**Abstract**

Pricing and hedging derivative contracts is of core importance for financial market participants. To accomplish these tasks, it is necessary to develop models that accurately represent the dynamics of the risk factors and to deploy efficient numerical methodologies to implement such models. However, designing tractable models and techniques that properly deal with the frequent and dramatic changes of financial markets is typically hard to achieve, especially in multidimensional problems.

In this thesis, we propose several approaches to address these issues. To accurately reproduce the dynamics of financial log-returns, we mainly focus on models based on pure jump processes. Leveraging on established multivariate Lévy constructions, we present a novel model, namely the component-wise Sato-subordinated Brownian motion (CSB), which introduces time inhomogeneity at the multivariate level. The CSB has characteristic function in closed form and preserves the independence of the increments: these properties are crucial for the development of an efficient Monte Carlo scheme and for extracting the market-implied correlation. We investigate the CSB features by deriving the analytical moments and carrying out a sensitivity analysis on the parameters that drive the time inhomogeneity.

We then propose a number of calibration procedures to fit the presented multivariate models in equity and FX rate markets. We explore the tradeoff between the marginal and dependence fits of several Lévy models, when the marginal laws of these constructions are imposed to be of known class, and study the implications of removing such constraint. In addition, we calibrate the CSB model to several FX rate markets, showing that it outperforms established benchmarks and that its joint time inhomogeneity plays a crucial role in this outcome.

Afterwards, we develop an efficient deep learning methodology to improve the calibration speed. We use an artificial neural network to learn the option pricing function and the partial derivatives with respect to the model parameters, and run the calibration problem with the approximated pricing function. We show that our method is significantly faster than traditional global optimizers and more accurate than deep learning methods in which only the option price is learned. Our technique is tested on the Heston model; however, it can be easily extended to other cases.

We then study the valuation and hedging of more general classes of multiasset derivatives, typically requiring simulation methods. We design Monte Carlo schemes to price selected exotic derivatives, and develop an efficient Fourier-based Monte Carlo sampler for our CSB process. Furthermore, we explore approaches based on stochastic optimization that can cater market frictions and user preferences. We develop a multistage stochastic programming model for hedging derivatives and show that it can also be used for valuation purposes.