

APU-TMU Joint International Workshop on Quantitative Finance

January 12, 2025 (Sun) 9:00–17:35
January 13, 2025 (Mon) 10:00–18:00

APU PLAZA OITA (AP House 4), Ritsumeikan Asia Pacific University, Beppu, Oita, Japan

Plenary Speakers

Sebastian Jaimungal	University of Toronto
Kyunghyun Park	Nanyang Technological University
Silvana Pesenti	University of Toronto
Yong Hyun Shin	Sookmyung Women's University
Kazutoshi Yamazaki	University of Queensland

Speakers

Chiaki Hara	Kyoto University
Tomonori Nakatsu	Shibaura Institute of Technology
Takashi Shibata	Tokyo Metropolitan University
Makoto Shimoshimizu	Tokyo University of Science
Teruyoshi Suzuki	Hokkaido University

Scientific Committee

Takanori Adachi	Tokyo Metropolitan University
Katsushi Nakajima	Ritsumeikan Asia Pacific 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
Co-hosted by Nakajima Laboratory, Ritsumeikan Asia Pacific University

January 12 (Sun)

9:00–9:05 Opening address by Katsushi Nakajima, Co-Host, Ritsumeikan Asia Pacific University

Session 1 Chair: Takanori Adachi, Tokyo Metropolitan University

9:05–9:50 Yong Hyun Shin Sookmyung Women's University
“Impact of Income and Leisure on Optimal Portfolio, Consumption, and Retirement Decisions under Exponential Utility”

9:50–10:20 Chiaki Hara Kyoto University
“Shareholder Engagement in an ESG-CAPM with Incomplete Markets: Much ado about nothing?”

Session 2 Chair: Tomonori Uchiyama, Tokyo Metropolitan University

10:35–11:20 Sebastian Jaimungal University of Toronto
“Partial Information Nash Equilibria between Broker and Traders”

11:20–11:50 Teruyoshi Suzuki Hokkaido University
“A Continuous Piecewise-Differential Function and its Application to Financial Systemic Risks”

Session 3 Chair: Toshinao Yoshiba, Tokyo Metropolitan University

13:20–14:05 Kazutoshi Yamazaki University of Queensland
“Refraction strategies in stochastic control: optimality for a general Lévy process model”

14:05–14:35 Takashi Shibata Tokyo Metropolitan University
“Investment, financing, strategic debt service, and liquidation”

Session 4 Chair: Katsushi Nakajima, Ritsumeikan Asia Pacific University

14:50–15:35 Silvana Pesenti University of Toronto
“How to really outperform a benchmark strategy”

15:35–16:05 Tomonori Nakatsu Shibaura Institute of Technology
“Computation of Greeks of continuous/discrete time barrier options”

Session 5 Chair: Tomooki Yuasa, Tokyo Metropolitan University

16:20–17:05 Kyunghyun Park Nanyang Technological University
“Sensitivity analysis of robust optimization problems and nonlinear Kolmogorov PDEs”

17:05–17:35 Makoto Shimoshimizu Tokyo University of Science
“Continuous-time optimal execution under a transient market impact model in a Markovian environment”

January 13 (Mon)

10:00–17:55 Reports and discussions on recent developments on the quantitative finance

17:55–18:00 Closing address by Tomonori Uchiyama, Director of Research Center for Quantitative Finance, Tokyo Metropolitan University

January 12, 9:05–9:50

Impact of Income and Leisure on Optimal Portfolio, Consumption, and Retirement Decisions under Exponential Utility

Yong Hyun Shin

Sookmyung Women's University

We study an optimal control problem encompassing investment, consumption, and retirement decisions under exponential (CARA-type) utility. The financial market comprises a bond with constant drift and a stock following geometric Brownian motion. The agent receives continuous income, consumes over time, and has the option to retire irreversibly, gaining increased leisure post-retirement compared to pre-retirement. The objective is to maximize the expected exponential utility of weighted consumption and leisure over an infinite horizon. Using a martingale approach and dual value function, we derive implicit solutions for the optimal portfolio, consumption, and retirement time. The analysis highlights key contributions: first, the equivalent condition for no retirement is characterized by a specific income threshold; second, the influence of income and leisure levels on optimal portfolio, consumption, and retirement decisions is thoroughly examined. These results provide valuable insights into the interplay between financial and lifestyle choices in retirement planning. This talk is based on joint work with Tae Ung Gang (KAIST).

Shareholder Engagement in an ESG-CAPM with Incomplete Markets: Much ado about nothing?

Chiaki Hara

Kyoto University

ESG (Environment, Social, and Governance) attracts a lot of attention in the global economy. On the first one, environment, it is often argued that investors, institutional or individual, should actively engage in the firm's production decision making to induce its managers to employ greener technologies. While it seems nice, at first glance, to encourage green activists to engage in firms' management, the social value of such engagement should ultimately be judged by its welfare consequences. Since such consequences, in turn, depend on how the investors and the stock markets react to the firms' production changes, any sound theoretical analysis would require a general equilibrium model that takes all repercussion effects into consideration.

In this paper, we provide a general equilibrium model of asset markets with production, where the firms (endogeneously) determine their production plans by taking its shareholders' view on environment into consideration. Investors have the same mean-variance utility functions as in the Capital Asset Pricing Model, except that they have possibly heterogeneous view on environment, in a way that can be formally embedded in their utility functions. We use two notions of equilibrium. One is a market-value maximization equilibrium, where the firms maximize their profit without paying special attention to the shareholders' ESG concerns. The other is Dreze equilibrium, named after Jacques Dreze, where the firms maximize profit with respect to the weighted average of its shareholders' utility gradients. This latter criterion respects the shareholders' environment concerns and can thus be considered as a proper, albeit condensed, formulation of shareholder engagement in this context.

We establish some important and interesting properties of these two notions of equilibrium.

1. We establish their existence. The mathematical techniques needed to prove their existence are quite different. To establish the existence of a market-value maximization equilibrium, it suffices to use the well known fact that every continuous function on a compact set attains a maximum. For the existence of a Dreze equilibrium, we need to construct a vector bundle whose base space is a Grassmann manifold and apply a theorem on its mod 2 Euler number.
2. We give a necessary and sufficient condition for the two equilibria to coincide. Based on this condition, we can show that for shareholder engagement to matter, two things are necessary. First, shareholders' ESG concerns need to be heterogeneous; that is, some shareholders need to be more green-conscious than others, possibly in different dimensions. Second, the asset markets need to be incomplete in the sense that the investors' ESG concerns cannot be fully diversified via asset trades.
3. We show that shareholders' engagement has only a second-order impact on social welfare. More precisely, starting a profile of investors' ESG concerns under which the market value maximization equilibrium and Dreze equilibrium coincide, we change the profile to induce the two to diverge. We prove that the induced difference in the sum of investors' utilities between the two equilibria is of (at most) second order with respect to the size of the change, formulated as probability distortions, in ESG profiles.

January 12, 10:35–11:20

Partial Information Nash Equilibria between Broker and Traders

Sebastian Jaimungal

University of Toronto

We study the partial information Nash equilibrium between a broker and an informed trader. In our model, the broker trades in the lit exchange where trades have instantaneous and transient price impact with exponential resilience. The informed trader trades solely with the broker but has an additional trading signal that the broker lacks. We characterise the Nash equilibrium of the trading strategies as the solution to a coupled system of FBSDEs and prove uniqueness and existence. Further, we provide insights on the trading strategies when compared to the Stackleberg equilibria.

[based on joint works with Xuchen Wu, Álvaro Cartea, and Leandro Sanchez-Betancourt]

January 12, 11:20–11:50

A Continuous Piecewise-Differential Function and its Application to Financial Systemic Risks

Teruyoshi Suzuki

Hokkaido University

We introduce the continuous piecewise-differential function and model systemic risk problems in the market where credit default swaps (CDSs) and straight debts are traded and where the investors and issuers of the debts (CDSs and straight debts) are interconnected by buying and issuing those debts in the market. We first show the Lipschitz constant of the continuous piecewise-differential function employing the mean value inequality. We then show sufficient conditions for that the amounts of repayment from the debts are uniquely determined in the interconnected market. We show the results for both cases where the repayments are made through the Pari-pass principle and an absolute priority rule. Although these results do not consider default costs, they extend existing research on cases where repayments are not monotonic with state variables. This is a joint work with Katsumasa Nishide and Kyoko Yagi.

January 12, 13:20–14:05

Refraction strategies in stochastic control: optimality for a general Lévy process model

Kazutoshi Yamazaki

University of Queensland

We revisit an absolutely-continuous version of the stochastic control problem driven by a Lévy process. A strategy must be absolutely continuous with respect to the Lebesgue measure and the running cost function is assumed to be convex. We show the optimality of a refraction strategy, which adjusts the drift of the state process at a constant rate whenever it surpasses a certain threshold. The optimality holds for a general Lévy process, generalizing the spectrally negative case presented in Hernández-Hernández et al. (2016). This is a joint work with Kei Noba and Jose Luis Perez.

January 12, 14:05–14:35

Investment, financing, strategic debt service, and liquidation

Takashi Shibata

Tokyo Metropolitan University

We develop a dynamic model of real options to examine how the introduction of both collateral and debt renegotiation (strategic debt service) affects a firm's investment and financing (capital structure) decisions. Our results reveal that such an introduction hastens investment and decreases debt issuance, leading to a decreased credit spread and increased leverage. When firms are allowed to issue one of two kinds of debt—bank (renegotiable) debt and market (non-renegotiable) debt—with collateral, firms with substantial collateral are more likely to prefer market debt rather than bank debt. These results fit well with empirical findings. This is a joint work with Michi Nishihara and Yuan Tian.

January 12, 14:50–15:35

How to really outperform a benchmark strategy

Silvana Pesenti

University of Toronto

In this talk, we revisit the classical portfolio choice problem, where an investor aims at finding the portfolio with maximal expected utility of terminal wealth subject to a budget problem. In many real-world applications, however, investors aim at tracking or outperforming a benchmark strategy. Thus, important to this problem is how deviations from a benchmarks' terminal wealth distribution are quantified. We first consider the portfolio problem with the Wasserstein distance. While the Wasserstein distance leads to semi-closed form solutions, its is symmetric in that gains and losses are treated equally. Many investors, however, value gains and losses differently, which is achieved with the Bregman Wasserstein divergence, a recently introduced asymmetric divergence on the space of distribution, that generalises the Wasserstein distance. More importantly, investors often not only aim at penalising losses and gains asymmetrically, but rather wish to penalise under- and outperformance relative to the benchmark; thus asymmetrically penalise outcomes where the portfolio wealth is below / above that of the benchmarks'. This is achieved by the novel α -Bregman Wasserstein divergence, which generalises the Bregman Wasserstein and the Wasserstein divergence.

For the different portfolio choice problems, we prove existence and uniqueness of the optimal portfolio strategy and give explicit criteria when the divergence constraints and the budget constraints are binding. We conclude with numerical examples illustrating the optimal terminal wealth.

January 12, 15:35–16:05

Computation of Greeks of continuous/discrete time barrier options

Tomonori Nakatsu

Shibaura Institute of Technology

In this talk, we obtain formulas to compute the Greeks for continuous and discrete time barrier options. In particular, we generalize the results in Gobet and Kohatsu-Higa (Electron. Comm. Probab., 2003) and Nakatsu (J. Comput. Finance, 2017). Some numerical results will also be shown.

January 12, 16:20–17:05

Sensitivity analysis of robust optimization problems and nonlinear Kolmogorov PDEs

Kyunghyun Park

Nanyang Technological University

In this talk we provide sensitivity analysis of robust optimization problems and nonlinear Kolmogorov partial differential equations (PDEs). In the optimization problems, an investor has the opportunity to trade in a stock with the goal of maximizing her worst-case cost of cumulative gains and losses. Here, worst-case refers to taking into account all possible drift and volatility processes for the stock that fall within a ε -neighbourhood of predefined baseline processes. Our goal is to quantify how sensitive a given robust optimization problem is to model uncertainty, which can be attained by showing that the robust problem can be approximated as $\varepsilon \downarrow 0$ by the baseline problem. In the nonlinear Kolmogorov PDEs, the nonlinearity comes from its Hamiltonian where one maximizes over all possible drift and diffusion coefficients which fall within a ε -neighborhood of pre-specified baseline coefficients. Our subsequent aim is to quantify how sensitive those PDEs are to such a small nonlinearity, and then use the results to develop an efficient numerical method for their approximation. We show that as $\varepsilon \downarrow 0$, the nonlinear Kolmogorov PDE can be approximated by the linear Kolmogorov PDEs involving the baseline coefficients. As these linear Kolmogorov PDEs can be efficiently solved in high-dimensions by exploiting their Feynman-Kac representation, our derived sensitivity analysis provides a Monte Carlo based numerical method which can efficiently solve these nonlinear Kolmogorov PDEs.

This talk is based on joint works with Daniel Bartl (Univ. Vienna) and Ariel Neufeld (NTU Singapore).

January 12, 17:05–17:35

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 various features observed in financial markets.

This talk is based on the joint work with Prof. Masaaki Fukasawa and Prof. Masamitsu Ohnishi.