Department of Mathematics

Joint Risk & Stochastics and Financial Mathematics Seminar in 2017/18

Seminars are listed in reverse chronological order, most recent first

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Thursday 24th May - Mike Ludkovski (UC Santa Barbara)

Capacity Expansion Games: Non-zero-sum Switching/Multiple Stopping Equilibrium
We consider non-zero-sum stochastic games of timing. Our motivation is from competitive capacity investment for a duopoly of two distinct producers. The producers are exposed to stochastically fluctuating costs and interact through aggregate supply. Capacity expansion is modeled in terms of timing strategies, i.e. repeated real options. The overall market is then described through the stochastic factor (X_t) that captures short-term fluctuations and the (relative) capacity that summarizes the current market organization. Working in a continuous-time diffusion framework, we characterize and analyze the resulting Nash equilibrium and game payoffs using tools of optimal stopping. An example of competing green and fossil-fuel producers will be used as illustration. The second part of the talk will then consider ongoing work extending this model to a stationary switching game characterized via a sequence of switching thresholds. Joint work with Rene Aid (Paris Dauphine, Part I) and Liangchen Li (UCSB, Part I and II).

Monday 30 April 2018 - Albert N. Shiryaev (Steklov Mathematical Institute)

Optimal Stopping Procedures in financial models with disorder of trends ("drift-bubbles")
We consider the financial model

$$X(t)=[aI(t<R)+bI(t>R)]+B(t)$$

where B is a Brownian motion, R is random positive variable, a and b some constants (known or unknown). Many financial models can be described by a similar way. For example, the stock AAPL (Apple computer stock) can be modelled using the above (here we consider the interval from September 1984 until the end of 2012). In the given Apple model we shall assume that the time R when the drift changes is uniformly

distributed on the interval. In our talk we describe theoretical results on optimal stopping ("American options") of discovering the disorder time R (with some minimal risk) and practical results for the Apple stock.

Thursday 26 April - Lukasz Stettner (Institute of Mathematics, Polish Academy of Sciences)

Long Run Risk Sensitive Control and Portfolio Optimization

I'm going to present several results concerning risk sensitive control of discrete and continuous time Markov processes over infinite time horizon and then similar results concerning risk sensitive portfolio optimization. The last problem is closely related to asymptotics of optimal power utility from terminal wealth. The talk shall consist of published and new results. The approach will be mainly probabilistic. Major problems and difficulties will be pointed out.

Thursday 15 March - Sergio Pulido (ENSIIE)

Affine Volterra Processes

A growing body of empirical research indicates that volatility fluctuates more rapidly than Brownian motion, which is inconsistent with standard semimartingale models. Fractional volatility models and their relatives have emerged as compelling alternatives- however, their non-Markovian structure makes computations more difficult. We show that, for a large class of such models, it is nonetheless possible to compute the characteristic function by solving an integral equation similar to the Riccati equations associated with standard affine processes. Joint work with Eduardo Abi Jaber and Martin Larsson.

Wednesday 7 March - Alfred Galichon (New York)

Topics in Equilibrium Transportation

Motivated by problems from Economics, I will present a framework for "Equilibrium Transport", which embeds the Monge-Kantorovich "Optimal Transport" problem, but is more general, and more natural in some applications. In the discrete case, this framework allows for a unified description of Gale and Shapley's stable marriage problem, as well as Koopmans and Beckmann's optimal assignment problem. I will sketch the link with "Galois connections" and recent results by Trudinger on the local theory of prescribed Jacobian equations. I will then turn to computational issues, and

will present an extension of Sinkhorn's algorithm that allows for efficient approximate computation of these problems. Finally, I will discuss the statistical estimation of these models.

Thursday 1 March - Jan Palczewski (Leeds)

(Un)discounted Optimal Stopping Problems and Applications

I will talk about an infinite horizon optimal stopping problem with a functional comprising of a running reward and a final reward. I will establish the feasibility of the stopping problem, prove the existence of optimal stopping times and a variational characterisation (in the viscosity sense) of the value function when interest rates are not uniformly separated from 0. These results rely on certain ergodic properties of the underlying (non-uniformly) ergodic Markov process. I will further sketch how these results apply to impulse control problems with average cost per unit time functional and, if time allows, present an example of optimal control of a battery for provision of Fast Reserve balancing service to National Grid.

Wednesday 21 February - Budhi Surya (Victoria University of Wellington)

A Rating-Based Model of Credit Risk Under Non-Markov Chains

In many credit risk applications, the rating based model of Jarrow-Lando-Turnbull (Journal of Finance, Vol. 50, p. 53-86, 1995) has been widely used for the pricing and hedging of corporate bonds. The model is driven by a continuous-time absorbing Markov chain. However, there have been mounting empirical evidences to suggest the contrary, see e.g. Frydman and Schuermann (Journal of Banking and Finance Vol. 32, p.1062-1075, 2008), that bonds of the same credit rating can move at different rates to other credit ratings and that the incorporation of past credit information helps improve the Nelson-Aalen estimate of cumulative default intensity. Based on these empirical findings, I propose a new rating based model of credit risk under a non-Markov chain. The model is developed based on the mixture of continuous-time absorbing Markov chains moving at different speeds, where the mixture occurs at a random time. Variety of associated distributional properties of the Markov mixture process are discussed, for example the transition matrix, the default-time distribution and forward default intensity. Identities are explicit in terms of the Bayesian update of switching probability and intensity matrices of the underlying Markov chains despite the mixture process is non Markovian. They form non-stationary function of time and

have the ability to capture heterogeneity and past credit information when conditioning on available information (either full or partial) up to current time. Their availability in closed forms offers appealing features for applications in credit risk.
Reference:
B.A. Surya. (2017). Distributional properties of the mixture of continuous time absorbing Markov chains moving at different speeds. Stochastic Systems - INFORMS Applied Probability Society.

Thursday 15 February - Cristina Di Girolami (Pescara)

Path Dependent Stochastic Calculus, an Infinite Dimensional PDE and Financial Perspectives

This talk develops some aspects of stochastic calculus via regularization for path dependent random variables. After some brief reminds on stochastic calculus in a general Banach space B, main interest will be devoted to the case when *B* is the space of real continuous functions defined on [-*T*; 0], *T* > 0 and the process is the window process *X*(.) associated with a continuous real process *X* which, at time t, it takes into account the past of the process. If *X* is a finite quadratic variation process (for instance Dirichlet, weak Dirichlet), it is possible to represent a large class of path-dependent random variable *h* as a real number plus a real forward integral in a semiexplicite form. This representation result of h makes use of a functional solving a path dependent infinite dimensional partial differential equation of Kolmogorov type. Two recent general existence results of its classical solutions related to different classes of final conditions will be presented. The decomposition result generalizes, in some cases, the well known Clark-Ocone formula which is true when *X* is the standard Brownian motion *W*. Some examples will be given explicitly developed and discussed. This is a joint work with Francesco Russo (ENSTA ParisTech Paris).

Thursday 1 February - Denis Villemonais (Lorraine)

Exponential convergence of conditioned processes

In a previous work in collaboration with Nicolas Champagnat, we provided necessary and sufficient criterion for the uniform exponential convergence of Markov processes conditioned not to be killed. This criterion, and hence the uniform exponential convergence, only applies to cases where the conditioned process is uniformly exponentially ergodic. Our aim during this talk is to present applications to a new framework of assumptions that entails the non-uniform exponential convergence of

conditioned Markov processes. In this new framework, most of the difficulties usually involved in proving the convergence of a conditioned Markov process to a quasi-stationary distribution are easily overcome.

Thursday 18 January - Christine Gruen (Toulouse School of Economics)

On games with asymmetric information

In this talk we will consider two player zero sum games where the two players have access to different informations about payoffs and the dynamics driving the game. We assume that the players can observe the actions of their opponents, which allows them to guess the private information of the other player. Optimal strategies in these games are thus much more complex than in games where both players have access to the same information. Not only do the players aim to optimise a payoff while not giving away too much information, but they choose their strategy in order to optimally manipulate the beliefs of the other players while defending themselves against the manipulation of their adversary. This typical behaviour is found in a large class of games, notably also for stopping games on which we will concentrate in this talk.

Thursday 7 December - Thomas Kruse (Duisburg-Essen)

Multilevel Picard approximations for high-dimensional nonlinear parabolic partial differential equations

In this talk we present a family of new approximation methods for high-dimensional PDEs and BSDEs.

A key idea of our methods is to combine multilevel approximations with Picard fixed-point approximations. Thereby we obtain a class of multilevel Picard approximations. Our error analysis proves that for semi-linear heat equations, the computational complexity of one of the proposed methods is bounded by $O(d\,\eps^{-(4+\delta)})$ for any $\delta > 0$, where d is the dimensionality of the problem and $\eps\in(0,\infty)$ is the prescribed accuracy.

We illustrate the efficiency of one of the proposed approximation methods by means of numerical simulations presenting approximation accuracy against runtime for several nonlinear PDEs from physics (such as the Allen-Cahn equation) and financial engineering (such as derivative pricing incorporating default risks) in the case of $d=100$ space dimensions. The talk is based on joint work with W. E, M. Hutzenthaler, and A. Jentzen.

Thursday 23 November - **Charles-Albert Lehalle (Capital Fund Management)**

Closing The Loop of Optimal Trading: a Mean Field Game of Controls

This talk explains how to formulate the now classical problem of optimal liquidation (or optimal trading) inside a Mean Field Game (MFG). This is a noticeable change since usually mathematical frameworks focus on one large trader in front of a " background noise " (or " mean field "). In standard frameworks, the interactions between the large trader and the price are a temporary and a permanent market impact terms, the latter influencing the public price. Here the trader faces the uncertainty of fair price changes too but not only. He has to deal with price changes generated by other similar market participants, impacting the prices permanently too, and acting strategically. Our MFG formulation of this problem belongs to the class of " extended MFG ", we hence provide generic results to address these " MFG of controls ", before solving the one generated by the cost function of optimal trading. We provide a closed form formula of its solution, and address the case of " heterogenous preferences " (when each participant has a different risk aversion). Last but not least we give conditions under which participants do not need to instantaneously know the state of the whole system, but can " learn " it day after day, observing others' behaviours.

Thursday 9 November - **Thibaut Mastrolia (CMAP)**

An overview of contract theory: from the Holmström-Milgrom paradigm to multi-agent systems

In this talk, we investigate a situation in which two economical entities interact to maximize their own payoff. One of them is called the Principal (she) and proposes to the second one, named the Agent (he), some incentives to modify her wealth. The main difficulty comes from the fact that the Principal observes the result of the work of her Agent without observing his work directly. This kind of situation coincides exactly with a moral hazard problem in which the Principal has to design an employment contract given to her Agent to maximize her utility without observing directly his work. We identify this paradigm with a Stackelberg equilibrium that can be explicitly solved in several examples. We begin to study the example of Holmström and Milgrom dealing with one Principal and one Agent in the continuous case. We then extend this investigation to N-interacting Agents hired by one Principal and to a model with one Agent hired by several Principals.

26 October - **Joaquin Narro (Alcazar Investment Management Ltd / Bainbridge Partners LLP)**

Forecasting Prices of Electricity Futures: Practice vs. Theory

Electricity plays a major role in people's lives. The reliability and affordability of electricity, together with the need to address climate change, are major issues for our society at large. The world-wide drive to support low-carbon electricity generation is based on a myriad of legislative initiatives with implications far beyond traditional power systems. In this complex environment, it is vital for all stakeholders involved in electricity generation, from consumers to producers, from investors to regulators, to understand the pricing of electricity. This presentation explores several examples of forecasting of electricity prices using different mathematical models, highlighting the practical benefits and hindrances of different approaches.

12 October - **Saul Jacka (Warwick)**

Optimal stopping, the dual problem and smooth pasting

Let G be a semimartingale, and S its Snell envelope. Under the assumption that $G\in\mathcal{H}^1$, we show that the finite-variation part of S is absolutely continuous with respect to the decreasing part of the finite-variation part of G. In the Markovian setting, this enables us to identify sufficient conditions for the value function of the optimal stopping problem to belong to the domain of the extended (martingale) generator of the underlying Markov process. We then show that the dual of the optimal stopping problem is a stochastic control problem for a controlled Markov process, and the optimal control is characterised by a function belonging to the domain of the martingale generator. Finally, we give an application to the smooth pasting condition.

28 September - **Christoph Belak (Trier)**

Utility Maximization with Constant Costs

We study the problem of maximizing expected utility of terminal wealth for an investor facing a mix of constant and proportional transaction costs. While the case of purely proportional transaction costs is by now well understood and existence of optimal strategies is known to hold for very general class of price processes, the case of constant costs remains a challenge since the existence of optimal strategies is not even known in tractable models (such as, e.g., the Black-Scholes model). In this talk,

we present a novel approach which allows us to construct optimal strategies in a multidimensional diffusion market with price processes driven by a factor process and for general lower-bounded utility functions.

The main idea is to characterize the value function associated with the optimization problem as the pointwise infimum V of a suitable set of superharmonic functions. The advantage of this approach is that the pointwise infimum inherits the superharmonicity property, which in turn allows us to prove a verification theorem for candidate optimal strategies under mild regularity assumptions on V. Indeed, for the verification procedure based on superharmonic functions to be applicable, it suffices that the pointwise infimum V is continuous.

In order to establish the continuity of V, we adapt the stochastic Perron's method to our situation to show that V is a discontinuous viscosity solution of the associated quasi-variational inequalities. A comparison principle for discontinuous viscosity solutions then closes the argument and shows that V is continuous. With this, the verification theorem becomes applicable and it follows that the pointwise infimum V coincides with the value function and that the candidate optimal strategies are indeed optimal.

This talk is based on joint work with Sören Christensen (University of Hamburg) and Frank T. Seifried (University of Trier).

20 September - Keita Owari (Ritsumeikan University)

A Komlós-Type Theorem in Dual Orlicz Spaces

We give a Komlós type result for bounded sequences in dual Orlicz spaces (i.e. Orlicz spaces which are the duals of (Δ_2) Orlicz spaces; e.g. the space of random variables with some exponential moments). Its "utility grade" version asserts that any bounded sequence in such a space has an (a.s. convergent) sequence of forward convex combinations whose supremum remains in the same space. If the probability space is atomless, this type of Komlós theorem characterises the class of dual Orlicz spaces, or their preduals, the Δ_2-Orlicz spaces. Some consequences in convex duality in finance are also given.

28 September - Chiara Donnini (Naples)

Strictly fair allocations in economies with atoms

We investigate the fairness property of Walrasian allocations in mixed exchange markets that are economies having both atoms (large or non-negligible traders) and an atomless sector (small or negligible traders). We provide two sufficient conditions under which equal-income Walrasian equilibria are the only efficient allocations which are also strictly equitable as defined by Zhou. A further characterization is obtained without extra assumptions via a weaker notion of envy-freeness based on the Aubin approach. Our analysis proceeds with a discussion on the problems arising in differential information economies.