London-Paris Bachelier Workshop

September 19 –20, 2024, Amphi Hermite, IHP, Paris.

Thursday 19th September

2pm – 2:30pm **Charles-Albert LEHALLE**, Ecole polytechnique, Paris.

Title : Synthetic Data Generation For Portfolios Optimisation: Traps and counter measures.

Abstract : There are already a dozen of papers dedicated to generating synthetic data for portfolio optimization, ranging from risk-replicating methods for derivative pricing to those similar to Markowitz's ones. The goal of this talk is to identify the main mathematical reasons of the complexity of this generative task: first the available sample is often small, and generating more data than what is available can provide a false sentiment of confort, second I will show why the standard distance used by GANs is not adequate for portfolio construction that involves hedging of large variance components (that is often the case). I will make my best to show where the memory should be located in the generate processes to provide meaningful results. Last but not least, I will discuss that generating more than one time series can be needed, even to estimate a L-statistic (like a VaR or ES) on a one dimensional index. Finally, I will review the key features of the existing papers and present preliminary results from a work with Rengim Cetingoz on a new generative model designed to address many of these challenges.

2:30pm – 3pm **Camilo GARCIA TRILLOS**, University College London.

Title : A Conjugate Approach to solve a Stochastic Abatement Problem.

Abstract : We consider a stochastic pollution abatement model where we set ourselves to satisfy certain environmental constraints with a high probability (e.g. satisfying the Paris agreement limit on global warming). The framework is reminiscent of the well-studied quantile hedging problem and can also be recast in terms of a stochastic target model. However, we focus on the special case where only the drift is controlled. Our main result shows that the solution can be obtained by optimizing over a family of associated conjugate problems, which can be addressed using Backward Stochastic Differential Equations (BSDEs). Additionally, we discuss how this connection can be leveraged to design effective numerical methods for solving our main problem. This is a joint work with Yuxuan Wang.

3pm – 3:30pm **Yating LIU**, Paris Dauphine University.

Title : A statistical approach for simulating the density solution of a McKean-Vlasov equation.

Abstract : We prove convergence results of the simulation of the density solution to the McKean-Vlasov equation, when the measure variable is in the drift. Our method builds upon adaptive nonparametric results in statistics that enable us to obtain a data-driven selection of the smoothing parameter in a kernel-type estimator. In particular, we give a generalised Bernstein inequality for Euler schemes with interacting particles and obtain sharp deviation inequalities for the estimated classical solution. We complete our theoretical results with a systematic numerical study and gather empirical evidence of the benefit of using high-order kernels and data-driven smoothing parameters. This is a joint work with M. Hoffmann.

3:30pm – 4pm **David ITKIN**, London School of Economics and Political Science.

Title : Robust Maximization of Growth with Stochastic Factors and Price Stability.

Abstract : We consider a robust growth problem under model uncertainty and in the presence of both price stability and (non-Markovian) stochastic covariance. Building on previous work of Kardaras & Robertson we fix two inputs representing the instantaneous covariation and invariant density for the asset process, but additionally allow these quantities to depend on the stochastic factor process. Our main result establishes that, under mild technical conditions, the optimal strategy is given in feedback form by the gradient of a function that solves a certain elliptic PDE. Remarkably, this function (and hence the optimal strategy) does not depend on the stochastic factor. This provides a comprehensive answer to a question proposed by Fernholz in 2002 in the framework of Stochastic Portfolio Theory. We give two financial interpretations for this result and consider some examples. This talk is based on joint work with Benedikt Koch, Martin Larsson and Josef Teichmann.

4pm - 4:30pm **Break**

4:30pm – 4.50pm **Jiajie TAO**, University College London.

Title : High Rank Path Development: an approach of learning the filtration of stochastic processes.

Abstract : Since the weak convergence for stochastic processes does not account for the growth of information over time which is represented by the underlying filtration, a slightly erroneous stochastic model in weak topology may cause huge loss in multi-periods decision making problems. To address such discontinuities, Aldous introduced the extended weak convergence, which can fully characterise all essential properties, including the filtration, of stochastic processes; however, it was considered to be hard to find efficient numerical implementations. In this paper, we introduce a novel metric called High Rank PCF Distance (HRPCFD) for extended weak convergence based on the high rank path development method from rough path theory, which also defines the characteristic function for measure-valued processes. We then show that such HRPCFD admits many favourable analytic properties which allows us to design an efficient algorithm for training HRPCFD from data and construct the HRPCF-GAN by using HRPCFD as the discriminator for conditional time series generation. Our numerical experiments on both hypothesis testing and generative modelling validate the out-performance of our approach compared with several state-of-the-art methods, highlighting

its potential in broad applications of synthetic time series generation and in addressing classic financial and economic challenges, such as optimal stopping or utility maximisation problems.

4.50pm – 5:10pm **Alicia BASSIERE**, LGI, Centrale-Supélec, Université Paris-Saclay.

Title : A mean-field game of electricity market dynamics

Abstract : The global electricity sector's environmental transition has led to significant growth in wind and solar capacity and a decline in coal-based generation. However, this shift has also caused lower baseload electricity prices, impacting the profitability of conventional producers, and increased peakload price volatility, making the system more reliant on natural gas. This paper proposes a long-term model using a mean-field game (MFG) approach to describe the electricity industry's dynamics, focusing on gas as a substitute for coal. This paper extends the recent contribution [Aid, Dumitrescu, and Tankov, "The entry and exit game in the electricity markets: A mean-field game approach," Journal of Dynamics & Games 8.4 (2021): 331] in several ways, making the model much more realistic, especially for describing the medium-term impacts of energy transition on electricity markets. We also present a central planner counterpart using mean-field control (MFC) and demonstrate their equivalence. A case study calibrated on German data examines the impact of environmental policies. Our results show that without policies, gas power plants meet rising demand, leading to higher gas and electricity prices. A carbon tax eliminates coal plants by 2030 and encourages renewables, though it raises long-term electricity prices. Renewable subsidies promote wind power initially but are less effective beyond a certain threshold.

5:10pm – 5:30pm **Yueying SUN**, Department of Mathematics, London School of Economics and Political Science.

Title : Mandate Models and the Inelastic Market Hypothesis.

Abstract : Macroeconomic allocations in and out of the equity market lead to surprisingly large impacts on stock valuations. Gabaix and Koijen study this phenomenon and provide a theoretical framework to explain the observed price inelasticity. They assume that financial agents are constrained in their investment strategies and are subjected to a mandate that prescribes their investment allocations. Here we develop a rigorous framework of a mandate model for a representative agent and provide precise conditions under which the stock valuation dynamics are well-defined. We also explore the aggregation of mandate functions from two distinct mixed funds, each with distinct mandate function. The focus is on whether such aggregate mandate function exists and can still yield a nice behaving equilibrium. While our analysis concerns two mixed funds, a successful aggregation here implies potential scalability to systems with multiple mixed funds. This is a joint work with my supervisor Johannes Ruf.

5:30pm – 5:50pm **Timothée FABRE**, Laboratoire MICS, Centrale Supélec and SUN ZU Lab.

Title : Learning the Spoofability of Limit Order Books With Interpretable Probabilistic Neural Networks.

Abstract : This paper investigates the detection of spoofing activity in small tick limit order books, focusing on cryptocurrency centralized exchanges. Inspired by the literature on Hawkes processes applied to market microstructure, we introduce novel order flow variables which incorporate not only the size of limit orders but also their distance of placement in the order book. Using a market-by-order data set, we compute

these features over observed limit orders, and we build a neural network model adapted to the prediction of the probability distribution of price movements. Our empirical analysis highlights the critical role that the distance of limit orders plays in the price formation process. Building on these insights, we develop a spoofing detection framework where an agent uses a cost function to identify opportunities of profitable market manipulation. Strikingly, our model indicates that spoofing the best quote is a poor decision. The proposed detection algorithm is adapted to deployment in live trading environments, where it demonstrates significant effectiveness in identifying suspicious trading activity. This work contributes to enhancing market integrity by providing a robust tool for monitoring and mitigating spoofing in both cryptocurrency exchanges and traditional financial markets.

5:50pm – 6:20pm **Teemu PENNANEN**, King's College London.

Title : Dynamic programming and duality in convex stochastic optimization.

Abstract : We study a general class of convex stochastic optimization (CSO) problems that unifies many common problem formulations from operations research, financial mathematics and stochastic optimal control. We extend the theory of dynamic programming and convex duality to allow for a unified and simplified treatment of various special problem classes found in the literature. In particular, we establish the existence of solutions to Bellman equations under quite general conditions that cover many instances of e.g. Markov decision processes where measurability questions are difficult in general. In addition, we establish the existence of primal solutions and the absence of a duality gap without compactness or boundedness assumptions. In the context of financial mathematics, the relaxed assumptions are satisfied under the well-known no-arbitrage condition and the reasonable asymptotic elasticity condition of the utility function. The existence of dual solutions is established in the general format under conditions that extend those given by Rockafellar and Wets for stochastic problems of Bolza. The extended theory allows also for significant generalizations to existing problem formulations in financial mathematics and elsewhere. This is joint work with Ari-Pekka Perkkio.

Friday 20th September

9am – 9:30am **Peter TANKOV**, CREST, ENSAE-IP Paris.

Title : Optimal stopping and divestment timing under scenario ambiguity and learning.

Abstract : Aiming to analyze the impact of environmental transition on the value of assets and on asset stranding, we study optimal stopping and divestment timing decisions for an economic agent whose future revenues depend on the realization of a scenario from a given set of possible futures. Since the future scenario is unknown and the probabilities of individual prospective scenarios are ambiguous, we adopt the smooth model of decision making under ambiguity aversion of Klibanoff et al (2005), framing the optimal divestment decision as an optimal stopping problem with learning under ambiguity aversion. We then prove a minimax result reducing this problem to a series of standard optimal stopping problems with learning. The theory is illustrated with two examples: the problem of optimally selling a stock with ambigous drift, and the problem of optimal divestment from a coal-fired power plant under transition scenario ambiguity.

9:30am – 10am **Laura BALLOTA**, Bayes Business School.

Title : Multivariate Additive Subordination with Applications in Finance.

Abstract : We introduce a tractable multivariate pure jump process in which the trading time is described by an additive subordinator. The multivariate process retains the additivity property, and therefore is time inhomogeneous, i.e., its increments are independent but nonstationary. We provide the theoretical framework of our process, perform a sensitivity analysis with respect to the time inhomogeneity parameters, and design a Monte Carlo scheme to simulate the trajectories of the process. We then employ the model in the context of option pricing in the FX market. We take advantage of the specific features of currency triangles to extract the joint dynamics of FX log-rates. Extensive tests based on observed market data show that our model outperforms well established pure jump benchmarks. This is joint work with Giovanni Amici and Patrizia Semeraro.

10am – 10:30am **Cyril BENEZET**, LaMME, ENSIIE, UEVE UPS.

Title : Learning conditional distributions on continuous spaces.

Abstract : We investigate sample-based learning of conditional distributions on multi-dimensional unit boxes, allowing for different dimensions of the input and output spaces. Our approach involves grouping data near varying query points in the input space to create empirical measures in the output space. We employ two distinct grouping methods: one based on a fixed-radius ball and the other on nearest neighbors. We establish upper bounds for the convergence rates of both methods and, from these bounds, deduce optimal configurations for the radius and the number of neighbors. We propose to incorporate the nearest neighbor method into neural network training, as our empirical analysis indicates an improvement in accuracy. For efficiency, the training process utilizes approximate nearest neighbor search with random binary space partitioning. Additionally, it employs the Sinkhorn algorithm and a sparsity-enforced transport plan. Our empirical findings demonstrate that, with a suitably designed structure, the neural network has the ability to adapt to a suitable level of Lipschitz continuity locally. This is a joint work with Ziteng Cheng and Sebastian Jaimungal.

10:30am – 11am **Break**

11am – 11:20am **Natascha HEY**, Ecole Polytechnique & CFM.

Title : Trading with Concave Cross-Impact and Impact Decay.

Abstract : This paper investigates concave cross-impact models with impact decay, focusing on conditions that rule out price manipulation. By formulating the profit and loss (PnL) in terms of alpha and Impact, we solve a first instance of a concave cross-impact model. To prove applicability we present the first empirical fit of an arbitrage free instance. Our results demonstrate that without manipulation constraints, the phase space of models expands significantly. The empirical results confirm that cross-impact is, first, high when correlations are strong and, second, asymmetric when liquid assets impact illiquid ones.

11:20am – 11:40am **Waleed TAOUM**, King's College London.

Title : Statistical modeling of SOFR term structure.

Abstract : SOFR derivatives market is still illiquid and incomplete so it is not amenable to classical risk-neutral term structure models which are based on the assumption of perfect liquidity and completeness. We develop a statistical SOFR term structure model that is well-suited for risk management and derivatives pricing within the incomplete markets paradigm. The model incorporates relevant macroeconomic factors that drive central bank policy rates which, in turn, cause random jumps often observed in the SOFR rates. The model is easy to calibrate to historical data, current market quotes, and the user's views concerning the future development of the relevant macroeconomic factors. The model is illustrated by indifference pricing of SOFR derivatives. This is joint work with Teemu Pennanen.

11:40am – 12am **Nathan De CARVALHO**, LPSM, Université Paris Cité.

Title : Trading with propagators and constraints: applications to optimal execution and battery storage.

Abstract : Motivated by optimal execution with stochastic signals, market impact and constraints in financial markets, and optimal storage management in commodity markets, we formulate and solve an optimal trading problem with a general propagator model under linear functional inequality constraints. The optimal control is given explicitly in terms of the corresponding Lagrange multipliers and their conditional expectations, as a solution to a linear stochastic Fredholm equation. We propose a stochastic version of the Uzawa algorithm on the dual problem to construct the stochastic Lagrange multipliers numerically via a stochastic projected gradient ascent, combined with a least-squares Monte Carlo regression step to approximate their conditional expectations. We illustrate our findings on two different practical applications with stochastic signals: (i) an optimal execution problem with transient impact, with either a 'no-shorting' constraint in the presence of a 'sell' signal or a 'no-buying' constraint in the presence of a 'buy' signal; (ii) a battery storage problem with seasonal signals and constraints on both the charging power and the load capacity of the battery.

12pm – 12:30pm **Philippe BERGAULT**, Université Paris Dauphine-PSL.

Title: Mean Field Games in a Stackelberg problem with an informed major player.

Abstract : We investigate a stochastic differential game in which a major player has a private information (the knowledge of a random variable), which she discloses through her control to a population of small players playing in a Nash Mean Field Game equilibrium. The major player's cost depends on the distribution of the population, while the cost of the population depends on the random variable known by the major player. We

show that the game has a relaxed solution and that the optimal control of the major player is approximatively optimal in games with a large but finite number of small players. Joint work with Pierre Cardaliaguet and Catherine Rainer.

2pm – 2:30pm **Laurence CARASSUS**, MICS, Centrale-Supélec, Université Paris-Saclay.
Title : No free lunch for markets with multiple numeraires.
Abstract : We consider a new framework, that of a global market with a finite number of submarkets, where there is a tradable numéraire for each submarket, but no tradable numéraire for the global market. Under a global no arbitrage condition, we show the existence of a common density from which equivalent (local) martingale measures are constructed for each submarket. We also introduce several super-replication prices, depending on the chosen type of hedging: on the global market, on a given submarket or on all submarkets separably. We prove duality results on these prices that allow to assess differences in characteristics between the submarkets, such as liquidity or credit quality. The results are applied in concrete situations, in particular in a Brownian setup.

2:30pm – 2:50pm **Ruben WIEDEMANN**, Imperial College London.
Title : Operator Deep Smoothing for Implied Volatility.
Abstract : We devise a novel method for implied volatility smoothing based on neural operators. The goal of implied volatility smoothing is to construct a smooth surface that links the collection of prices observed at a specific instant on a given option market. Such price data arises highly dynamically in ever-changing spatial configurations, which poses a major limitation to foundational machine learning approaches using classical neural networks. While large models in language and image processing deliver breakthrough results on vast corpora of raw data, in financial engineering the generalization from big historical datasets has been hindered by the need for considerable data pre-processing. In particular, implied volatility smoothing has remained an instance-by-instance, hands-on process both for neural network-based and traditional parametric strategies. Our general operator deep smoothing approach, instead, directly maps observed data to smoothed surfaces. We adapt the graph neural operator architecture to do so with high accuracy on ten years of raw intraday S&P 500 options data, using a single set of weights. The trained operator adheres to critical no-arbitrage constraints and is robust with respect to subsampling of inputs (occurring in practice in the context of outlier removal). We provide extensive historical benchmarks and showcase the generalization capability of our approach in a comparison with SVI, an industry standard parametrization for implied volatility.

2:50pm – 3:10pm **Anna De CRESCENZO**, LPSM, Université Paris Cité.
Title: Nonlinear Graphon mean-field systems.
Abstract : We address a system of weakly interacting particles where the heterogenous connections among the particles are described by a graph sequence and the number of particles grows to infinity. Our results extend the existing law of large numbers and propagation of chaos results to the case where the interaction between one particle and its neighbors is expressed as a nonlinear function of the local empirical measure. In the limit of the number of particles which tends to infinity, if the graph sequence converges to a graphon, then we show that the limit system is described by an infinite collection of processes and can be seen as a process in a suitable L^2 space constructed via a Fubini extension. The proof is built on decoupling techniques

and careful estimates of the Wasserstein distance.

3:10pm – 3:30pm **Mingwei LIN**, Department of Statistics, London School of Economics and Political Science.

Title : Equilibrium and market impact with uncertain insiders in limit order market.

Abstract : We consider the one-period Nash equilibrium among informed traders and competitive liquidity suppliers in the limit order market, where liquidity suppliers are uncertain about both the existence and quantity of informed traders in the market. We discuss how informed traders, if they exist, seek to exploit their information advantage and how liquidity suppliers adjust the limit prices in equilibrium based on their beliefs about these informed traders. Our findings confirm the existence of the equilibrium, obtained through a fixed-point mapping problem when the explicit solution is unavailable for general distributions of asset value and informed trader quantity. In equilibrium, we further show that fat-tailed trading asset returns lead to power law asymptotic market impact, while light tails cause logarithmic market impact. Furthermore, we provide the numerically solvable fixed-point equations for the exponents and parameters in power law impact and logarithmic impact.

3:30pm – 4pm **Johannes MUHLE-KARBE**, Imperial College London.

Title : A comparison of FX fixing methodologies.

Abstract : FX fixings are measurements of the exchange rate, published at regular intervals throughout the day. They are widely used by market participants as benchmark rates. However, the methods by which they are calculated differ between providers and have been changing over time. In this paper we provide a framework to assess competing fixing methodologies in terms of the dealer's ability to hedge their fix exposure and the client's effective transaction costs of executing at the fix. We demonstrate that the fixing window width is the primary driver of dealer and client outcomes and that a weighting scheme by which prices are averaged over the calculation window is only of secondary importance. A fixing window that is too narrow leads to excessive client transaction costs while a window that is too wide makes the hedging of fixing risk commercially unviable for the dealer. This trade-off should be balanced by the fix administrators when they settle on their preferred methodology. Joint work with Roel Oomen.

References:

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