Optimal ratcheting of dividends in insurance

Hansjoerg Albrecher (University of Lausanne)

In this talk, we give an overview of recent developments in identifying optimal dividend payment strategies for an insurance company,
when the dividend rate is not allowed to decrease. The optimality criterion here is to maximize the expected value of the aggregate discounted dividend payments up to the time of ruin. In the framework of the classical risk model and its Brownian approximation, the solution of the corresponding two-dimensional optimal control problem is presented and optimal strategies are numerically determined for several concrete examples.
The implementations illustrate that the restriction of ratcheting does not lead to a large efficiency loss when compared to the classical unconstrained optimal dividend strategy. We also consider an extension of the results to drawdown constraints on the dividend rate, where a curious square-root rule emerges.

ON EXPONENTIAL ALMOST SURE SYNCHRONIZATION OF A ONE-DIMENSIONAL DIFFUSION WITH NONREGULAR DRIFT

OLGA ARYASOVA

The main object of our study is a one-dimensional stochastic differential equation (SDE) of the type

$$\begin{cases} d\varphi_t = (-\lambda\varphi_t + a(\varphi_t))\,dt + \sigma(\varphi_t)\,dw_t,\ t > 0, \\ \varphi_0 \equiv x, \end{cases}$$

where λ is a positive real number, the drift a is measurable, the diffusion coefficient σ is a Lipschitz continuous non-degenerate function, and $(w_t)_{t\geq 0}$ is a Wiener process.

Thanks to the celebrated transform method, Zvonkin proved in [1] that this SDE admits a unique strong solution $(X_t^x)_{t>0}$. Moreover, it was proved during the last decade that due to the presence of noise, the flow $(X_t^x)_{t\geq 0, x\in\mathbb{R}}$ shows good spatial-regularity properties even if the drift function is discontinuous. Concerning the asymptotic stability of the flow there are much less results in the literature.

We solve the question of almost sure synchronization in high dissipative regime (λ large). We prove that two trajectories of that diffusion converge almost surely to one another at an exponential explicit rate as soon as the dissipative coefficient is large enough. The result is obtained for a wide class of SDEs with irregular drift functions: the function a is only supposed to be the sum of a Lipschitz function and of a bounded measurable one. Furthermore, we exhibit an explicit exponential convergence rate to 0 for $|X_t^x - X_t^y|$, both almost surely and in L_p. To our knowledge it is the first result of that type under such general assumptions.

In the spirit of Zvonkin, our approach is based on an accurately chosen space-transform in such a way that the transformed SDE - written via the new coordinate - has a simpler structure. A similar method could theoretically be used in more general context - multidimensional diffusions or Lévy-noise. However, the construction of corresponding transforms requires the investigation of elliptic equations whose solution is a non-trivial problem.

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Parameter estimation in stochastic heat equation with fractional Brownian motion

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We study stochastic heat equations with three types of noises: white noise, fractional Brownian noise and a mixed fractional Brownian noise. We investigate the covariance structure, stationarity, and asymptotic behavior of the solution for each case.

For the stochastic heat equation with white noise we construct a strongly consistent and asymptotically normal estimator of diffusion parameter.

For the equation driven by a fractional Brownian motion we construct strongly consistent estimators of two unknown parameters, namely, the diffusion parameter σ and the Hurst parameter $H \in (0,1)$. We also prove joint asymptotic normality of the estimators in the case $H \in (0, \frac{3}{4})$.

For the stochastic heat equation with mixed fractional Brownian motion we construct a strongly consistent estimator for the Hurst index H and prove its asymptotic normality for $H < 3/4$. Then assuming the parameter H to be known, we deal with joint estimation of the coefficients at Wiener process and at fractional Brownian motion.

PROPERTIES OF UTILITY MAXIMIZATION FUNCTIONALS FOR NON-CONCAVE UTILITY FUNCTION IN COMPLETE MARKET MODEL

OLENA BAHCHEDJIOGLOU AND GEORGIY SHEVCHENKO

This work is devoted to the study of the utility maximization problem. There are a lot of different aspects which can be considered while solving the optimization problem, such as completeness of the market, properties of the utility function, model settings, modeling of the payoff, and so on. We consider the complete market model, non-decreasing upper-semicontinuous non-concave utility function satisfying mild growth condition, and study the standard and constrained optimization problems while considering both the standard and robust utility maximization problems.

We proved the existence and uniqueness of the optimal solution to the standard non-concave utility maximization problem and constructed its explicit form under the assumption of standard budget constraints. It was shown that this solution is also a unique optimal solution for the maximization problem of the concavified utility function.

In the case of implementing an additional upper bound given by some random variable, we proved a similar theorem if the given random variable is discrete. Moreover, we presented examples that show that previous conclusions may fail in the case of a continuous random variable that represents an upper bound.

Subsequently, in the case of a robust utility maximization problem deriving the optimal solution is based on the study of the minimax identity for the initial non-concave utility function. We obtained equalities and inequalities to relate the robust utility functional of the initial utility function and its concavification and derived the assumptions under which minimax identity holds for the initial utility function. Besides, similar results were obtained in the case with an additional upper bound on the budget, represented, as before, by some random variable. The crucial step for obtaining the mentioned results with implementing an additional upper bound is the use of the regular conditional distribution which sheds new light on the possible approaches for solving the optimization problem.

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Large-scale Wasserstein gradient flows with applications for computing diffusions

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Wasserstein gradient flows provide a powerful means of understanding and solving many diffusion equations. Specifically, Fokker-Planck equations, which model the diffusion of probability measures, can be understood as gradient descent over entropy functionals in Wasserstein space. This equivalence, introduced by Jordan, Kinderlehrer and Otto, inspired the so-called JKO scheme to approximate these diffusion processes via an implicit discretization of the gradient flow in Wasserstein space. Solving the optimization problem associated to each JKO step, however, presents serious computational challenges. We introduce a scalable method to approximate Wasserstein gradient flows, targeted to machine learning applications. Our approach relies on input-convex neural networks (ICNNs) to discretize the JKO steps, which can be optimized by stochastic gradient descent. Unlike previous work, our method does not require domain discretization or particle simulation. As a result, we can sample from the measure at each time step of the diffusion and compute its probability density. We demonstrate our algorithm's performance by computing diffusions following the Fokker-Planck equation and apply it to unnormalized density sampling as well as nonlinear filtering.

Joint calibration of SPX and VIX options with signature-based models

Christa Cuchiero

University of Vienna

We consider a stochastic volatility model where the dynamics of the volatility are described by linear functions of the (time extended) signature of a primary underlying process, which is supposed to be some multidimensional continuous semimartingale. Under the additional assumption that this primary process is of polynomial type, we obtain closed form expressions for the VIX squared, exploiting the fact that the truncated signature of a polynomial process is again a polynomial process. Adding to such a primary process the Brownian motion driving the stock price, allows then to express both the log-price and the VIX squared as linear functions of the signature of the corresponding augmented process. This feature can then be efficiently used for pricing and calibration purposes. Indeed, as the signature samples can be easily precomputed offline, the calibration task can be split into offline sampling and a standard optimization. For both the SPX and VIX options we obtain highly accurate calibration results, showing that this model class allows to solve the joint calibration problem without adding jumps or rough volatility, but just path-dependence via the signature process.

Backward Stochastic Differential Equations with interaction

Jasmina Đorđević

University of Niš, Serbia and University of Oslo, Norway

Backward stochastic differential equations with interaction (shorter BSDEs with interaction) are introduced. Existence and uniqueness result for BSDE with interaction is proved under version of Lipschitz condition with respect to Wasserstein distance. Such kind of BSDE arises naturally when considering the Monge-Kantorovich problem. In the proof we start from discrete measures using known result of Pardoux and Peng and approximate general measure via Wasserstein distance.

Second Order Random Fields and Yield Curve Modeling

Raphael Douady

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The calibration of yield curve models imply the difficult task of estimating the covariance structure of the rates at the various maturities. This covariance structure drives the shape of risk factors in the HJM or BGM models. Expanding to infinite dimensional models, using either SPDEs or cylindrical Brownian motions, the shape of risk factors becomes even more unstable. Forcing a finite dimensional model, even more so, forcing a Markovian constraint on the dynamics leads to instabilities when recalibrating the model. We introduce a different type of constraint on the covariance structure, based on random fields after a change of variable in the range of maturities. This provides a very stable variance structure and provides a framework which is easy to expand to infinite dimensions.
We then propose to make this volatility structure stochastic in the space of Hilbert-Schmidt operators and state an existence result of mild solutions when a smoothing term is introduced in the yield curve dynamics.

Joint work with Zeyu Cao.

New Exact Solutions for PDEs with Mixed Boundary Conditions

Martino Grasselli

University of Padua

We develop methods for the solution of inhomogeneous Robin type boundary value problems (BVPs) that arise for certain linear parabolic Partial Differential Equations (PDEs) on a half line, as well a second order generalisation. We are able to obtain non-standard solutions to equations arising in a range of areas, including mathematical finance, stochastic analysis, hyperbolic geometry and mathematical physics. Our approach uses the odd and even Hilbert transform methods. The solutions we obtain and the method itself seem to be new.

Joint work with Mark Craddock and Andrea Mazzoran

Optimal stopping: Bermudan strategies meet non-linear evaluations

Miryana Grigorova
University of Warwick

January 6, 2023

Abstract:

We address an optimal stopping problem over the set of Bermudan-type strategies Θ (which we understand in a more general sense than the stopping strategies for Bermudan options in finance) and with non-linear operators (non-linear evaluations) assessing the rewards, under general assumptions on the non-linear operators ρ. We provide a characterization of the value family V in terms of what we call the (Θ, ρ)-Snell envelope of the the pay-off family. We establish a Dynamic Programming Principle. We provide an optimality criterion in terms of a (Θ, ρ)-martingale property of V on a stochastic interval. We investigate the (Θ, ρ)-martingale structure and we show that the "first time" when the value family coincides with the pay-off family is optimal. The reasoning simplifies in the case where there is a finite number n of pre-described stopping times, where n does *not* depend on the scenario ω. We provide examples of non-linear operators entering our framework.

Paolo Guasoni

Title: Rogue Traders

Abstract:

Investing on behalf of a firm, a trader can feign personal skill by committing fraud that with high probability remains undetected and generates small gains, but that with low probability bankrupts the firm, offsetting ostensible gains. Honesty requires enough skin in the game: if two traders with isoelastic preferences operate in continuous-time and one of them is honest, the other is honest as long as the respective fraction of capital is above an endogenous fraud threshold that depends on the trader's preferences and skill. If both traders can cheat, they reach a Nash equilibrium in which the fraud threshold of each of them is lower than if the other one were honest. More skill, higher risk aversion, longer horizons, and greater volatility all lead to honesty on a wider range of capital allocations between the traders.

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3870658

Ruin problems with investments on a finite interval: PIDEs and their viscosity solutions

Yuri Kabanov

Université de Franche-Comté and Lomonosov MSU

We study the ruin problem when an insurance company invests its reserve in a risky asset whose the price dynamics is given by a geometric Lévy process. We show that the ruin probabilities on a finite interval satisfy a partial integro-differential equation understood in the viscosity sense and prove a result on the uniqueness of solution for a boundary value problem.

Joint work with Viktor Antipov.

Mild to classical solutions for XVA equations under stochastic volatility

Alexander Kalinin, LMU Munich

Joint work with Damiano Brigo and Federico Graceffa

Abstract

We extend the valuation of contingent claims in presence of default, collateral and funding to a random functional setting and characterise pre-default value processes by martingales. Pre-default value semimartingales can also be described by BSDEs with random path-dependent coefficients and martingales as drivers. En route, we generalise previous settings by relaxing conditions on the available market information, allowing for an arbitrary default-free filtration and constructing a broad class of default times. Moreover, under stochastic volatility, we characterise pre-default value processes via mild solutions to parabolic semilinear PDEs and give sufficient conditions for mild solutions to exist uniquely and to be classical.

The normal approximation of compound Hawkes functionals

Mahmoud Khabou

December 2022

We derive quantitative bounds in the Wasserstein distance for the approximation of stochastic integrals of deterministic and non-negative integrands with respect to Hawkes processes by a normally distributed random variable. Our results are specifically applied to compound Hawkes processes, and improve on the current literature where estimates may not converge to zero in large time, or have been obtained only for specific kernels such as the exponential or Erlang functions.

Dynamic programming principle and computable prices in financial market models with transaction costs

Emmanuel Lépinette

Paris Dauphine University, PSL

How to compute (super) hedging costs in rather general financial market models with transaction costs in discrete-time ? Despite the huge literature on this topic, most of results are characterizations of the super-hedging prices while it remains difficult to deduce numerical procedure to estimate them. We establish here a dynamic programming principle and we prove that it is possible to implement it under some conditions on the conditional supports of the price and volume processes for a large class of market models including convex costs such as order books but also non convex costs, e.g. fixed cost models.

Joint work with Vu Duc Think.

Joint SPX--VIX calibration with Gaussian polynomial volatility models: deep pricing with quantization hints

Shaun (Xiaoyuan) Li

Université Paris 1 Panthéon-Sorbonne

We consider the joint SPX-VIX calibration within a general class of *Gaussian polynomial volatility models* in which the volatility of the SPX is assumed to be a polynomial function of a Gaussian Volterra process defined as a stochastic convolution between a kernel and a Brownian motion. By performing joint calibration to daily SPX-VIX implied volatility surface data between 2012 and 2022, we compare the empirical performance of different kernels and their associated Markovian and non-Markovian models, such as rough and non-rough path-dependent volatility models. In order to ensure an efficient calibration and a fair comparison between the models, we develop a generic unified method in our class of models for fast and accurate pricing of SPX and VIX derivatives based on functional quantization and Neural Networks. For the first time, we identify a *conventional one-factor Markovian continuous stochastic volatility model* that is able to achieve remarkable fits of the implied volatility surfaces of the SPX and VIX together with the term structure of VIX futures. What is even more remarkable is that our *conventional one-factor Markovian continuous stochastic volatility model* outperforms, in all market conditions, its rough and non-rough path-dependent counterparts with the same number of parameters.

Joint work with Eduardo Abi Jaber and Camille Illand

Fractional integral equations with weighted Takagi-Landsberg functions

Vitalii Makogin

January 6, 2023

In the talk, we find fractional Riemann-Liouville derivatives for the Takagi-Landsberg functions. Moreover, we introduce their generalizations called weighted Takagi-Landsberg functions. Namely, for constants $c_{m,k} \in [-L, L]$, $k, m \in \mathbb{N}_0$, we define a *weighted Takagi-Landsberg function* as $y_{c,H} : [0,1] \to \mathbb{R}$ via

$$y_{c,H}(t) = \sum_{m=0}^{\infty} 2^{m\left(\frac{1}{2}-H\right)} \sum_{k=0}^{2^m-1} c_{m,k} e_{m,k}(t), t \in [0,1],$$

where $H > 0$, $\{e_{m,k}, m \in \mathbb{N}_0, k = 0, \ldots, 2^m - 1\}$ are the Faber-Schauder functions on [0,1]. The class of the weighted Takagi-Landsberg functions of order $H > 0$ on $[0,1]$ coincides with the H-Hölder continuous functions on $[0,1]$. Based on computed fractional integrals and derivatives of the Haar and Schauder functions, we get a new series representation of the fractional derivatives of a Hölder continuous function. This result allows to get the new formula of a Riemann-Stieltjes integral. The application of such series representation is the new method of numerical solution of the Volterra and linear integral equations driven by a Hölder continuous function.

Misfortunes Never Come Singly: Managing the Risk of Chain Disasters

Alexandra Brausmann*, Lucas Bretschger**, Aleksey Minabutdinov** and Clément Renoir**

* University of Vienna
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December 20, 2022

Abstract

The paper studies optimal disaster prevention and growth policies in an environment where the arrivals of primary disasters trigger subsequent shocks through contagion effects. To model the interrelated disasters, we use the Hawkes process, which is a novelty in general equilibrium economics. We derive analytical solutions for the optimal growth path and an optimal mitigation policy. We find that the existence of interrelationships between different shocks makes optimal disaster spending stochastic, which is in contrast to the previous literature that advocates a constant share of income for disaster mitigation. An efficient abatement policy depends positively on the arrival rate of the primary shock and jumps upwards when an initial disaster occurs. Such behavior is consistent with the evidence on economy-wide aid during the recent COVID-19 pandemic. We extend the analysis by including Brownian uncertainty and random catastrophe magnitude in the Hawkes process, which shows the versatility of our approach.

Convex stochastic optimization

Teemu Pennanen

King's College London

We study dynamic programming, duality and optimality conditions in general convex stochastic optimization problems introduced by Rockafellar and Wets in the 70s. We give a general formulation of the dynamic programming recursion and derive an explicit dual problem in terms of two dual variables, one of which is the shadow price of information while the other one gives the marginal cost of a perturbation much like in classical Lagrangian duality. Existence of primal solutions and the absence of duality gap are obtained without compactness or boundedness assumptions. In the context of financial mathematics, the relaxed assumptions are satisfied under the well-known no-arbitrage condition and the reasonable asymptotic elasticity condition of the utility function. We extend classical portfolio optimization duality theory to problems of optimal semi-static hedging. Besides financial mathematics, we obtain several new results in stochastic programming and stochastic optimal control.

Mean Field Optimization Problem Regularized by Fisher Information

Abstract: Recently there is a rising interest in the research of mean-field optimization, in particular because of its role in analyzing the training of neural networks. In this talk, by adding the Fisher Information (in other word, the Schrodinger kinetic energy) as the regularizer, we relate the mean-field optimization problem with a so-called mean field Schrodinger (MFS) dynamics. We develop a free energy method to show that the marginal distributions of the MFS dynamics converge exponentially quickly towards the unique minimizer of the regularized optimization problem. We shall see that the MFS is a gradient flow on the probability measure space with respect to the relative entropy. Finally we propose a Monte Carlo method to sample the marginal distributions of the MFS dynamics. This is an ongoing joint work with Julien Claisse, Giovanni Conforti and Songbo Wang.

ROBUST ASYMPTOTIC INSURANCE-FINANCE ARBITRAGE

THORSTEN SCHMIDT

Abstract. In most cases, insurance contracts are linked to the financial markets, such as through interest rates or equity-linked insurance products. To motivate an evaluation rule in these hybrid markets, (Artzner, Eisele, Schmidt, 2022) introduced the notion of insurance-finance arbitrage. We extend their setting by incorporating model uncertainty. To this end, we allow statistical uncertainty in the underlying dynamics to be represented by a set of priors $\mathscr{P}$. Within this framework we introduce the notion of *robust asymptotic insurance-finance arbitrage* and characterize the absence of such strategies in terms of the concept of $Q\mathscr{P}$-evaluations. This is a nonlinear two-step evaluation which guarantees *no robust asymptotic insurance-finance arbitrage*. Moreover, the $Q\mathscr{P}$-evaluation dominates all two-step evaluations as long as we agree on the set of priors $\mathscr{P}$ which shows that those two-step evaluations do not allow for robust asymptotic insurance-finance arbitrages.

This is joint work with Katharina Oberpriller and Moritz Ritter
Published at: `arXiv:2207.13350`

Approximation of PDEs on Wasserstein space and application to mean field control

Mehdi Talbi

ETH Zürich

We present a finite-dimensional approximation for a class of partial differential equations on the space of probability measures. These equations are satisfied in the sense of viscosity solutions. Our main result states the convergence of the viscosity solutions of the finite-dimensional PDE to the viscosity solutions of the PDE on Wasserstein space, provided that uniqueness holds for the latter, and heavily relies on an adaptation of the Barles & Souganidis monotone scheme to our context. We then apply this result to the Hamilton-Jacobi-Bellman and Bellman-Isaacs equations arising in stochastic control and differential games, for which we show the convergence of the value function of the finite population problem to the value function of the mean field problem under rather weak regularity requirements.

Ergodic robust maximization of asymptotic growth under stochastic volatility

Josef Teichmann (ETH)

We consider an asymptotic robust growth problem under model uncertainty and in the presence of (non-Markovian) stochastic covariance. We fix two inputs representing the instantaneous covariance for the asset process X, which depends on an additional stochastic factor process Y, as well as the invariant density of X together with Y. The stochastic factor process Y has continuous trajectories but is not even required to be a semimartingale. Our setup allows for drift uncertainty in X and model uncertainty for the local dynamics of Y. This work builds upon a recent paper of Kardaras & Robertson, where the authors consider an analogous problem, however, without the additional stochastic factor process. Under suitable, quite weak assumptions, we are able to characterize the robust optimal trading strategy and the robust optimal growth rate. The optimal strategy is shown to be functionally generated and, remarkably, does not depend on the factor process Y. Our result provides a comprehensive answer to a question proposed by Fernholz in 2002. Mathematically, we use a combination of partial differential equation (PDE), calculus of variations and generalized Dirichlet form techniques. This is a joint work with David Itkin, Benedikt Koch, and Martin Larsson.

Noncommutative martingale inequalities

Quanhua Xu

Université de Franche-Comté

We will present the noncommutative analogues of the classical Burkholder-Gundy square function inequalities, as well as a bref introduction to Ito-Clifford stochastic integral.

VOLTERRA SANDWICHED VOLATILITY MODEL: MARKOVIAN APPROXIMATION AND HEDGING

G. DI NUNNO[1] AND A. YURCHENKO-TYTARENKO[2]

We propose a new market model with a stochastic volatility driven by a general Hölder continuous Gaussian Volterra process, i.e. the resulting price is not a Markov process. On the one hand, it is consistent with empirically observed phenomenon of market memory, but, on the other hand, brings a vast amount of issues of a technical nature, especially in optimization problems. In the talk, we describe a way to obtain a Markovian approximation to the model as well as exploit it for the numerical computation of the optimal hedge. Two numerical methods are considered: Nested Monte Carlo and Least Squares Monte Carlo. The results are illustrated by simulations.

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