Mathematical Finance
Finance mathématique
(Org: **Christoph Frei** and/et **Alexander Melnikov** (University of Alberta))

ALEXANDRU BADESCU, University of Calgary

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Pricing formulas for vulnerable claims and death derivatives

We consider the discrete-time market model described by the triplet $(S, \mathbb{F}, \tau)$. Herein $\mathbb{F}$ is the "public" flow of information which is available to all agents overtime, S is the discounted price process of d-tradable assets, and τ is an arbitrary random time whose occurrence might not be observable via $\mathbb{F}$. This framework covers the credit risk theory where τ represents the default time, the life insurance setting where τ models the death time, and other areas of finance. For various vulnerable claims in credit risk and death derivatives in life insurance, we address the super-hedging pricing valuation problem in many aspects. First of all, we discuss how the Immediate-Profit arbitrage (IP for short), which is the economical assumption that guarantees the existence of the "minimal" super-hedging price $\widehat{P}^{\mathbb{G}}$, is affected by τ. Then we show, as explicit as possible, how the set of all super-hedging prices expands under the stochasticity of τ and its various risks. Afterwards, we elaborate, as explicit as possible, the pricing formulas for vulnerable claims and death derivatives. Finally, we single out explicitly the various informational risks in the dynamics of the price process $\widehat{P}^{\mathbb{G}}$ and quantify them. This latter fact is highly important for the mortality and longevity securitizations.

This talk is based on the following joint work with Emmanuel Lepinette (Paris-Dauphine, France):

T. Choulli and Emmanuel: Super-hedging-pricing formulas and Immediate-Profit arbitrage for market models under random horizon. to appear in Finance and Stochastics. A version of the paper is available at: arXiv:2401.05713.

MATT DAVISON, Western University

DENA FIROOZI, University of Toronto

CHRISTOPH FREI, University of Alberta
A Doubly Continuous Model for Equilibrium Trading Dynamics

Analysis of financial markets is usually based on rational expectations, where investors use all available information to trade in order to maximize their expected utility. In equilibrium models, prices are determined so that the market clears, meaning that demand equals supply. Typically, diverging information among homogeneous agents is not enough to generate trade in equilibrium. To address this issue, we introduce and analyze a doubly continuous model with continuous time and continuous agent space. In this setting, each agent is infinitesimally small, contributing zero to trade, while collective trade emerges from

the aggregation over non-negligible sets of agents. Our approach leverages tools from Brownian sheets and multiparametric stochastic calculus, providing insights into the interplay of information, behaviour, and equilibrium in financial markets.

This talk is based on joint work with Efstathios Avdis (University of Alberta), Sergei Glebkin (INSEAD), and Raphael Huwyler (University of Alberta).

NIUSHAN GAO, Toronto Metropolitan University

GENEVIÈVE GAUTHIER, HEC Montréal

Beyond volatility of volatility: Decomposing the informational content of VVIX

This study investigates the informational content of the VVIX, traditionally viewed as a proxy for the S&P 500 index's volatility of the volatility (VOV). We show that this interpretation is incomplete: the VVIX also embeds a long-run variance (LRV) component. To establish this result, we first demonstrate that regressions of squared VVIX on VOV proxies gain substantial explanatory power once LRV measures are incorporated. We then develop a tractable theoretical framework linking VVIX to three risk drivers—instantaneous variance, LRV, and VOV—and show that the VVIX loads on both VOV and LRV. Our empirical analysis reveals that VVIX dynamics are dominated by LRV in calm markets, but by VOV during financial stress. We further show that these variance components explain option returns in distinct markets: S&P 500 index option straddles load on the instantaneous variance and LRV, while VIX option straddles load on the VOV. Taken together, our results redefine the role of the VVIX, establishing it as a measure of both VOV and LRV uncertainty, with important implications for how it should be read and used by finance practitioners.

FRÉDÉRIC GODIN, Concordia University

Deep Hedging with Options Using the Implied Volatility Surface

We propose a deep hedging framework for index option portfolios, grounded in a realistic market simulator that captures the joint dynamics of S&P 500 returns and the full implied volatility surface. Our approach integrates surface-informed decisions with multiple hedging instruments and explicitly accounts for transaction costs. The hedging strategy also considers the variance risk premium embedded in the hedging instruments, enabling more informed and adaptive risk management. Tested on a historical out-of-sample set of straddles from 2020 to 2023, our method consistently outperforms traditional delta-gamma hedging strategies across a range of market conditions.

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