NUS National University of Singapore | Centre for Quantitative Finance Faculty of Science

THE UNIVERSITY OF SYDNEY

NUS-USyd-NUSRI joint online workshop on Quantitative Finance and Stochastic Analysis

15 to 16 Dec 2021

This workshop provides a forum for academics, including those from the National University of Singapore and the University of Sydney, to exchange research ideas and to present current advances in quantitative finance, stochastic analysis, and their related fields. The workshop aims to facilitate and support research collaboration in the above-mentioned areas, and to strengthen the two universities' strategic priorities as well as to develop cutting-edge research to create academic and societal impact.

Speakers

- Anna AKSAMIT (The University of Sydney, Australia)
- Min DAI (The Hong Kong Polytechnic University, Hong Kong *and* National University of Singapore, Singapore)
- Guanxing FU (The Hong Kong Polytechnic University, Hong Kong)
- Ivan GUO (Monash University, Australia)
- Zhuo JIN (University of Melbourne, Australia)
- Edward KIM (The University of Sydney, Australia)
- Libo LI (University of New South Wales, Australia)
- Huafu LIAO (Humboldt University of Berlin, Germany *and* National University of Singapore, Singapore)
- Ruyi LIU (The University of Sydney, Australia)
- Chenchen MOU (City University of Hong Kong, Hong Kong)
- Marek RUTKOWSKI (The University of Sydney, Australia)
- Xizhi SU (National University of Singapore, Singapore)
- Marko Hans WEBER (National University of Singapore, Singapore)
- Ge ZHANG (National University of Singapore, Singapore)

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Programme

Wednesday, 15 December 2021		
Singapore Time	**Sydney Time**	**Presentation**
8:30 - 9:10	11:30 - 12:10	**Libo LI** University of New South Wales, Australia *Numerical schemes for jump-extended Constant-Elasticity-of-Variance (CEV) process*
9:10 - 9:50	12:10 - 12:50	**Ruyi LIU** The University of Sydney, Australia *An optimal pricing policy under a Markov chain model*
9:50 - 10:50	12:50 - 13:50	Break
10:50 - 11:30	13:50 - 14:30	**Xizhi SU** National University of Singapore, Singapore *Peer Preference and Asset-Liability Management in InsurTech Market*
11:30 - 12:10	14:30 - 15:10	**Ivan GUO** Monash University, Australia *Robust hedging of American options in continuous time*
12:10 - 12:50	15:10 - 15:50	**Edward KIM** The University of Sydney, Australia *General Nonlinear Dynkin Games with Unordered Payoffs*
12:50 - 13:50	15:50 - 16:50	Break
13:50 - 14:30	16:50 - 17:30	**Marko Hans WEBER** National University of Singapore, Singapore *Incomplete-Market Equilibrium with Heterogeneous Preferences*
14:30 - 15:10	17:30 - 18:10	**Chenchen MOU** City University of Hong Kong, Hong Kong *Mean field games master equations with non-separable Hamiltonian*

Thursday, 16 December 2021		
Singapore Time	**Sydney Time**	**Presentation**
8:30 - 9:10	11:30 - 12:10	**Anna AKSAMIT** The University of Sydney, Australia *Information modelling: new type of filtration enlargement and applications*
9:10 - 9:50	12:10 - 12:50	**Zhuo JIN** University of Melbourne, Australia *A Hybrid Deep Learning Markov Chain Approximation Method*
9:50 - 10:50	12:50 - 13:50	Break
10:50 - 11:30	13:50 - 14:30	**Guanxing FU** The Hong Kong Polytechnic University, Hong Kong *Portfolio Liquidation with Self-exciting Order Flow: Market Regularity and Beyond*
11:30 - 12:10	14:30 - 15:10	**Huafu LIAO** Humboldt University of Berlin, Germany and National University of Singapore, Singapore *Deep Residual Learning via Large Sample Mean-Field Stochastic Optimization*
12:10 - 12:50	15:10 - 15:50	**Marek RUTKOWSKI** The University of Sydney, Australia *Multi-Curve Pricing of SOFR Derivatives*
12:50 - 13:50	15:50 - 16:50	Break
13:50 - 14:30	16:50 - 17:30	**Min DAI** The Hong Kong Polytechnic University, Hong Kong and National University of Singapore, Singapore *Portfolio Rebalancing with Realization Utility*
14:30 - 15:10	17:30 - 18:10	**Ge ZHANG** National University of Singapore, Singapore *Optimal Execution with Hidden Orders under Self-Exciting Dynamics*

Abstract

Speaker: Libo LI

Title: Numerical schemes for jump-extended Constant-Elasticity-of-Variance (CEV) process

Abstract: We propose a positivity-preserving implicit numerical scheme for the jump- extended Cox-Ingersoll-Ross (CIR) process and Constant-Elasticity-of-Variance (CEV) process, where the jumps are governed by a compensated spectrally positive alpha-stable Levy process for alpha in (1, 2). This class of models has first been studied in the context of con- tinuous branching processes with interaction and/or immigration, and in this class, a model has been introduced to mathematical finance for modeling sovereign interest rates and the energy market.

Speaker: Ruyi LIU

Title: An optimal pricing policy under a Markov chain model

Abstract: This paper is about an optimal pricing control under a under a continuous review inventory model of Markov chain. The objective is to dynamically adjust the product price over time to maximize a discounted reward function. It is shown that the optimal control policy is of threshold type. Closed-form solutions are obtained. A numerical example is also provided to illustrate our results.

Speaker: Xishi SU

Title: Peer Preference and Asset-Liability Management in InsurTech Market

Abstract: Technology advances have enhanced competition in insurance industry. This paper investigates a class of dynamic asset and liability management(ALM) games among insurers with mean-variance of relative log return performance. We obtain the unique time- consistent equilibrium ALM strategies explicitly, for both the finite non-zero-sum game and mean field game. The results show that competition leads to the increases of insurers? risky asset investment and the insurance liability. The equilibrium solution implies that ?social utility?(relative concerns) leads to ?social learning?(herd effect) in the complete information market. In particular, the peer relative concern can induce preference interaction. We find the Granger causal relation- ship between industry competition and herd behavior in the empirical data. Finally, we conduct sensitivity analysis of the competition outcome with respect to risk parameters.

Speaker: Ivan GUO

Title: Robust hedging of American options in continuous time

Abstract: In this work, we look at the problem of robust pricing and hedging American-style options whose underlyings are modelled by continuous semimartingales. Similar to previous related works in discrete time (e.g., Aksamit et al (2019)), we enlarge the probability space with the stopping decision and use path-dependent optimal transport (Guo and Loeper (2021)) to establish pricing-hedging dualities for European claims in the enlarged space. To connect this to the original space, we show that martingale measures in the enlarged space can be expressed as convex combinations of martingale measures in the original space coupled with true stopping times. This combination is identified by decomposing the optional projection of a raw IV process. This in turn allows us to prove the pricing-hedging duality for American options in continuous time.

Speaker: Edward KIM

Title: General Nonlinear Dynkin Games with Unordered Payoffs

Abstract: Two-person zero-sum stopping games where payoffs are evaluated by taking conditional expectations are classical and were first analysed by Dynkin (1969). More recently, some authors have studied nonlinear variants of the Dynkin game by evaluating payoffs under a nonlinear evaluation induced by a solution of a backward stochastic differential equation (BSDE) and have shown that the theory naturally applies to stopping policies for hedging game-type options. Under suitable conditions, a Nash equilibrium of the game can be char- acterised using appropriately defined first hitting times of a doubly reflected BSDE. In turn, this Nash equilibrium can be interpreted as a rational exercise / break-even time pair for a given party of the game contract.

A constant assumption in the literature is that the stochastic payoffs of the nonlinear Dynkin game are ordered. However, this is somewhat artificial and is not always a natural assumption to make in applications. In this talk, we will show that this ordering assumption is not needed. Namely, we will discuss extensions of some results for the classical Dynkin game with unordered payoffs from Guo (2014) to the case of a nonlinear Dynkin game. In particular, we will show necessary and sufficient conditions for a Dynkin game with unordered RCLL payoffs to have a value. An important consequence of this result is that DRBSDEs (with appropriate adjustments) can still serve as useful tools for characterising solutions even in the case of fully unordered nonlinear Dynkin games.

Speaker: Marko Hans WEBER

Title: Incomplete-Market Equilibrium with Heterogeneous Preferences

Abstract: We solve a general equilibrium model of an incomplete market with heteroge- neous preferences, identifying first-order and second-order effects. Several long-lived agents with different absolute risk-aversion and discount rates make consumption and investment decisions, borrowing from and lending to each other, and trading a stock that pays a dividend whose growth rate has random fluctuations over time. For small fluctuations, the first-order equilibrium implies no trading in stocks, the existence of a representative agent, predictabil- ity of returns, and multi-factor asset pricing, and that agents use a few public signals for consumption, borrowing, and lending. At the second-order, agents trade stocks dynamically and no representative agent exist, as both the interest rate and asset prices depend on the dispersion of agents' preferences.

Speaker: Chenchen MOU
Title: Mean field games master equations with non-separable Hamiltonian
Abstract: In this talk, we give a structural condition on non-separable Hamiltonians, which we term displacement monotonicity condition, to study second order mean field games master equations. A rate of dissipation of a bilinear form is brought to bear a global (in time) well- posedness theory, based on a–priori uniform Lipschitz estimates in the measure variable. Displacement monotonicity being sometimes in dichotomy with the widely used Lasry-Lions monotonicity condition, the novelties of this work persist even when restricted to separable Hamiltonians. This is based on the joint work with W. Gangbo, A. Meszaros, J. Zhang.

Speaker: Anna AKSAMIT
Title: Information modelling: new type of filtration enlargement and applications
Abstract: I will review the classical results about enlargement of filtration. The main challenge is to find conditions under which martingales in the reference filtration remain semimartingales in the large filtration. If this is the case, the canonical decomposition is of particular interest. I will then present enlargement of a reference filtration through the observation of a random time and a mark. Random time considered is such that its graph is included in the countable union of graphs of stopping times. Mark revealed at this random time is assumed to satisfied generalised Jacod's condition. Classical Jacod's condition concerns initial enlargements and says that the conditional law of a random variable
w.r.t. elements of a reference filtration is absolutely continuous w.r.t. its unconditional law. Our relaxation of Jacod's condition accounts for the dynamic structure of the problem.

Speaker: Zhuo JIN
Title: A Hybrid Deep Learning Markov Chain Approximation Method
Abstract: This work develops a hybrid deep learning Markov chain approximation method to solve optimisation problems arising in insurance portfolio management. Due to the ran- domness of the financial ruin time to terminate the control processes, a Markov chain approximation-based iterative deep learning algorithm is developed to study this type of infinite-horizon optimal control problems. The optimal controls are approximated as deep neural networks. The framework of Markov chain approximation plays a key role in build- ing the iterative equations and initialization of the algorithm. Optimal parameters of neural networks are then obtained iteratively. Convergence of the algorithm is studied. Satisfactory computation efficiency and accuracy are achieved as presented in numerical examples.

Speaker: Guanxing FU
Title: Portfolio Liquidation with Self-exciting Order Flow: Market Regularity and Beyond
Abstract: In this talk, we will incorporate self-exciting child order flow into liquidation problems. In economics, such order flow brings us issues of market regularity. In mathe- matics, such order flow makes the optimization non-convex. We characterize the optimal strategy by an FBSDE and establish a novel verification theorem without convexity. The optimal trading rate is proved to be regular. We will also talk about how to incorporate block sales, with time permitting. The talk is based on a series of joint works with Ulrich Horst and Xiaonyu Xia.

Speaker: Huafu LIAO
Title: Deep Residual Learning via Large Sample Mean-Field Stochastic Optimization
Abstract: We study a class of stochastic optimization problems of the mean-field type arising in the optimal training of a deep residual neural network. We consider the sampling problem arising from a continuous layer idealization, and establish the existence of optimal relaxed controls when the training set has finite size. The core of our paper is to prove the Gamma-convergence of the sequence of sampled objective functionals, i.e., show that as the size of the training set grows large, the minimizer of the sampled relaxed problem converges to that of the limiting optimization problem. We connect the limit of the large sampled objective functional to the unique solution, in the trajectory sense, of a nonlinear Fokker- Planck-Kolmogorov (FPK) equation in a random environment. We construct an example to show that, under mild assumptions, the optimal network weights can be numerically com- puted by solving a deterministic second-order differential equation with Neumann boundary conditions in the sense of distributions.

Speaker: Marek RUTKOWSKI
Title: Multi-Curve Pricing of SOFR Derivatives
Abstract: We study the pricing of ?xed income derivatives within a multi-curve modelling framework. Since the 1970s, the LIBOR has served as a fundamental measure for ?oating term rates across multiple currencies and maturities. Many derivative securities, including swaps, caps and swaptions, still rely on LIBOR as the reference forward-looking rate. How- ever, in 2017 the Financial Conduct Authority announced the discontinuation of LIBOR from the end of 2021 and, subsequently, the New York Fed announced the backward-looking SOFR as a candidate for a new reference rate for USD denominated swaps. We outline the classical single-curve modelling framework, before transitioning to the multi-curve setup. We consider the replication of SOFR-based swaps using SOFR futures and a self-?nancing trading strategy with and without collateral backing. For concreteness, Vasicek's model is used to specify the joint dynamics of several overnight rates, including SOFR and EFFR, although other factor models can also be used as well to describe the dynamics of overnight rates.

Speaker: Min DAI
Title: Portfolio Rebalancing with Realization Utility
Abstract: We develop a dynamic tractable model where an investor derives realization utility as in Barberis and Xiong (2012) and Ingersoll and Jin (2013), but importantly can dynamically rebalance her portfolio between a risky asset and a risk-free asset. We show that the option of investing in the risk-free asset is quite valuable, even though the investor only derives utility from realized gains and losses of trading the risky asset. We also show that in the jump-diffusion case, an investor may hold on to her position after a large paper loss due to a downside jump but tend to realize a moderate loss after a price rally. This work is jointly with Cong Qin and Neng Wang.

Speaker: Ge ZHANG

Title: Optimal Execution with Hidden Orders under Self-Exciting Dynamics

Abstract: Hidden liquidity is attracting significant volume share in modern order-driven markets, providing exposure risk reduction and mitigating adverse selection risk. In a continuous-time framework, we show there is a switching in the optimal liquidation strategy for a risk-neutral agent who uses both hidden and displayed limit orders controlling the order sizes. When market order arrivals are modeled as the Poisson process, we derive a closed-form solution that contains a switching time, at which the agent changes from a pure- hidden-order phase to a mixed-orders phase until termination. Under the Hawkes process with self-exciting dynamics, a numerical solution is provided. We show that the optimal strategy exhibits a similar two-phase pattern, except that the switching time becomes a function of the market order intensity. Simulation experiments show that the use of hidden order reduces liquidation cost, accompanied by an increase in liquidity. Given event-level limit order book data of 100 NASDAQ stocks, we test the liquidation strategies, where our strategy (with mixed type under the self-exciting dynamics) leads to cost reduction up to 57% to the pure limit order strategy and 15% to the strategy with both order types under the Poisson process.

Organisers

- Chao ZHOU (National University of Singapore, Singapore)
- Zhou ZHOU (The University of Sydney, Australia)