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Research Title:

Hedging portfolios in equity derivatives markets.

Abstract:

The objective of the proposed research activity is the calculation of trading strategies for an institution trying to hedge the risk of possible losses in an illiquid derivative position. Significant for this proposal is that the hedging instruments are themselves (liquid) derivative securities. The academic goal of this proposal then is to characterise, mathematically and economically, the structure of such hedging strategies within a general modelling framework.

Key Research Findings to date:

The key results related to my original proposal is an investigation (together with S. Cheng) of a new class of tractable pricing models. This class of polynomial models is well-suited for modelling the interest rate term structure, and shows promise in modelling equity derivatives in the presence of stochastic volatility. We now study a generalisation of the polynomial modelling framework, based on the spectral decomposition, with the aim of understanding the joint dynamics of the prices of equity derivatives and their use as hedging instruments.

Project Update – Michael Tehranchi

My PhD student, Si Cheng, and I are investigating of a new class of tractable pricing models. This class of polynomial models is well-suited for modelling the interest rate term structure, and shows promise in modelling equity derivatives in the presence of stochastic volatility. We now study a generalisation of the polynomial modelling framework, based on the spectral decomposition, with the aim of understanding the joint dynamics of the prices of equity derivatives and their use as hedging instruments.

Another PhD student, David Driver, and I are studying a certain class of reaction-diffusion partial differential equation. This particular class arises from a natural optimal investment problem under constant relative risk aversion and stochastic volatility. Coincidentally, variations of this same equation appear in the study of branching Brownian motion, as well as in applications to biology and chemistry. We have used economic insight, including the key role of duality, to analyse this equation.

I am continuing my work on implied volatility modelling. A new result is that implied volatility can be computed in a reasonably explicit way, transforming formulae that were previously known to hold asymptotically into bounds which can be shown to hold uniformly.

Finally, I am working on the underpinnings of arbitrage theory, expressing the duality between portfolios and prices. This analysis leads to a new fundamental theorem of asset pricing which holds without the assumption of the existence of a numeraire portfolio.

Since the beginning of my CERF fellowship, the following papers have been submitted for publication:

Arbitrage theory without a numeraire. Revision requested from *Mathematical Finance*. Available at <http://arxiv.org/abs/1410.2976>

Polynomial term structure models. (with S. Cheng) Available at <http://arxiv.org/abs/1504.03238>

An equilibrium model of market efficiency with Bayesian learning: Explicit modes of convergence to rational expectations equilibrium in the presence of noise traders (with O. Ross and S. Satchell) Available at <http://ssrn.com/abstract=2545031>

If B and $f(B)$ are Brownian motions, then f is affine. To appear in the *Rocky Mountain Journal of Mathematics*. Available at <http://arxiv.org/abs/1307.3155>

Uniform bounds for Black-Scholes implied volatility. Revision requested from *SIAM Journal on Financial Mathematics*. Available at <http://arxiv.org/abs/1512.06812>

The following papers are under preparation.

A spectral interest rate model. (with S. Cheng)

Optimisation problems for the FKPP equation. (with D. Driver)

I have also presented my work on the following occasions:

TMU Finance Workshop 2014, Tokyo, November 2014

University of Michigan Financial/Actuarial Mathematics Seminar, September 2014

Tenth Cambridge-Princeton Conference, Cambridge, October 2014

Stochastic Analysis for Risk Modeling, Luminy, France, September 2014

Conference on Stochastic Calculus, Martingales and Financial Modeling, St Petersburg, June 2014

Labex Louis Bachelier - SIAM-SMAI Conference on Financial Mathematics, Paris, June 2014

Advanced Methods in Mathematical Finance, Angers, France, September 2015

Seminar series on Pricing Kernels, Interest Rates, and Long-Term Risk Management, Brunel University, November 2015.

Stochastic Analysis Seminar, University of Loughborough, November 2015