SECOND NUS-UPARIS DIDEROT WORKSHOP ON QUANTITATIVE FINANCE

14-15 September 2015

France

Jointly organized by:

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

université PARIS DIDEROT PARIS 7

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- ❖ Huyên PHAM (University Paris Diderot, France)
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Programme Overview

Monday 14 September 2015	Tuesday 15 September 2015
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10:20 – 10:50 Group Photo & Tea break	**10:20 – 10:50** Tea Break
10:50 – 11:30 Steven KOU	**10:50 – 11:30** Min DAI
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13:30 – 14:10 Mathieu ROSENBAUM	**13:30 – 14:10** Frédéric ABERGEL
14:10 – 14:50 Hao XING	**14:10 – 14:50** Fahuai YI
14:50 – 15:30 Chao ZHOU	**14:50 – 15:30** Jean-François CHASSAGNEUX
15:30 – 16:00 Tea Break	**15:30 – 16:00** Tea Break
16:00 – 16:40 Marie-Claire QUENEZ	**16:00 – 16:25** Amine ISMAIL
16:40 – 17:05 Wei JIANG	**16:25 – 16:50** Jiatu CAI
17:05 – 17:30 Pierre GRUET	**16:50 – 17:15** Jing XU
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* Please note that the first talk on the second day starts at 9 am.

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11:30 – 12:10	**Laurence CARASSUS** University of Reims Champagne-Ardenne, France *Non-Concave Utility Maximisation in Discrete Time*	5
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13:30 – 14:10	**Mathieu ROSENBAUM** Université Pierre et Marie Curie, France *The Microstructural Foundations of Rough Volatility Models*	10
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10:50 – 11:30	**Min DAI** National University of Singapore, Singapore *Singular Stochastic Control in Optimal Investment*	6
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Abstract

Mathematical Structure of Limit Order Books
Frédéric ABERGEL, École Centrale Paris, France

In this talk, I will comment on the mathematical structure of Markovian order books. The role of cancellations will be addressed, and some results pertaining to the behaviour of Hawkes process-driven LOB will be presented.

Asymptotic Lower Bounds for Optimal Tracking:
A Linear Programming Approach
Jiatu CAI, Université Paris Diderot, France

We consider the problem of tracking a target whose dynamics is modeled by a continuous Itô semi-martingale. The aim is to minimize both deviation from the target and tracking efforts. We establish the existence of an asymptotic lower bound for the corresponding control problem, which can be related to the time-average control problem of Brownian motion. A comprehensive list of examples with explicit expressions for the lower bounds is also provided.

This is a joint work with Mathieu Rosenbaum and Peter Tankov.

Non-Concave Utility Maximisation in Discrete Time
Laurence CARASSUS, University of Reims Champagne-Ardenne, France

This talk will investigate the problem of maximizing expected terminal utility in a (generically incomplete) discrete-time financial market model with finite time horizon. We will present the case of a non-concave utility function U with domain of definition either equal to $(0,\infty)$ or to $\mathbb{R}$ under various assumptions. It is based on three joint papers:

- L. Carassus and M. R\'asonyi. Maximization of non-concave utility functions in discret-time financial market. To appear in Math. Oper. Res., 2015.

- L. Carassus, R\'asonyi M., and A. M. Rodrigues. Non-concave utility maximisation on the positive real axis in discrete time. Mathematics and Financial Economics, DOI 10.1007/s11579-015-0146-4 2015.

- L. Carassus, R\'asonyi M., and R. Blanchard. No arbitrage condition and Non-concave utility maximisation in discrete time. Preprint.

Numerical Approximation of Switching Problem
Jean-François CHASSAGNEUX, Université Paris Diderot, France

In my talk, I will discuss the discrete time approximation of a special kind of reflected BSDEs, which are linked to optimal switching problem. After introducing the obliquely reflected BSDEs, I will build a scheme for their approximation. Then, I will present the main difficulties encountered to prove convergence results: in particular the stability issue for the scheme.

Singular Stochastic Control in Optimal Investment
Min DAI, National University of Singapore, Singapore

I talk about two singular stochastic control problems arising from optimal investment: one with transaction costs and the other with capital gains taxes. The associated value functions are governed by variational inequality equations which give rise to two free boundaries corresponding to optimal buy and sell boundaries. The difference between the two models is emphasized.

No-Arbitrage Conditions in HJM Multiple Curve Term Structure Models
Zorana GRBAC, Université Paris Diderot, France

Multiple interest rate curves emerged in the fixed income markets as a consequence of the financial crisis, which created a need for new interest rate models referred to in general as multiple curve models. The goal of this talk is to present several possible extensions of the classical HJM setup to include multiple curves and to study the related no-arbitrage drift conditions. Based on a specific interpretation of the interest rates and the implied zero coupon bonds in a given multiple curve HJM-type model, we shall distinguish between what we call "true" and "pseudo" no-arbitrage conditions. We then derive the corresponding drift conditions in each model and discuss their relationship.

This is joint work with Wolfgang RUNGGALDIER.

Efficient Estimation in a Two-Factor Model from Historical Data: Application to Electricity Prices
Pierre GRUET, Université Paris Diderot, France

We aim at modeling the prices of forward contracts on electricity, by adopting a stochastic model with two Brownian motions as stochastic factors to describe their evolution over time. In contrast to the model of (Kiesel *et al.*, 2009), the diffusion coefficients are stochastic processes; the one of the first factor is left totally unspecified, and the other one is the product of an unspecified process and of an exponential function of time to the maturity of the forward contract. This exponential term is characterized by a positive parameter, measuring the rate of increase of the second factor as we are moving toward the maturity. As a source of randomness, the second factor is thus important at short term, and is neglictable at long term.

We will consider that price processes following this model are observed simultaneously, in discrete time, over a given time interval. This is a high-frequency framework, in which we estimate the parameter of the exponential factor in volatility, with the usual rate. We explain how it can be estimated efficiently in the Cramér-Rao sense. We are also able to estimate the trajectories of the two unspecified volatility processes, using nonparametric methods, with the standard rate of convergence.

Numerical tests are performed on simulated data and on real prices data, so that we may see how appropriate our two-factor model is when applied to those data.

This is a joint work with Olivier FÉRON (EDF, France) and Marc HOFFMANN (Université Paris-Dauphine).

Some references:
• Fred Espen BENTH and Steen KOEKEBAKKER. Stochastic modeling of financial electricity contracts. *Energy Economics*, 30:1116–1157, 2008.
• Juri HINZ, Lutz von GRAFENSTEIN, Michel VERSCHUERE, and Martina WILHELM. Pricing electricity risk by interest rate methods. *Quantitative Finance*, 5(1):49–60, 2005.
• Rüdiger KIESEL, Gero SCHINDLMAYR, and Reik H. BÖRGER. A two-factor model for the eletricity forward market. *Quantitative Finance*, 9(3):279–287, April 2009.

Regime Switching Stochastic Volatility Model : Estimation and Calibration to VIX options
Amine ISMAIL, Université Paris Diderot, France

We develop and implement a method for maximum likelihood estimation of a regime switching stochastic volatility model. Our model uses a continuous time stochastic process for the stock dynamics with the instantaneous variance driven by a Cox-Ingersoll-Ross (CIR) process and each parameter modulated by a hidden Markov chain. We propose an extension of the EM algorithm through the Baum-Welch implementation to estimate our model and filter the hidden state of the Markov chain while using the VIX index to invert the latent volatility state. Using Monte Carlo simulations, we test the convergence of our algorithm and compare it with an approximate likelihood procedure where the volatility state is replaced by the VIX index. We found that our method is more accurate than the approximate procedure .Then, we take advantage of Fourier methods to derive a semi-analytical expression of S\&P 500 and VIX option prices which we calibrate to market data. We show that the model is rich enough to encapsulate important features of the joint dynamics of the stock and the volatility and to fit consistently option market prices.

Simulating Risk Measures
Wei JIANG, National University of Singapore, Singapore

Risk measures, Value-at-risk (VaR), defined as the p quantile: $v(p) = \inf\{x : F(x) \geq p\}$, and Expected Shortfall (ES), defined as the expected loss beyond VaR: $E(L|L < v(p))$ play vital role in risk management. When simulate risk measures, how to choose a proper simulation method and how to evaluate its performance tend to be the main points of concern. Crude Monte Carlo is chose due to three reasons: easy programming, fast computing and simple evaluating. Certain algorithm is proposed to simulate risk measures and to be compared with naive one in terms of computational complexity. We propose the method to evaluate simulations with relative error (RE). Based on RE, we are able to determine a proper sample size and to compare performance of simulations across different estimators. We derive the approximation formulas for moments of ES estimator, the approximations of REs for both VaR and ES estimators, as well as approximation formulas for sample sizes. Our theoretical comparison results implying the superior of VaR, i.e., under some regular conditions, the ratio of REs of VaR and ES is always less than 1 for small p.

This is a joint work with Steven KOU (National University of Singapore, Singapore).

Key words: Crude Monte Carlo, Value-at-risk, Expected Shortfall, Order Statistics, Efficiency

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Comparison Theorem in Spatial Birth and Deaths Processes with application to Population Dynamics
Nicole El KAROUI, Université Pierre et Marie Curie, France

Microsimulation takes an increasing place in different areas as microeconomics, demographics, finance,… Motived by longevity issues, we have studied for a long time, a human population model where the population is subject to multiple changes at the level of individuals, who have demographic intensities linked to birth, death and evolution of their characteristics. Results are very complex to analyze, and comparison issues appears as an useful tools. The representation of SBD process as "thinned" from a Spatial Poisson measure allows to pathwise comparison. The role of aging population will highlight by the links with Hawkes processes, widely used in financial and actuarial mathematics. More generally, this point of view may be used to analyze the evolution of loans portfolio, or heterogeneous credit portfolio.

On the Measurement of Economic Tail Risk
Steven KOU, National University of Singapore, Singapore

This paper attempts to provide a decision-theoretic foundation for the measurement of economic tail risk, which is not only closely related to utility theory but also relevant to statistical model uncertainty. The main result is that the only tail risk measure that satisfies a set of economic axioms proposed by Schmeidler (1989, Econometrica) and the statistical property of elicitability (i.e. there exists an objective function such that minimizing the expected objective function yields the risk measure; see Gneiting (2011, J. Amer. Stat. Assoc.)) is median shortfall, which is the median of tail loss distribution. Elicitability is important for backtesting. Median shortfall has a desirable property of distributional robustness with respect to model misspecification. We also extend the result to address model uncertainty by incorporating multiple scenarios. As an application, we argue that median shortfall is a better alternative than expected shortfall for setting capital requirements in Basel Accords.

This is a joint work with Xianhua PENG.

Reflected Backward Stochastic Differential Equations with a Non Right-Continuous Obstacle
Marie-Claire QUENEZ, Université Paris Diderot, France

In the first part of the paper, we study reflected backward stochastic differential equations (RBSDEs) with lower obstacle which is assumed to be right upper-semicontinuous but not necessarily right-continuous. We prove existence and uniqueness of the solutions to such RBSDEs in appropriate Banach spaces. The result is established by using some tools from the general theory of processes such as Mertens decomposition of optional strong (but not necessarily right-continuous) supermartingales, some tools from optimal stopping theory, as well as an appropriate generalization of Itô's formula due to Gal'chouk and Lenglart. In the second part of the paper, we provide some links between the RBSDE studied in the first part and an optimal stopping problem in which the risk of a financial position ξ is assessed by an f-conditional expectation $\mathcal{E}^f(\cdot)$ (where f is a Lipschitz driver). We characterize the "value function" of the problem in terms of the solution to our RBSDE. Under an additional assumption of left upper-semicontinuity along stopping times on ξ, we show the existence of an optimal stopping time. We also provide a generalization of Mertens decomposition to the case of strong $\mathcal{E}^f$-supermartingales.

Authors: Miryana Grigorova & Peter Imkeller, Humboldt Universität zu Berlin, Germany; Elias Offen, University of Botswana, Botswana; Youssef Ouknine, Université Cadi Ayyad, Morocco; and Marie-Claire Quenez, Université Paris-Diderot, France

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The Microstructural Foundations of Rough Volatility Models
Mathieu ROSENBAUM, Université Pierre et Marie Curie, France

It has been recently shown that rough volatility models reproduce very well the statistical properties of low frequency financial data. In such models, the volatility process is driven by a fractional Brownian motion with Hurst parameter of order 0.1. The goal of this talk is to explain how such fractional dynamics can be obtained from the behaviour of market participants at the microstructural scales. Using limit theorems for Hawkes processes, we show that a rough volatility naturally arises in the presence of high frequency trading combined with metaorders splitting.

This is joint work with Thibault JAISSON.

Expected Utility Maximization under Incomplete Information and with Cox-Process Observations
Wolfgang RUNGGALDIER, University of Padova, Italy

We consider the portfolio optimization problem for the criterion of maximization of expected terminal utility (log-and power-utility). The underlying market model is a regime-switching diffusion model where the regime is determined by an unobservable factor process forming a finite state Markov process. The main novelty is due to the fact that prices are observed and the portfolio is rebalanced only at random times corresponding to a Cox process where the intensity is driven by the same unobserved Markovian factor process. This leads to a more realistic modeling for many practical situations, like in markets with liquidity restrictions; on the other hand it considerably complicates the problem to the point that traditional methodologies cannot be directly applied.

This is a joint work with Kazufumi FUJIMOTO and Hideo NAGAI.

Hedging Under Multiple Risk Constraints
Peter TANKOV, Université Paris Diderot, France

Motivated by the asset-liability management problems under shortfall risk constraints, we consider in a general discrete-time framework the problem of finding the least expensive portfolio whose shortfalls with respect to a given set of stochastic benchmarks are bounded by a specific shortfall risk measure. We first show how the price of this portfolio may be computed recursively by dynamic programming for different shortfall risk measures, in complete and incomplete markets. We then focus on the specific situation where the shortfall risk constraints are imposed at each period on the next period shortfalls, and obtain explicit results. Finally, we apply our results to a realistic asset-liability management problem of an energy company, and show how the shortfall risk constraints affect the optimal hedging of liabilities.

This is a joint work with Ying JIAO and Olivier KLOPFENSTEIN.

Consumption Investment Optimization with Epstein-Zin Utility in Incomplete Markets
Hao XING, London School of Economics and Political Science, United Kingdom

In a market with stochastic investment opportunities, we study an optimal consumption investment problem for an agent with recursive utility of Epstein-Zin type. Focusing on the empirically relevant specification where both the risk aversion and the elasticity of intertemporal substitution are in excess of one, we characterize optimal consumption and investment strategies via backward stochastic differential equations. The state price density is also obtained, meeting demands from applications where Epstein-Zin utilities were used to resolve several asset pricing puzzles. The empirically relevant utility specification introduces difficulties to the optimization problem due to the fact that the Epstein-Zin aggregator is neither Lipschitz nor jointly concave in all its variables.

A Rational Explanation of Disposition Effect
Jing XU, National University of Singapore, Singapore

Disposition effect has been widely documented and behavioral types of explanations have dominated in the literature. In this paper, we develop an optimal portfolio rebalancing model in the presence of transaction costs and committed consumption. We show that almost all of the disposition effect patterns found in the existing literature are consistent with optimal trading strategies implied by our model. In addition, selling winners that subsequently outperform held losers on average can be optimal. Therefore, it becomes an empirical question how much disposition effect cannot be explained by optimal portfolio rebalancing.

Debt-Equity Swap in Finite Time Horizon
Fahuai YI, South China Normal University, China

This talk concerns the finite-horizon optimal reorganization problem under debt-equity swap. The model of equity is formulated as a parabolic variational inequality, or equivalently, a free boundary problem, where the free boundary corresponds to the optimal reorganization boundary. The existence and uniqueness of the solution (value function) are proven and the behavior of the free boundary, such as smoothness, monotonicity and boundedness, is studied. In addition, we present numerical results, financial interpretations and monotonicity of free boundary with respect to volatility and risk free rate.

Stochastic Control for a Class of Nonlinear Kernels
Chao ZHOU, National University of Singapore, Singapore

A stochastic control problem for a class of nonlinear stochastic kernels is studied. We prove a dynamic programming principle (DPP) for the value function by a measurable selection argument and consider several applications of the DPP.

This is a joint work with Dylan POSSAMAI and Xiaolu TAN.