TMU Workshop on Finance 2024

September 26, 2024 (Thu) 12:50–18:00
September 27, 2024 (Fri) 13:00–18:10

Marunouchi Satellite Campus, Tokyo Metropolitan University, Tokyo, Japan

Plenary Speakers

Jie Yen Fan	Monash University
Andrea Macrina	University College London
Tai-Ho Wang	The City University of New York
Kazutoshi Yamazaki	University of Queensland

Speakers

Rusudan Kevkhishvili	Kyoto University
Kiichi Kitajima	Mitsubishi UFJ Trust Investment Technology Institute
Tomohiro Koike	Kyoto University
Wataru Nozawa	Fukuoka University
Benjamin Poignard	Osaka University
Makoto Shimoshimizu	Tokyo University of Science
Takaaki Shiotani	The University of Tokyo
Ryoichi Suzuki	Ritsumeikan University
Ryoji Takano	Osaka University
Kohta Takehara	Tokyo Metropolitan University
Yuma Tamura	Ritsumeikan University
Tomooki Yuasa	Tokyo Metropolitan University

Scientific Committee

Takanori Adachi	Tokyo Metropolitan University
Yukio Muromachi	Tokyo Metropolitan University
Kohta Takehara	Tokyo Metropolitan University
Tomonori Uchiyama	Tokyo Metropolitan University
Kyoko Yagi	Tokyo Metropolitan University
Toshinao Yoshiba	Tokyo Metropolitan University
Tomooki Yuasa	Tokyo Metropolitan University

Organized by Research Center for Quantitative Finance, Tokyo Metropolitan University
Supported by Kyoto Institute of Economic Research Foundation

September 26 (Thu)

12:50–13:00	Opening address by Tomonori Uchiyama, Director of Research Center for Quantitative Finance, Tokyo Metropolitan University
Session 1	Chair: Kazutoshi Yamazaki, University of Queensland
13:00–13:45	Tai-Ho Wang The City University of New York "Relative entropy-regularized robust optimal order execution under transient impact"
13:45–14:15	Kiichi Kitajima Mitsubishi UFJ Trust Investment Technology Institute "High-Frequency Trading and Risk Sharing Capacity in Market Making with Asymmetric Information"
14:15–14:45	Tomooki Yuasa Tokyo Metropolitan University "Randomized multi-factor approximation for stochastic volterra equations with fractional kernel"
Session 2	Chair: Andrea Macrina, University College London
15:00–15:45	Jie Yen Fan Monash University "From mimicking to local Brownian motions"
15:45–16:15	Yuma Tamura Ritsumeikan University "Formulas for "delta" of the options whose underlying asset prices are given by affine processes"
16:15–16:45	Ryoji Takano Osaka University "Large deviation principle for rough volatility models"
Session 3	Chair: Takanori Adachi, Tokyo Metropolitan University
17:00–17:30	Rusudan Kevkhishvili Kyoto University "On Decomposition of the Last Passage Time of Diffusions and its Financial Application"
17:30–18:00	Wataru Nozawa Fukuoka University "A Model of Asset Price Booms"

September 27 (Fri)

Session 4	Chair: Tai-Ho Wang, The City University of New York
13:00–13:45	Andrea Macrina University College London "Transition Risk Mitigation: The CLoCo Bond"
13:45–14:15	Makoto Shimoshimizu Tokyo University of Science "Continuous-time optimal execution under a transient market impact model in a Markovian environment"
14:15–14:45	Tomohiro Koike Kyoto University "Optimal timing of energy efficiency policies based on household utility: Using a general equilibrium model for optimal stopping problems"
Session 5	**Chair: Jie Yen Fan, Monash University**
15:00–15:45	Kazutoshi Yamazaki University of Queensland "Non-zero-sum optimal stopping game with continuous versus periodic exercise opportunities"
15:45–16:15	Ryoichi Suzuki Ritsumeikan University "Clark-Ocone-Haussmann type formulas for additive processes and their application to finance"
16:15–16:45	Takaaki Shiotani The University of Tokyo "Modeling lead-lag effect using bivariate Neyman-Scott processes with gamma kernels"
Session 6	**Chair: Toshinao Yoshiba, Tokyo Metropolitan University**
17:00–17:30	Benjamin Poignard Osaka University "Factor multivariate stochastic volatility models of high dimension"
17:30–18:00	Kohta Takehara Tokyo Metropolitan University "Strategic Interactions in Setting Up Decentralized Exchanges: Conflict of Interest between Liquidity Providers and Platformers"

18:00–18:10 Closing address by Yukio Muromachi, Directer of Finance Program, Graduate School of Management, Tokyo Metropolitan University

September 26, 13:00–13:45

Relative entropy-regularized robust optimal order execution under transient impact

Tai-Ho Wang

The City University of New York

In this talk, we cast optimal liquidation under linear temporary and transient price impact as a relative entropy-regularized robust optimal control problem. The problem is formulated as to maximize a reward-risk functional associated with the order execution agent's profit-and-loss of trading and the execution risk taking into account market's liquidity and uncertainty over a class of absolutely continuous strategies. The problem is made into an entropy-regularized stochastic differential game and is solved by adopting the principle of dynamic programming, yielding that the value function of the differential game satisfies an entropy-regularized Hamilton-Jacobi-Isaacs (rHJI) equation. Under the assumption of aggregate exponential transient impact and Gaussian prior, the rHJI equation reduces to a matrix Riccati differential equation. Further imposing constancy of the corresponding coefficients, the matrix Riccati differential equation can be linearized, resulting in analytical expressions for optimal strategy and trajectory as well as the posterior distribution of market activity. The talk is based on a joint work with Xue Cheng and Meng Wang.

September 26, 13:45–14:15

High-Frequency Trading and Risk Sharing Capacity in Market Making with Asymmetric Information

Kiichi Kitajima

Mitsubishi UFJ Trust Investment Technology Institute

We examine how the impact of asymmetric information on market liquidity and informational efficiency in a market where some of the market makers have high-frequency trading capabilities. Our proposed market microstructure model consists of heterogeneous-speed market makers and liquidity traders, the latter bringing private information. We find that the degree of information asymmetry may or may not improve liquidity, depending on the market structure. We also show that the increase in the number of high-frequency market makers basically improves the market liquidity, but degrades the liquidity in some situations. Our theoretical results imply that financial authorities need to examine the effect of high-frequency market making carefully, especially if asymmetric information is significant among traders. This study is a joint work with Katsumasa Nishide (Waseda University).

September 26, 14:15–14:45

Randomized multi-factor approximation for stochastic volterra equations with fractional kernel

Tomooki Yuasa

Tokyo Metropolitan University

This talk introduces a numerical simulation method for the stochastic volterra equation (SVE) with the fractional kernel. The SVE with the fractional kernel appears in various rough volatility models, which have recently gained attention as a model for the price process of risk assets.

The SVE is non-Markovian and non-semimartingale because the fractional kernel has a singularity. This makes it difficult to apply traditional methods used for stochastic differential equations (SDEs) directly. To address this, Jaber and Euch (2019) developed a method to approximate the SVE with a multi-factor SDE by representing the fractional kernel as the Laplace (gamma) integral and approximating the integral with numerical integration. The usual discrete-time approximation can be applied to the multi-factor SDE, allowing option prices to be calculated numerically by the Monte Carlo method.

In this study, we employ the Monte Carlo method instead of numerical integration to approximate the fractional kernel (gamma integral). For instance, if we use a gamma-distributed random variable in the Monte Carlo method, the error in the multi-factor approximation is not finite. We present conditions and a construction method for the random variable used in the Monte Carlo method that ensures a finite error in the multi-factor approximation, and show that the random number can be generated by the inverse transform method. Although numerical integration is generally considered more accurate than the Monte Carlo method for one-dimensional integrals such as the fractional kernel (gamma integral), our numerical experiments show that the accuracy of the both methods is comparable. The reason for this is presumably that the Monte Carlo method is also used in the numerical calculation of option prices, which has the effect of increasing the number of the Monte Carlo method used to approximate the fractional kernel.

This work is conducted in collaboration with Takanori Adachi, Natsuno Sawamura, and Kohta Takehara from Tokyo Metropolitan University.

September 26, 15:00–15:45

From mimicking to local Brownian motions

Jie Yen Fan

Monash University

Motivated by questions in finance, we are interested in constructing new processes from existing ones while preserving the marginal distributions and the martingale property. We call this mimicking. This would enable us to develop alternative models for asset prices, with the hope of improving upon the existing ones, while retaining the (European) option prices. In this talk, I will give some results on mimicking and introduce local Brownian motions, which are processes that behave locally like a Brownian motion.

September 26, 15:45–16:15

Formulas for "delta" of the options whose underlying asset prices are given by affine processes

Yuma Tamura

Ritsumeikan University

If $(X_t^x)_{t\geq 0}$ is an underlying asset price whose initial value is x, $\partial_x E[f(X_t^x)]$ can be thought of as the "delta" of the option. This study focused on squared Bessel processes and affine processes, and we derived some formulas concerning $\partial_x E[f(X_t^x)]$. The results can be applied to the CIR model.

September 26, 16:15–16:45

Large deviation principle for rough volatility models

Ryoji Takano

Osaka University

A rough volatility model is a stochastic volatility model for an asset price process with volatility being rough, meaning that the Hölder regularity of the volatility path is less than half. In this talk, we will focus on the asymptotic behavior of implied volatility for short maturity under those models and show that the large deviation principle provides the asymptotic behavior of implied volatility.

September 26, 17:00–17:30

On Decomposition of the Last Passage Time of Diffusions and its Financial Application

Rusudan Kevkhishvili

Kyoto University

This talk is based on the joint work with Masahiko Egami: "On Decomposition of the Last Passage Time of Diffusions" (arXiv, 2024). First, we will discuss the role played by the last passage time of a diffusion in financial applications. Then, for a regular transient diffusion, we provide a new decomposition formula of its last passage time to a certain state α together with its application. This is accomplished by transforming the original diffusion into two diffusions using the occupation time of the area above and below α. Based on these two processes, both having a reflecting boundary at α, we derive the decomposition formula of the Laplace transform of the last passage time explicitly in a simple form in terms of Green functions. This equation also leads to the Green function's decomposition formula. We demonstrate an application of these formulas to a diffusion with two-valued parameters.

September 26, 17:30–18:00

A Model of Asset Price Booms

Wataru Nozawa

Fukuoka University

Episodes indicate that asset price booms are often triggered by the introduction of new assets or technologies coupled with expansionary monetary policy. We propose a model to explore this phenomenon. In our model, traders hold diverse opinions on asset valuation, with only the more optimistic traders choosing to purchase the asset from producers. This selection leads to asset overpricing. Expansionary monetary policy reduces borrowing costs for traders, allowing a greater number of optimistic traders to enter the market, which can further amplify the overpricing under certain parameter conditions.

September 27, 13:00–13:45

Transition Risk Mitigation: The CLoCo Bond

Andrea Macrina

University College London

Adjustments to governmental climate transition policies and uncertainties linked to the ability for industry sectors and consumers to manufacture and purchase low carbon technologies, respectively, have led to an increasing need to embed a richer framework for uncertainty in climate transition outcomes. Such uncertainties create a number of financial risks for firms, their investors, the banking sector, and potentially sovereign risks. The need thus arises for the development of a bespoke pricing setup and financial instruments, which offer a mechanism to share climate transition risk. As an example, we propose the so-called climate-contingent convertible (CLoCo) bond. This instrument enables firms to reduce the risk of default due to adverse climate transition policies over the product's lifetime. The proposed financial innovation implies reduced risk of default for firms, thereby increasing the expected firm value, but it also reduces the dependency of firm failures on the banking sector and potential bail-out costs incurred by sovereign nations. Joint work with C. Cormack – SSRN working paper: https://dx.doi.org/10.2139/ssrn.4851975

September 27, 13:45–14:15

Continuous-time optimal execution under a transient market impact model in a Markovian environment

Makoto Shimoshimizu

Tokyo University of Science

This paper examines a continuous-time optimal trade execution problem under a transient market impact model. We also analyze the effect of an exogenous random factor that affects the market price on the optimal trade execution strategy. Our execution problem is formulated as a continuous-time stochastic control problem over a finite horizon of maximizing the expected utility from the final wealth of a risk-averse large trader. By examining the Hamilton-Jacobi-Bellman (HJB) equation, we characterize the optimal trade execution strategy and its associated optimal value function. The trade execution strategy becomes a time-dependent affine function of state variables. Further, the time-dependent coefficients could be derived from a solution of a system of ordinary differential equations (ODEs) with terminal conditions, which is numerically tractable. In addition, we conduct simulation-based numerical experiments and confirm that the optimal execution strategy captures some features observed in financial markets.

September 27, 14:15–14:45

Optimal timing of energy efficiency policies based on household utility: Using a general equilibrium model for optimal stopping problems

Tomohiro Koike

Kyoto University

Policymakers are concerned with effects of energy efficiency policies (EEPs) not only on environmental quality but also on household consumption. Thus, we study the optimal timing of EEP implementation by considering household consumption and incorporating a general equilibrium model with an optimal stopping problem. This model is general in that energy prices are governed by a stochastic process in a wide class of one-dimensional diffusion processes, and we solve it by an analytical method. Moreover, we specify the energy price in an exponential Ornstein-Uhlenbeck process and quantitatively analyze this model. Key results are as follows: (i) The additional household utility gained from EEPs is larger when energy prices are higher. Thus, EEPs can mitigate the loss of household utility caused by high energy prices. (ii) An increase in energy price volatility causes an increase in energy usage and output, but it has little impact on the households' utility of the economy. (iii) Increasing volatility and sustained price shocks delay EEP implementation. (iv) The ability of EEPs to reduce energy consumption depends on the average level of energy prices and the energy intensity of production technology. The baseline model of this study shows that the EEPs reduce energy consumption.

September 27, 15:00–15:45

Non-zero-sum optimal stopping game with continuous versus periodic exercise opportunities

Kazutoshi Yamazaki

University of Queensland

We introduce a new non-zero-sum game of optimal stopping with asymmetric exercise opportunities. Given a stochastic process modelling the value of an asset, one player observes and can act on the process continuously, while the other player can act on it only periodically at independent Poisson arrival times. The first one to stop receives a reward, different for each player, while the other one gets nothing. We study how each player balances the maximisation of gains against the maximisation of the likelihood of stopping before the opponent. In such a setup, driven by a Lévy process with positive jumps, we not only prove the existence, but also explicitly construct a Nash equilibrium with values of the game written in terms of the scale function. Numerical illustrations with put-option payoffs are also provided to study the behaviour of the players' strategies as well as the quantification of the value of available exercise opportunities. (Joint with Jose Luis Perez and Neofytos Rodosthenous)

September 27, 15:45–16:15

Clark-Ocone-Haussmann type formulas for additive processes and their application to finance

Ryoichi Suzuki

Ritsumeikan University

This presentation investigates the development and application of Clark-Ocone-Haussmann (COH) type formulas for additive processes within the field of mathematical finance, based on collaborative research with M. Handa, N. Sakuma, and M. E. Mancino. COH formulas are fundamental in stochastic analysis, providing explicit martingale representations of random variables in terms of their Malliavin derivatives. Additionally, we explore Malliavin-Mancino-Taylor type formulas, which extend the COH framework through high-order Malliavin derivatives, and examine their applications in finance.

September 27, 16:15–16:45

Modeling lead-lag effect using bivariate Neyman-Scott processes with gamma kernels

Takaaki Shiotani

The University of Tokyo

We propose noisy bivariate Neyman-Scott point processes with gamma kernels (NBNSP-G) to model the lead-lag relationships in high-frequency financial data. The model tolerates noises that are not necessarily Poissonian, and the diverging gamma kernels represent fast responses to new information in high-frequency trading. Our experiments suggest that NBNSP-G can explain the correlation structure of executed orders of two stocks well. A composite-type quasi-likelihood is employed to estimate the model's parameters. However, when one tries to prove consistency and asymptotic normality, NBNSP-G breaks the boundedness assumption on the moment density functions commonly assumed in the literature. Therefore, we show consistency and asymptotic normality under more relaxed conditions for bivariate point process models, including NBNSP-G.

September 27, 17:00–17:30

Factor multivariate stochastic volatility models of high dimension

Benjamin Poignard

Osaka University

Building upon the pertinence of the factor decomposition to break the curse of dimensionality inherent to multivariate volatility processes, we develop a factor model-based multivariate stochastic volatility (fMSV) framework that relies on two viewpoints: sparse approximate factor model and sparse factor loading matrix. We propose a two-stage estimation procedure for the fMSV model: the first stage obtains the estimators of the factor model, and the second stage estimates the MSV part using the estimated common factor variables. We derive the asymptotic properties of the estimators. Simulated experiments and real data applications are performed to assess the forecasting performances of the covariance matrices.

September 27, 17:30–18:00

Strategic Interactions in Setting Up Decentralized Exchanges: Conflict of Interest between Liquidity Providers and Platformers

Kohta Takehara

Tokyo Metropolitan University

Decentralized exchanges(DEXs) are a key concept in DeFi. Automated market makers, which are algorithms that pool liquidity and make it available to users of the DEX at automatically determined prices, are a common feature of such platforms. This study categorizes DEX players into four groups: Platformers, Liquidity Providers, Arbitrageurs, and Traders. It then analyzes how the structure of DEXs is affected by the actions and optimizations of these players, which is intuitively illustrated by several numerical examples. This is a joint work with Chiaki Hara, Takanori Adachi and Tomooki Yuasa.