Kim (*Gyeongsang National University, South Korea, Korea, Republic of*); **Doobae Jun** (*Gyeongsang National University, South Korea, Korea, Republic of*)

Abstract: *This paper studies partial double barrier options (PDBOs) with two constant boundaries. We classify PDBOs into two types according to the monitoring structure: early-ending PDBOs, whose monitoring starts at inception and ends prior to maturity, and forward-starting PDBOs, whose monitoring starts at a prespecified time before maturity and continues until maturity. We derive closed-form pricing formulas for both types. We further verify the formulas by showing convergence to the standard vanilla and standard double-barrier option prices as limiting cases when the monitoring period is shifted. The results provide an efficient tool for the valuation and hedging of complex path-dependent options.*

Recovering the Physical Measure from Options: A Non-Parametric Approach with Economic Constraints

Niccolò Bagnoli (*ESADE Business School, Ramon Llull University, Spain*); **Carlo Sala** (*ESADE Business School, Ramon Llull University, Spain*)

Abstract: *We propose a non-parametric approach to recovering the physical measure from options without directly estimating the pricing kernel. Instead, we begin with the empirical risk-neutral measure derived from option prices and project it onto a set of economically plausible densities, ensuring adherence to fundamental economic constraints. By leveraging the Wasserstein metric, our method preserves the structural relationships between probability distributions, ensuring theoretical consistency with observed option data while providing a flexible reconstruction of the physical measure. We find that enforcing pricing-kernel monotonicity and variance capping is sufficient to recover an economically plausible distribution.*

How Patterns Dictate Learnability in Sequential Data

Mario Morawski (*Université Paris Dauphine PSL, France*); **Anaïs Després** (*Université Paris-Saclay, France*)

Abstract: *Efficient modeling of sequential data requires distinguishing between model limitations and intrinsic data unpredictability. We introduce a unified information-theoretic framework based on* predictive information *and the* universal learning curve *to quantify learnability. We derive a theoretical bound on the minimal achievable prediction risk, establishing a fundamental limit imposed by temporal patterns. Building on this, we propose a practical estimator to benchmark model performance against this intrinsic limit. Our experiments demonstrate that this framework accurately assesses model adequacy, revealing whether prediction errors stem from architectural constraints or the data's inherent stochastic nature.*

Computing the Implied Volatility through Neural Networks with Asymptotic Regimes

Samira Amiriyan (*University of Liverpool, United Kingdom*); **Youness Boutaib** (*University of Liverpool, United Kingdom*)

Abstract: *The accurate computation of implied volatility (IV) is fundamental in financial modelling, particularly for option pricing. Recent works used neural networks (NN) to estimate IV, often for model calibration, but such methods struggle in extreme regimes, including very large or small strikes and maturities. We propose a novel approach combining the universal approximation capability of NN with structural properties of IV surfaces. Inspired by Jäckel's approach, the price–log-moneyness domain is partitioned into three regions, with the NN learning a partition of unity and local IV approximations. Numerical experiments demonstrate superior accuracy and generalisation compared with asymptotic formulas and classical NN.*

The Probability Distribution Function of a Call Option

Michele Bogliardi (*International Resources Holding, United Arab Emirates*); **Zoubida Charif Khalifi** (*International Resources Holding, United Arab Emirates*); **Yerkin Kitapbayev** (*Khalifa University of Science and Technology, United Arab Emirates*); **Giulio Occhionero** (*International Resources Holding, United Arab Emirates*); **Jorge Zubelli** (*Khalifa University of Science and Technology, United Arab Emirates*); **Maria Latifa Benkhalifa** (*Khalifa University of Science and Technology, United Arab Emirates*)

Abstract: *This paper presents a novel framework for modeling the probability distribution of derivative payoffs, shifting the analytical focus from the underlying asset to the derivative contract itself. The approach makes no approximations, introduces no free parameters, and initially assumes Geometric Brownian Motion, an assumption later relaxed. The central insight is that, given a probability distribution for the underlying asset, the distribution of any dependent derivative is fully determined by its payoff function, leaving no room for alternative analytical expressions.*

On the First Hitting Time Problem for General Diffusions: Local Time-Space Approach

Danila Shabalin (*Lomonosov Moscow State University, Russian Federation*); **Jerome Detemple** (*Boston University, United States*); **Yerkin Kitapbayev** (*Khalifa University of Science and Technology, United Arab Emirates*)

Abstract: *Using the Peskir (2005) local time-space calculus, we derive a new integral equation for the distribution of the first passage time of a diffusion process to a time-dependent barrier. An algorithm for numerical computation is proposed and implemented in the context of specific examples, including time-inhomogeneous Wiener, Bessel, CEV, Ornstein-Uhlenbeck and Feller processes. Convergence properties are established. Extensions to double barrier problems and to stochastic volatility models are carried out.*

Integrated Risk Assessment for Photovoltaic Energy Production: Climate Uncertainty, Market Exposure, and Derivative-Based Hedging

Lucas Prates (*NA, Italy*)

Abstract: *The growing penetration of photovoltaic generation exposes solar power producers (SPP) to compounding financial risks: volumetric risk, driven by the variability of solar irradiance and temperature-dependent efficiency losses, and revenue risk, arising from price cannibalization during peak solar generation hours. Since existing hedging instruments primarily address conventional price exposure, this work proposes an integrated framework combining stochastic irradiance modeling, climate-scenario analysis under RCP pathways, future PV penetration trajectories, and derivative-based hedging strategies calibrated to incomplete markets. The framework translates compounded physical and market uncertainty into actionable risk metrics, supporting more resilient investment and operational decisions for SPP.*