Department of Mathematics

Joint Risk & Stochastics and Financial Mathematics Seminar in 2018/19

Seminars are listed in reverse chronological order, most recent first

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Wednesday 8 May - Guy Flint

A primer on rough path theory

Stochastic differential equations provide a way to describe the evolution of a multidimensional system affected by some stochastic input signal:

\[

dy_t = V(y_t)\, dx_t, \, \, \, y_0 = \xi \in \mathbb{R}^q.

\]

As it is random, $x = (x_t) \subset\mathbb{R}^d$ is typically highly oscillatory and thus far from differentiable. Traditionally we can use It\^{o} calculus to define a solution to the differential equation but the It\^{o} mapping, $\pi = (\pi_t) : x \mapsto y$, is not continuous in the uniform topology unless $d=1$ or we impose very restrictive conditions on the vector field V. For example, given two correlated Brownian motions W_1,W_2, stochastic calculus cannot be used to make useful quantitative statements about the difference in their outputs:

\[

\sup_{t\in [0,1]} \| \pi_t(W_1) - \pi_t(W_2) \|.

\]

Rough path theory solves this predicament by lifting the original input x into a path in a higher-dimensional Lie group. This so-called rough path encodes enough extra information to make such continuity statements precise. In fact, the estimates can be factored into deterministic and stochastic parts which has enabled simple proofs

of fundamental results in stochastic analysis as well as providing the motivating example for the theory of regularity structures, (the latter was used in Martin Hairer's Fields medal-winning work on the KPZ equation).
This talk aims to provide a primer on the main ideas of rough path theory. With a minimum of Lie group theory, we hope to show some examples on how rough paths can be used by the non-specialist.

Thursday 4 April - Michael Kupper (University of Konstanz)

Computation of model-free hedging problems via penalization and neural networks
We present a widely applicable approach to solving model-free hedging problems via neural networks. The core idea is to penalize the optimization problem in its dual formulation and reduce it to a finite dimensional one which corresponds to optimizing a neural network with smooth objective function. As an application we discuss a version of the martingale transport problem with homogeneous stock movements and illustrate the approach with several numerical examples. The talk is based on joint work with Stephan Eckstein.

Lent Term 2019

Thursday 28 March - Flavia Barsotti

Behavioural modeling: contagion effects among customers' decisions and macroeconomic drivers
The aim of the talk is to present a methodological approach suitable to model customers' behaviours by embedding i) correlation and contagion effects among their decisions and ii) the role of macroeconomic factors. The proposed approach is suitable to model both stable economic regimes and stress scenarios. As an example, the problem of lapse risk will be discussed. The mathematical setting assumes the lapse intensity following a dynamic contagion process with both endogenous and exogenous jump components. This allows to capture both correlation and contagion potentially arising among customers' behaviours and the macroeconomic driver. The shot-noise intensity is then not constant and the resulting intensity process is not Markovian. Closed-form expressions and analytic sensitivities for the moments of the lapse intensity are provided, showing how lapses can be affected by massive copycat behaviours. Further analyses are then conducted to illustrate how the mean risk varies depending on the model's parameters.

Friday 22 March - Oleksii Mostovyi (University of Connecticut)

Optimal consumption from investment and labor income in a unifying framework of admissibility

We consider a problem of optimal consumption from investment and labor income in an incomplete semimartingale market. We introduce a set of constraint times, i.e., a set of stopping times, at which the wealth process must stay positive, in a unifying way such that borrowing against the future income might be allowed or prohibited. Upon this, we increase dimensionality and treat as arguments of the value function not only the initial wealth but also a function that specifies the amount of labor income. Assuming finiteness of the primal and dual value functions and that the labor income is superreplicable (these are essentially the minimal model assumptions), we establish the existence and uniqueness of a solution to the underlying problem and provide several characterizations of the optimizer and the value functions. This talk is based on the joint work with Mihai Sirbu.

Thursday 21 March - Hyeng Keun Koo (Ajou University)

Duesenberry, Long-term Wealth Management, and Asset Pricing

I will talk about Duesenberry's theory of consumption and propose a formal model of the theory. I will show how the model can be used for long-term investors' risk management. I will also discuss asset pricing implications of the model.

Thursday 14 March - Lukas Gonon (University of St.Gallen)

Reservoir Computing with Stochastic Inputs: Universality, Error Bounds and Financial Applications

We study dynamic machine learning for discrete-time stochastic processes based on reservoir computing. Putting particular emphasis on echo state networks, we present results on universal approximation properties as well as error bounds for learning tasks based on these systems. Finally, we apply them to the problem of predicting realized covariances of financial time series.

The talk is based on joint works with Juan-Pablo Ortega and Lyudmila Grigoryeva.

Thursday 28 February - Pierre-Olivier Goffard (ISFA)

Fraud risk assessment within blockchain transactions

The probability of successfully spending twice the same bitcoins is considered. A double-spending attack consists in issuing two transactions transferring the same bitcoins. The first transaction, from the fraudster to a merchant, is included in a block of the public chain. The second transaction, from the fraudster to himself, is recorded in a block that integrates a private chain, exact copy of the public chain up to substituting the fraudster-to-merchant transaction by the fraudster-to-fraudster transaction. The double-spending hack is completed once the private chain reaches the length of the public chain, in which case it replaces it. The growth of both chains are modeled by two independent counting processes. The probability distribution of the time at which the malicious chain catches up with the honest chain, or equivalently the time at which the two counting processes meet each other, is studied. The merchant is supposed to await the discovery of a given number of blocks after the one containing the transaction before delivering the goods. This grants a head start to the honest chain in the race against the dishonest chain.

A preprint is available on my website.

Thursday 14 February - Sara Svaluto-Ferro (University of Vienna)

Infinite dimensional polynomial jump-diffusions

We introduce polynomial jump-diffusions taking values in an arbitrary Banach space B via their infinitesimal generator. We obtain two representations of the (conditional) moments in terms of solution of a systems of ODEs on $(R, B^*, \dots, (B \otimes k)^*)$ and $(R, B^{**}, \dots, (B \otimes k)^{**})$, respectively. We illustrate how the well known moment formulas for finite dimensional polynomial jump diffusions can be deduced in this general framework. As an application, we consider probability measure-valued polynomial diffusions and polynomial forward variance curve models.

Thursday 31 January - Hyejin Cho (Université de Paris)

The Order-theoretic Single Crossing Property in a One-Dimensional Screening Model:

We consider a finite one-dimensional screening of choices in monotone comparative statics (MCS). Before revealing the true state of the world, a principal sorts on actions of the agent to cause the social value of production as an informed principal. The model produces a rich order-theoretic single-crossing property according to Pick's theorem pursuing no distortion at the top.

Thursday 17 January - Mykhaylo Shkolnikov (Princeton University)

Particles interacting through the hitting times: an application to systemic risk
I will discuss a class of particle systems that form a natural framework for the study of systemic risk. The interaction between the particles falls into the mean field framework pioneered by McKean and Vlasov in the late 1960s, but many new phenomena arise due to the singularity of the interaction. The most striking of them is the loss of regularity of the particle density caused by the self-excitation of the system, which triggers systemic crises. Mathematically, the evolution of the system can be captured initially by a suitable Stefan problem, while the following irregular behavior necessitates a more robust probabilistic approach. Extensions to the setting where the interaction takes place on networks will be also discussed. Based on joint works with Sergey Nadtochiy.

Thursday 17 January - Adam Iqbal (Goldman Sachs)

Book presentation
Volatility - Practical Options Theory

Thursday 13 December - Charles Bertucci (Université Paris-Dauphine)

Optimal stopping in mean field games
Mean field games are model in which a continuum of indistinguishable players face a game in which they interact between each other only through mean field terms. Such models have been introduced by Lasry and Lions in 2006. The most commonly studied case is the one in which the players control their velocity and interacts through a running/terminal cost. I will begin by recalling the main features of this seminal model as well as some results. Then I will explain how we can establish new results in a mean field game in which the players can decide to exit the game.

Thursday 29 November - Tiziano De Angelis (University of Leeds)

Dynkin games with incomplete and asymmetric information
We study Nash equilibria for a two-player zero-sum optimal stopping game with incomplete and asymmetric information. In our set-up, the drift of the underlying diffusion process is unknown to one player (incomplete information feature), but known to the other one (asymmetric information feature).
We formulate the problem and reduce it to a fully Markovian setup where the

uninformed player optimises over stopping times and the informed one uses randomised stopping times in order to hide their informational advantage. Then we provide a general verification result which allows us to find Nash equilibria by solving suitable quasi-variational inequalities with some non-standard constraints. Finally, we study an example with linear payoffs, in which an explicit solution of the corresponding quasi-variational inequalities can be obtained.

The talk is based on https://arxiv.org/abs/1810.07674

Thursday 15 November - Miklos Rasonyi (CEU)

Ergodic properties of certain financial models
We consider certain Markov chains in random environments and prove their stochastic stability as well as a law of large numbers for their functionals. The results apply, in particular, to variants of rough volatility models which can be regarded as Markov chains in a Gaussian stationary environment.

Thursday 8 November - Johannes Muhle-Karbe (Carnegie Mellon University)

A Risk-Neutral Equilibrium Leading to Uncertain Volatility Pricing
We study the formation of derivative prices in equilibrium between risk-neutral agents with heterogeneous beliefs about the dynamics of the underlying. Under the condition that the derivative cannot be shorted, we prove the existence of a unique equilibrium price and show that it incorporates the speculative value of possibly reselling the derivative. This value typically leads to a bubble; that is, the price exceeds the autonomous valuation of any given agent. Mathematically, the equilibrium price operator is of the same nonlinear form that is obtained in single-agent settings with strong aversion against model uncertainty. Thus, our equilibrium leads to a novel interpretation of this price. (Based on joint work with Marcel Nutz)

Thursday 1 November - Kwok Chuen Wong (DCU)

Portfolio Optimisation with Semivariance
In this talk, I shall investigate dynamic portfolio management using semivariance of portfolio payoff as a portfolio risk measure. Comparing with variance which is widely used in the literature, semivariance is considered to be more plausible risk measure because semivariance penalizes adverse situations only. However, in the literature, it was shown that mean-semivariance optimisation under the Black-Scholes model has

no optimal solution.
Inspired by this non-existence result, I shall establish necessary and sufficient conditions under which the mean-semivariance optimisation possesses an optimal solution. I shall suggest the models under which such sufficient conditions are satisfied, thus, under these models, the explicit optimal solution to mean-semivariance optimisation can be obtained; such models can be applied into the themes of insurance. Besides, I shall establish that utility-semivariance optimisation possesses an optimal solution even under the Black-Scholes model. In numerical studies, among mostly encountered market values of different model parameters, it is astonishing to observe that embedding downside risk measure into utility maximization framework can significantly reduce the downside risk of the optimal portfolio payoff with an asymmetrically tiny loss in utility.

This talk is based on joint works with Paolo Guasoni, Phillip Yam, and Harry Zheng.

Thursday 4 October - Zachary Feinstein (Washington University)

Pricing debt in interbank networks under comonotonic endowments
In this talk we present formulas for the pricing of debt and equity of firms in a financial network under comonotonic endowments. We demonstrate that the comonotonic setting provides a lower bound to the price of debt under Eisenberg-Noe financial networks with consistent marginal endowments. Such financial networks encode the interconnection of firms through debt claims. The proposed pricing formulas consider the realized, endogenous, recovery rate on debt claims. Special consideration will be given to the setting in which firms only invest in a risk-free bond and a common risky asset following a geometric Brownian motion.