International Summer School, Moscow, 26-30 Augiust 2019

Abstracts

Principal lectures

Pierre CARDALIAGUET (Paris-Dauphine)
Mean field games with a major player
We shall present the general model, discuss its theoretical foundation and review some of applications.

Bruno BOUCHARD (Paris-Dauphine)
Hedging with price impact
We shall discuss the possibility of considering price impact effects in the hedging of options. We will consider two situations. In the first one, the option is non-covered, meaning that the premium is paid in cash, and the payoff is settled in cash or stocks, according to the specifications of the option. In the second case, the option is covered, meaning that the seller chooses the amounts of stocks and cash he wants to receive as the payment of the premium, and can pay the payoff indifferently in stocks and cash.

Zhenjie REN (Paris-Dauphine)
An introduction to second-order backward stochastic differential equation (BSDE)
As a non-trivial extension to the BSDE theory, the second-order BSDE was introduced and studied in the last decade in order to analyse the volatility-control problem (with applications mainly in finance). It provides an Ito-process representation for the value process of the corresponding control problem, which, in particular, turns out to be crucial in the application of Principal-Agent problem. In the course, we shall show the main wellposedness theorems (existence, uniqueness, etc.) for the second-order BSDE on both finite horizon and random horizon.

Peter TANKOV (ENSAE)
Electricity markets and electricity trading
We shall review the role, structure and operation of different electricity markets, with a focus on Western European ones, including the recent evolutions provoked by the arrival of renewable energy and consumers/producers. Main differences and similarities with financial markets will be discussed, and strategies for trading and derivatives pricing will be reviewed.

Josef TEICHMANN (ETH Zurich)
Machine Learning in Finance
We shall present theoretical foundations and implementations of machine learning algorithms for Deep Hedging, Deep calibration, Deep Portfolio Optimization, and Deep Simulation.

Nizar TOUZI (Ecole polytechnique)
Principal-Agent problem.
The Principal-Agent problem is the corner stone for the modeling of optimal incentive schemes to account for moral hasard in economics. The problem is formulated as a Stackelberg game or two-stage optimization problem: the agent optimizes his effort, given the incentive proposed by the principal; the principal in turn optimizes her incentive given the optimal response of the agent. We provide a systematic method for solving this problem in continuous time, based on the dynamic

programming approach applied to the agent problem combined with a stochastic integral representation problem. The latter is a path-dependent version of the Hamilton-Jacobi-Bellman equation. The main result is a reduction of the Stackelberg game to a standard stochastic control problem. The method can be extended in various directions: random horizon, jump-diffusion dynamics, limited liability, multiple agents.

Contributed talks

Anna A. OBIZHAEVA (New Economic School, Moscow)

Dimensional Analysis, Leverage Neutrality, and Market Microstructure Invariance
We combine dimensional analysis, leverage neutrality, and a principle of market microstructure invariance to derive scaling laws expressing transaction costs functions, bid-ask spreads, bet sizes, number of bets, and other financial variables in terms of dollar trading volume and volatility. The scaling laws are illustrated using data on bid-ask spreads and number of trades for Russian and U.S. stocks. These scaling laws provide practical metrics for risk managers and traders; scientific benchmarks for evaluating controversial issues related to high frequency trading, market crashes, and liquidity measurement; and guidelines for designing policies in the aftermath of financial crisis. The talk is based on a joint work with Albert S. Kyle.

Dean FANTAZZINI (Moscow Economic School)

Presentation the book *Quantitative finance with R and cryptocurrencies.*

Olga S. ROZANOVA (Moscow State University)
Some analytically solvable problems of the mean field game theory and their applications to the study of market behavior

We study the mean field games equations, consisting of the coupled Kolmogorov - Fokker- Planck and Hamilton - Jacobi – Bellman equations. The equations are complemented by initial and terminal conditions. We show that with some specific choice of data, this problem can be reduced to solving a quadratically nonlinear system of ODEs. This situation occurs naturally in economic applications. As an example, we give a problem of forming an investor's opinion on an asset. Namely, we consider a market in which a large number of investors manage their own portfolio of securities, which includes the asset under consideration. Each investor solves the problem of maximizing a utility function of the capital, which is common for all investors, based on its own ideas about the true characteristics of the asset (trend and volatility). Investors get a penalty both for a deviation from the opinion of the majority and for deviation from the true values of trend and volatility, unknown for investors. The problem is to study the behavior of maxima of distribution of trend and volatility as a function of time, that is, to track how the opinion of the majority of investors about the asset changes in response to the method of control.
The talk is based on a joint work with Sergey Nikulin.

Mikhail ZHITLUKHIN (Steklov Mathematical Institute)
Optimal investment in markets with competition

We consider a game-theoretic model of a market where investors compete for payoffs yielded by several short-lived assets. The main result consists in a proof of existence and uniqueness of a

strategy, called relatively optimal, such that the logarithm of its wealth is a submartingale for any strategies of the competitors. It is also shown that this strategy has a number of other asymptotic optimality properties related to the growth of wealth generated by it. Based on the obtained results, we then study the asymptotic structure of the market when all the investors use the relatively optimal strategy.

Dmitry MURAVEI (Skolkovo)
Trading multiple mean reversion

We consider a utility maximization problem for the portfolio consisting of n-dimensional Ornstein-Uhlenbeck process. For the power utility investor, we derive semi-analytical formulas for optimal control and obtain some interesting qualitative results which are not appeared in the one-dimensional case. In particular, we prove that the value of the Bellman function is minimal if processes are not correlated. We also present an efficient ODE-based approach to analyze effects on parameters misspecification and demonstrate it on the estimations of the reversion speeds.

Oleg E. KUDRYAVTSEV (Russian Customs Academy Rostov branch, Rostov-on-Don)
Numerical methods for computing risk measures in Lévy models

Among the risk management tools promoted by the Basel committee, the most popular is the Value-at-Risk (VaR) which measures the potential loss in value of a risky asset or portfolio over a defined period for a given confidence interval. However, the measure does not give us the probability of the likely loss within that horizon. The latter risk measure is known as intra-horizon VaR (or iVaR). On the other side, it is also important to measure liquidity risks. An expected difference between the maximal stock price over the period and the price in the end of the period gives an upper bound for the value of the stock illiquidity. In both frameworks, the key object of interest is the extremum of the price process at a fixed time. In the talk, we suggest efficient numerical methods to compute the indicated risk measures in models admitting jumps. This work was supported by the RFBR (project 18-01-00910).

Practical part I. Integral transform methods for computing risk measures in Lévy models.
Practical part II. Monte Carlo methods for computing risk measures in Lévy models.