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Perfect replication under market impact

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ABSTRACT

We first extend the study of Bouchard et al. 2018 and Loeper 2017 to stochastic target problems with general market impacts. The perfect hedging problem amounts to solving a second order coupled FBSDEs. Unlike the previous studies, the related fully non-linear PDE is not concave and the regularization/verification approach of Bouchard et al. 2018 can not be applied. In place, we need to generalize the a priori estimates of Loeper 2017 and exhibit smooth solutions from the classical parabolic equations theory. Up to an additional approximating argument, this allows us to show that the super-hedging price solves the parabolic equation and that a perfect hedging strategy can be constructed when the coefficients are smooth enough. This representation suggests a dual formulation for the Brownian diffusion Markovian setting. We shall explain how this dual formulation can indeed be exploited to solve a general class of non-Markovian second order coupled FBSDEs driven by general continuous martingales.

Dynamic investment and financing with internal and external liquidity management

Nan Chen

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ABSTRACT

We develop a theoretical model of dynamic investments, dividend payouts, debt borrowing, external equity financing, and bankruptcy for financially constrained firms. The model characterizes the central importance of liquidity management in corporate decision making in the presence of external financing costs. Mathematically, to solve for the recursive equilibrium of the problem, we formulate it as an optimal stopping problem with a fixed-point structure embedded. Our model can generate rich implications. Particularly, we find that the debt may yield two opposing effects to the firm's investment decisions if it has limited liquidity. On one hand, debt issuance may enhance the size of current investment; on the other hand, debt may reduce the actual profit to the firm. Our model characterizes quantitatively how these two effects, interacting with the cash management, will shape up the firm's investment, financing, bankruptcy, and payout decisions. The paper also discusses the implications of liquidity and leverage requirements in the current banking regulatory framework.

Optimal investment in mutually exclusive projects and operating leverage: the value of green energy

Jerome Detemple

Boston University, USA

ABSTRACT

This paper studies investments in exclusive projects with different cost structures. The analysis incorporates the possibility of producing a stochastic revenue stream from two alternative technologies, respectively with stochastic variable cost and fixed cost, and accounts for endogenous operating decisions of project managers. The optimal investment decision is characterized by two boundaries, possibly non-monotone. The effect of operating leverage on managerial policies, investment decisions and values is examined. An application to power generation projects is carried out. The impact of knowledge acquisition, i.e., investments in growth options, is also assessed.

Intraday market making: a comparison between reinforcement learning and an analytical benchmark

JOSÉ E. FIGUEROA-LÓPEZ

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ABSTRACT

A market-maker aims to optimize his/her cumulative reward by recurrently updating his/her bid and ask quotes in a Limit Order Book through the day. In this work, we study an optimal discrete-time market making decision problem with random action times given by the arrival times of market orders. We apply reinforcement learning to the environment simulated by the proposed market-making model. A tile coding method is used to handle the underlying continuous state space. The reinforcement algorithm is able to find policies whose performance is competitive with those found by solving the model analytically, when possible. This is joint work with Agostino Capponi and Chuyi Yu.

Asset prices in segmented and integrated markets

Paolo Guasoni

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ABSTRACT

This paper evaluates the effect of market integration on prices and welfare, in a model where two Lucas trees grow in separate regions with similar investors. We find equilibrium asset price dynamics and welfare both in segmentation, when each region holds its own asset and consumes its dividend, and in integration, when both regions trade both assets and consume both dividends. Integration always increases welfare. Asset prices may increase or decrease, depending on the time of integration, but decrease on average. Correlation in assets' returns is zero or negative before integration, but significantly positive afterwards, explaining some effects commonly associated with financialization.

Forward rank-dependent performance criteria: time-consistent investment under probability distortion

Xuedong He

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ABSTRACT

We introduce the concept of forward rank-dependent performance criteria, extending the original notion to forward criteria that incorporate probability distortions. A fundamental challenge is how to reconcile the time-consistent nature of forward performance criteria with the time-inconsistency stemming from probability distortions. For this, we first propose two distinct definitions, one based on the preservation of performance value and the other on the time-consistency of policies and, in turn, establish their equivalence. We then fully characterize the viable class of probability distortion processes, providing a "bifurcation"-type result. Specifically, it is either the case that the probability distortions are degenerate in the sense that the investor would never invest in the risky assets, or the marginal probability distortion equals to a normalized power of the quantile function of the pricing kernel. We also characterize the optimal wealth process, whose structure motivates the introduction of a new, "distorted" measure and a related market. We then build a striking correspondence between the forward rank-dependent criteria in the original market and forward criteria without probability distortions in the auxiliary market. This connection also provides a direct construction method for forward rank-dependent criteria. Finally, our results on forward rank-dependent performance criteria motivate us to revisit the classical (backward) setting. We follow the so-called dynamic utility approach and derive conditions for existence and a construction of dynamic rank-dependent utility processes.

Optimal dynamic risk sharing under the time-consistent mean-variance criterion

BIN LI

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ABSTRACT

We consider a dynamic Pareto-optimal risk sharing problem under the time-consistent mean-variance criterion. A group of n insurers is assumed to share an exogenous risk whose dynamics is modelled by a Levy process. By solving the extended Hamilton-Jacobi-Bellman equation and utilizing the Lagrangian method, an explicit form of the equilibrium bearing function for each insurer is obtained. We show that the equilibrium bearing functions are mixtures of two common risk sharing strategies, namely the proportional and stop-loss strategies. We also consider some extensions to the original model by adding in turn one of the following features: a risk sharing constraint on the insurers, a set of financial investment opportunities, and the insurers' ambiguity towards the exogenous risk.

Representation formulas for limit values of long run stochastic optimal control

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ABSTRACT

A classical problem in stochastic ergodic control consists of studying the limit behavior of the optimal value of a discounted integral in infinite horizon (the so called Abel mean of an integral cost) as the discount factor λ tends to zero or the value defined with a Cesaro mean of an integral cost when the horizon T tends to $+\infty$. We investigate the possible limits in the norm of uniform convergence topology of values defined through Abel mean or Cesaro means when $\lambda \to 0^+$ and $T \to +\infty$, respectively. Here we give two types of new representation formulas for the accumulation points of the values when the averaging parameter converges.

Based on a joint work with Rainer Buckdahn (Brest, France), Marc Quincampoix (Brest, France), Jérôme Renault (Toulouse, France).

Open-loop and closed-loop solvabilities for stochastic linear quadratic optimal control problems under Markov regime-switching system

Xun Li

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ABSTRACT

This work investigates the stochastic linear quadratic (LQ, for short) optimal control problem of Markov regime switching system. The representation of the cost functional for the stochastic LQ optimal control problem of Markov regime switching system is derived using the technique of Ito's formula. For the stochastic LQ optimal control problem of Markov regime switching system, we establish the equivalence between the open-loop (closed-loop) solvability and the existence of an adapted solution to the corresponding forward-backward stochastic differential equation with constraint (the existence of a regular solution to the Riccati equation). Also, we analyze the interrelationship between the strongly regular solvability of the Riccati equation and the uniform convexity of the cost functional.

Incomplete-market equilibria and BSDEs

ANDREW LYASOFF

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ABSTRACT

The connection between Pontryagin's maximum principle and general incomplete-market asset pricing models will be developed in both discrete and continuous time, leading to a new computational strategy. This approach can be viewed as a special type of mean-field intercations, except that the "mean-filed" is the agreement among the agents on the prices. It will be demonstrated in terms of concrete examples that the "exact law of large numbers" (Duffie and Sun 2012) is not always compatible with the canonical notion of equilibrium (i.e., independent random full matching, as in Duffie & Sun, may fail to exist) even in some of the classical examples of Bewley-Ayiagari-Huggett models of the economy – a seemingly unknown phenomenon. An alternative program, based on the dual method from (Dumas and Lyasoff 2012), will be developed and illustrated with concerete applications to the classical Huggett model of the (incomplete-market) economy.

Optimal auction duration: a price formation viewpoint

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ABSTRACT

We consider an auction market in which market makers fill the order book during a given time period while some other investors send market orders. We define the clearing price of the auction as the price maximizing the exchanged volume at the clearing time according to the supply and demand of each market participants. Then we derive in a semi-explicit form the error made between this clearing price and the fundamental price as a function of the auction duration. We study the impact of the behavior of market takers on this error. To do so we consider the case of naive market takers and that of rational market takers playing a Nash equilibrium to minimize their transaction costs. We compute the optimal duration of the auctions for 77 stocks traded on Euronext and compare the quality of price formation process under this optimal value to the case of a continuous limit order book. Continuous limit order books are found to be usually sub-optimal. However, in term of our metric, they only moderately impair the quality of price formation process. Order of magnitude of optimal auction durations is from 2 to 10 minutes.

From Hotelling to Nakamoto: the economic meaning of Bitcoin mining

CONG QIN

Soochow University, China

ABSTRACT

Although Bitcoin mining activities are widely discussed in the media, as miners attempt to profit from transaction fees, there are few academic papers studying the transaction fees. We proposed a model for Bitcoin transaction fees from the miners' perspective. The model is rich enough to incorporate both inventory and demand levels. The model is calibrated to the empirical data and dynamics of the average transaction fees are discussed. The model is made possible by significantly extending the classical Hotelling model for exhaustible natural resources, via the addition of both feedback supply and an S-shaped stochastic demand function.

Dynamic noisy rational expectations equilibrium with insider information

MARCEL RINDISBACHER

Boston University, USA

ABSTRACT

We study equilibria in multi-asset and multi-agent continuous-time economies with asymmetric information and bounded rational noise traders. We establish existence of two equilibria. First, a full communication one where the informed agents' signal is disclosed to the market, and static policies are optimal. Second, a partial communication one where the signal disclosed is affine in the in- formed and noise traders' signals. Here, information asymmetry creates a demand for a dark pool with endogenous participation where private information trades can be implemented. Markets are endogenously complete and equilibrium prices have a three factor structure. Results are valid for multiple dimensions; constant absolute risk averse investors; fundamental processes following a general diffusion; and non-linear terminal payoffs. Asset price dynamics and public information flows are endogenous, and are established using multiple filltration enlargements, in conjunction with predictable representation theorems for random analytic maps. Rational expectations equilibria are special cases of the general results.

From martingale optimal transport to Mckean-Vlasov control problems

Xiaolu Tan

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ABSTRACT

The Martingale Optimal Transport (MOT) problem consists in maximizing a reward value among a class of martingales with given marginal distributions. It is motivated by its application in finance to obtain the no-arbitrage price bounds of derivative options in a data calibrated market. We consider a class of MOT problems and show how it could be related to a McKean-Vlasov (mean-field) control problem, which is a large population control problem. We then study the dynamic programming principle and the numerical approximation of the McKean-Vlasov control problem.

Maximum principle for one kind of discrete-time stochastic optimal control problem and its applications

ZHEN WU

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ABSTRACT

This talk is concerned with one kind of discrete-time stochastic optimal control problem with convex control domains, for which necessary condition in the form of Pontryagin's maximum principle and sufficient condition of optimality are derived. Two illustrative examples are presented to illustrate the applications of the theoretical results, which includes a discrete-time investment/consumption choice problem. For this problem, the optimal investment and consumption strategy in an explicit form is derived The results can also be extended to two kinds of discrete-time stochastic games, and necessary as well as sufficient conditions are obtained for the equilibrium point of the nonzero-sum game and the saddle point of the zero-sum one. The purpose of this talk is to establish a rigorous version of discrete-time stochastic maximum principle in a clear and concise way and pave a road for further related research topics.

Multiple birds, one stone: can portfolio rebalancing contribute to disposition-effect-related trading patterns?

JING XU

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ABSTRACT

Extant theories on the disposition effect are largely silent on most of the disposition-effect-related trading patterns, including the V-shape results for probabilities of buying and selling against unrealized profit. On the other hand, portfolio rebalancing and learning have been shown to be important, even for retail investors. We show that if expected returns are unknown and transaction costs are nonzero, then rational rebalancing alone can predict many disposition-effect-related trading patterns, including the V-shape results. Our paper complements the extant theories by suggesting that portfolio rebalancing may also constitute a significant driving force behind the disposition effect.

(This is a joint work with Min Dai and Hong Liu)

Optimal investment, heterogeneous consumption and the best time for retirement

ZUOQUAN XU

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ABSTRACT

This paper studies an optimal investment and consumption problem with heterogeneous consumption of basic and luxury goods, together with the choice of time for retirement. The utility for luxury goods is not necessarily a concave function. The optimal heterogeneous consumption strategies are shown to consume only basic goods when the wealth is small, to consume basic goods and make savings when the wealth is intermediate, and to consume small portion in basic goods and large portion in luxury goods when the wealth is large. The optimal retirement policy is shown to be universal, in the sense that all individuals should retire at the same level of marginal utility. This level is determined only by income, labor cost as well as market parameters, but independent of individual's utility, which could have important policy implications for government in making pension and retirement age decisions. It is also shown that individuals prefer to retire as time goes by if the marginal labor cost increases faster than that of income. The main tools used in analyzing the problem are from PDE and stochastic control theory including viscosity solution, variational inequality and dual transformation. This is a joint work with Harry Zheng at Imperial College London.

Switching diffusions with mean-field interactions

GEORGE YIN

Wayne State University, USA

ABSTRACT

We study switching diffusions with mean-field interactions. The motivation stems from regime-switching control systems and risk management involving mean-field terms, in which the random switching is modeled as a continuous-time Markov chain. We first obtain a law of large numbers of empirical measures. In contrast to the existing literature, the limit measure is not deterministic but random, characterized by the conditional distribution (given the history of the switching process) of the solution to a stochastic McKean-Vlasov differential equation with Markovian switching. Then stochastic maximum principles for switching diffusions are established. As an example, we examine LQG with Markovian switching and mean-field interactions. [Joint works with Son Luu Nguyen, Tuan Anh Hoang, and Dung Tien Nguyen.]

Equilibrium recursive utility and dynamic risk measure by backward stochastic Volterra integral equations

JIONGMIN YONG

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ABSTRACT

A continuous-time recursive utility process (or stochastic differential utility) for a given future payoff can be represented by the adapted solution to some backward stochastic differential equation (BSDE, for short). At the same time, a dynamic risk measure for a terminal payoff can also be represented by the adapted solution to a BSDE. Now, for a financial position process (which is not just a random variable and not necessary adapted), how one can define the corresponding recursive utility process and/or dynamic risk measure process. This can be successfully done by the adapted solution to the backward stochastic Volterra integral equation (BSVIEs, for short). In this talk, we will present an updated theory of BSVIEs, and obtain the equilibrium recursive utility process as well as equilibrium dynamic risk measure process, which all turn out to be time-consistent.

Weak solutions of mean field game master equations

Jianfeng Zhang

University of Southern California, USA

ABSTRACT

In this talk we consider master equations arising from mean field game problems, under the Lasry-Lions monotonicity condition. Classical solutions of such equations typically require very strong technical conditions. Moreover, unlike the equations arising from mean field control problems, the mean field game master equations are non-local and even classical solutions often do not satisfy the comparison principle, so the standard viscosity solution approach seems infeasible. We shall propose a new notion of weak solutions for such equations and establish its wellposedness. For the crucial regularity in terms of the measures, we construct a smooth mollifier for functions on Wasserstein space, which is new in the literature and is interesting in its own right. The talk is based on a joint work with Chenchen Mou.

Pairs trading under geometric Brownian motions

QING ZHANG

University of Georgia, USA

ABSTRACT

This talk is about an optimal strategy for simultaneously trading of a pair of stocks. The idea of pairs-trading is to monitor their price movements and compare their relative strength over time. A pairs trade is triggered by their prices divergence and consists of a pair of positions to short the strong stock and to long the weak one. Such strategy bets on the reversal of their price strengths. From the viewpoint of technical tractability, typical pairs trading models assume a difference of the stock prices follows a mean reversion equation. In this talk, we consider the optimal pairs-trading problem by allowing the stock prices to follow general geometric Brownian motions. The objective is to trade the pairs over time to maximize an overall return with a fixed commission cost for each transaction. The optimal policy is characterized by threshold curves obtained by solving the associated HJB equations. Numerical examples are included to demonstrate the dependence of our trading rules on various parameters and to illustrate how to implement the results in practice. Finally, some recent progress along this direction will also be presented.

Constrained quadratic risk minimization via primal-dual FBSDEs and deep learning

Harry Zheng

Imperial College London, UK

ABSTRACT

In this paper we study a stochastic control problem arising from mathematical finance. The goal is to minimize a quadratic cost function in a continuous time model with random market parameters and portfolio constraints. Following a convex duality approach, we prove the necessary and sufficient conditions for both the primal and dual problems in terms of fully coupled constrained FBSDEs. This allows us to explicitly characterise the primal control as a function of adjoint process coming from the dual FBSDEs in a dynamic fashion and vice versa. We show the usefulness of the dual approach with several examples, in particular, we give the explicit representation of the solution to the extended stochastic Riccati equation. Finally, we propose a deep learning primal-dual algorithm to solve fully coupled constrained FBSDEs.