Abstract list

Workshop on Stochastics, Statistics, Machine Learning and their Applications of Sustainable Finance and Energy Market

Contributed speakers

1. Fanny Cartellier (ENSAE Paris):

Title: Mean field coarse correlated equilibria in linear quadratic games and application to an abatement game.

Abstract:
Mean field equilibria studied so far in the literature of stochastic games are mostly Nash equilibria (NE), which can be far from socially desirable outcomes (Carmona et al. (2019)). We compute coarse correlated equilibria (CCEs) in a linear-quadratic mean-field game of abatement between countries. CCEs are non-cooperative equilibria but introduce a correlation device which makes them particularly relevant in a context of market failure. We show that, in the mean field setting of the abatement game, CCEs allow to reach higher socially desirable outcomes through higher abatement levels and higher global utility than the unique NE. The reasons for this social outperformance of CCEs over the NE are discussed in this case, following the reasoning on the Price of anarchy of Carmona et al. (2019). We also show that the mean field limit CCEs we found allow to build approximate CCEs in Nplayer settings.

Reference:

- Carmona, R., Graves, C. V., & Tan, Z. (2019). Price of anarchy for mean field games. *ESAIM: Proceedings and Surveys*, *65*, 349-383.

Further motivations for the study of coarse correlated equilibria can be found in the following papers:

- Dokka, T., Moulin, H., Ray, I., & SenGupta, S. (2023). Equilibrium design in an n-player quadratic game. *Review of Economic Design*, *27*(2), 419-438.
- Campi, L., Cannerozzi, F., & Fischer, M. (2023). Coarse correlated equilibria for continuous time mean field games in open loop strategies. *arXiv preprint arXiv:2303.16728*.

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2. Rüdiger Frey (Vienna University of Economics and Business, WU):

Title: Steady does it? On the impact of tax uncertainty on investment into carbon abatement technologies (Joint work with Katia Colaneri, University of Rome Tor Vergata and Verena Köck, WU).

Abstract:
Carbon taxes and emissions trading are a key policy tool for reducing carbon emissions. Most of the economics literature focuses on the structure of optimal taxes or optimal supply of emission certificates. However, in reality future emission tax rates are random since they are affected by

unpredictable events such as political sentiment or the outcome of elections. This is a special case of so-called climate policy uncertainty.
In this talk we study the problem of a profit maximizing electricity producer who decides on investments in technologies for abatement of CO2 emissions in an environment with random emission taxes. We compare two scenarios: in the first scenario, the taxation policy is deterministic; in the second scenario we allow for exogenous deviations from the deterministic setting, which arrive at exponential times, which may either increase or decrease the taxes. We show that in certain scenarios the uncertainty on the future taxation makes the company less willing to make investment and hence a clear and a priori fixed strategy would instead maximize the actions for emission reduction.

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3. **Luca Gonzato** (University of Vienna)**:**

Title: Econometric analysis of crude oil price dynamics using time series of option prices.

Abstract:
This paper investigates the dynamics of crude oil markets as proxied by the United States Oil (USO) exchange-traded fund (ETF). Based on a preliminary analysis of the time series of implied volatility surfaces, we propose a model for USO spot returns that accounts for stochastic volatility, disjoint jumps between price and volatility, and self-exciting price jump intensity, which also excites the volatility jump intensity. We estimate such a model on a time series of option prices using a Bayesian methodology that exploits up-to-date sequential Monte Carlo methods. Numerical results on both simulated and real data highlight the effectiveness of our proposed model and estimation method.

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4. **Julie Keisler** (EDF, France):

Title: Short-term load forecasting using optimized Deep Neural Networks.

Abstract:
While deep neural networks (DNNs) have achieved impressive results in computer vision, text mining, and time series prediction, their superiority in regression tasks such as load forecasting has yet to be demonstrated.
Load consumption forecasting is a challenging signal to estimate because it depends on many external factors, such as weather or economic indicators. Predicting its future values with recurrent DNNs based only on the signal's past values is proposed by the majority of papers in the field. DNNs struggled to win the recent load forecasting competitions and the first ranks are occupied by multiregression or regression tree-based models.
In this talk, we present a fully automated framework based on nature-inspired metaheuristics for the optimization of DNNs for load consumption forecast. From feature selection to hyperparameters optimization through neural architecture search, we achieve performance challenging that of multilinear or tree-based regression models on open-source industrial and competitive datasets, while simplifying the implementation of efficient models compared to state-of-the-art methods in industry or literature.

After presenting our framework, we will talk about the integration of weather maps as explanatory variables for the aggregated electricity consumption forecast of a country. Local meteorological phenomena can influence electricity consumption and are invisible in weather indicators aggregated to the national level. Deep Learning models and their capacity to treat image data are great candidates to deal with these new variables.

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5. **Annika Kemper** (Center for Mathematical Economics at Bielefeld University, Germany):

Title: A Principal-Agent Framework for Optimal Incentives in Renewable Investments.

(In collaboration with René Aïd and Nizar Touzi.)

Abstract:

We investigate the optimal regulation of energy production reflecting the long-term goals of the Paris climate agreement.

We analyze the optimal regulatory incentives to foster the development of non-emissive electricity generation when the demand for power is served either by a monopoly or by two competing agents. The regulator wishes to encourage green investments to limit carbon emissions, while simultaneously reducing intermittency of the total energy production. We find that the regulation of a competitive market is more efficient than the one of the monopolies as measured with the certainty equivalent of the Principal's value function. This higher efficiency is achieved thanks to a higher degree of freedom of the incentive mechanisms which involves cross-subsidies between firms. A numerical study quantifies the impact of the designed second-best contract in both market structures compared to the business-as-usual scenario. In addition, we expand the monopolistic and competitive setup to a more general class of tractable Principal-Multi-Agent incentives problems when both the drift and the volatility of a multi-dimensional diffusion process can be controlled by the Agents. We follow the resolution methodology of Cvitanić et al. (2018) in an extended linear quadratic setting with exponential utilities and a multi-dimensional state process of Ornstein Uhlenbeck type. We provide closed-form expression of the second-best contracts. In particular, we show that they are in rebate form involving time-dependent prices of each state variable.

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6. **Pietro Manzoni** (Politecnico di Milano):

Title: Tree-Based Learning in RNNs for Power Consumption Forecasting.

Abstract:

Neural networks (NNs) are highly accurate modelling tools for prediction tasks involving time series patterns. However, obtaining accurate forecasts is often not enough: in various real-world decisionmaking contexts, it is also crucial to precisely quantify predictive uncertainty, and NNs have been found to poorly predict probabilities. The overconfident forecasts of NNs could cause unintended consequences in safety-critical applications, especially in domains like the management of energy systems, where attaining a precise probabilistic description of the consumption is generally

more important than having accurate point predictions. We propose a simple method to detect overconfidence in time series probabilistic forecasting. We introduce two new (improper) loss functions that adjust forecasts for overconfidence, presenting an application in electricity load forecasting on the hourly scale: experimental results demonstrate a significant improvement in the reliability of out-of-sample forecasts.

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7. Andreas Erik Petersson (University of Oslo):

Title: The HEIDIH model and its numerical approximation.

Abstract:

In this presentation, I introduce the HEat modulated Infinite DImensional Heston (HEIDIH) model and its numerical approximation. This model falls into the general framework of infinite dimensional Heston stochastic volatility models of (F.E. Benth, I.C. Simonsen '18), for pricing forward contracts. It integrates a stochastic advection equation coupled with a stochastic volatility process, defined as a Cholesky-type decomposition of the tensor product of the solution to the stochastic heat equation on the real half-line. I present regularity results for the model in fractional Sobolev spaces under certain conditions applied to the incremental noise covariance kernels, which in particular allow for weighted Matérn kernels. Moreover, I discuss how combining a semi-explicit finite-difference scheme with a discrete finite element approximation of the stochastic heat equation yields an efficient numerical scheme with convergence rates shown to be sharp in numerical simulations. The talk is based on joint work with F.E. Benth, G. Di Nunno and G.J. Lord.

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8. Emanuel Rapsch (TU Berlin):

Title: On Climate policy choice when investing green is a real option game.

Abstract:

There is a plethora of climate-economic models designed for providing policy advice, e.g. by analysing different portfolios of policy instruments or estimating the social cost of carbon (SCC). In the literature, one major focus is set on the mutual interaction between the climate and the economy, general or partial equilibrium theory, long time horizons, and on the concept of intergenerational ``social welfare''. In this talk, I would like to discuss other factors, namely noncertainty -- in the simple sense of ``risk'' --, oligopolistic market structures, irreversibility, and agency problems, in the light of stochastic game and decision theory. By considering a stylised real options game whose underlying stochasticity is given by a $[0,1]$-valued Ito diffusion, alias a trend moving from 0 to 1 in the long run and aggregating consumer preferences, and whose n players are interpreted as firms endowed with the option to irreversibly upgrade to sustainable production, I will show that any of the four mentioned factors substantially affects the way a (politically) defined damage function translates into cost-benefit-optimal ex ante design of the game. If time permits, I will also comment on a concrete application of the model to the passenger car mobility sector. --- Part of ongoing doctoral research supervised by Christoph Belak.

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9. Paul Honore Takam (BTU Cottbus-Senftenberg, Germany):

Title: Optimal Management of a Residential Heating System with a Geothermal Energy Storage.

Abstract:

We consider the cost-optimal management of a residential heating system equipped with several heat production and consumption units. The manager is exposed to uncertainties about randomly fluctuating renewable heat production and environmental conditions driving the heat demand and supply. As a special feature the manager has access to a geothermal storage which allows for intertemporal transfer of thermal energy. This leads to a challenging mathematical optimization problem. The optimization problem is treated as a continuous-time stochastic optimal control problem for a controlled state process whose dynamics is described by a system of ordinary differential equations (ODEs), stochastic differential equations (SDEs) and a partial differential equation (PDE). We first apply semi-discretization to the PDE and use model order reduction techniques to reduce the dimension of the associated system of ODEs.
Our numerical experiments for the model reduction with the balanced truncation method show that the space-time dynamics of the temperature in the geothermal storage can be described by only a few controlled ODEs. Finally, time-discretization leads to a Markov decision process for which we apply numerical methods to determine a cost-optimal control and the associated value function.

This is a joint work with Ralf Wunderlich (Cottbus-Senftenberg) and Olivier Menoukeu Pamen (University of Liverpool, AIMS Ghana).

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10. **Qinxin Yan** (ETH Zürich):

Title: Viscosity solutions for Mckean-Vlasov control on a torus.

Abstract:

An optimal control problem in the space of probability measures, and the viscosity solutions of the corresponding dynamic programming equations defined using the intrinsic linear derivative are studied. The value function is shown to be Lipschitz continuous with respect to a novel smooth Fourier Wasserstein metric. A comparison result between the Lipschitz viscosity sub and super solutions of the dynamic programming equation is proved using this metric, characterizing the value function as the unique Lipschitz viscosity solution. This is joint work with Prof. H. Mete Soner.

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11. **Anton Yurchenko-Tytarenko** (University of Oslo):

Title: Hedging in Volterra volatility models.

Abstract:

We propose a new approach for explicit computation of optimal quadratic hedging strategy in models with stochastic volatility driven by general Hölder continuous Gaussian Volterra processes. In particular, 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 given by the non-anticipating stochastic derivative of the payoff. Two numerical methods are considered: Nested Monte Carlo and Least Squares Monte Carlo based on machine learning. The results are illustrated by simulations.

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12. **Zinn Toke** (Aalborg University and Centrica Energy Trading, Denmark):

Title: On the structure and modeling of European Power Markets.

Abstract:

In this talk, we propose a mathematical framework for describing market microstructure interactions with the aim of quantifying price impact in energy markets. Within our framework, we utilize tuples of finite but varying lengths to model the market. We show how one can endow the space with an algebraic structure and how it relates to trading activities within the market. Furthermore, we introduce an (extended) metric for the distance between two tuples and show how it can be used to gauge impact on the market. In addition, we showcase how one can use several pseudometrics to gauge impact on the specific parts of the market, such as, say, cleared quantity or price. Finally, we describe how the framework lends itself naturally to stochastic models for energy market, which we exemplify using the German day-ahead and intraday power markets.