Project Update – Michael Tehranchi

I am currently working on several projects.

Since my last report, I have begun a project with Steve Satchell, an economist from Trinity College. The idea is to explain why, in the context of a portfolio of hedge funds, the importance of residual risk may *increase* as the portfolio becomes diversified. This conclusion is exactly the opposite of the standard CAPM argument. The difference in conclusions arises from the presence of heavy tails in the return distributions.

The project most related to my original CERF proposal is on the development of polynomial models. This work was done jointly my former PhD student Si Cheng, who now works at a hedge fund in London. The paper has been reviewed, and a revision has been requested from *Mathematical Finance*. We are now working to give a financial interpretation to the various parameters and hence calibrate the model to market data.

Si and I have also have been working on a generalisation of the above polynomial models which we call spectral models. These models are in the spirit of the HJM framework, where the model input is the current interest rate term structure. A working paper has been written and we plan to submit it soon.

In another stream of research, I have discovered that the set of arbitrage-free call prices has the mathematical structure of a noncommutative semigroup. The analysis of this structure has given rise to new families of tractable equity derivative pricing models. The paper has been reviewed, and a revision has been requested from *Finance & Stochastics.*

I am continuing my work with my PhD student, David Driver, connecting certain Merton-style optimal investment problems with classical reaction-diffusion equations. Our approach sheds new insight on the equations; moreover, physically interesting quantities such as the speed of travelling wave fronts can be calculated from our new representations. A paper has been written and we plan to submit it soon.

In work not directly related finance, I have discovered an interesting inequality involving the probabilities that jointly normal random variables take values in symmetric convex sets. The paper has been submitted and is currently under review.

Since April 2016, the following papers have been accepted for publication:

MRI turbulence and thermal instability in accretion disks. *Monthly Notices of the Royal Astronomical Society.* https://doi.org/10.1093/mnras/stx564. (2017) (with J. Ross and H.N. Latter)

Uniform bounds for Black-Scholes implied volatility. *SIAM Journal on Financial Mathematics*. 7:893-916. (2016)

A revision has been requested by *Mathematical Finance* for the following paper:

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

A revision has been requested by *Finance & Stochastics* for the following paper:

A Black-Scholes inequality: applications and generalisation. Available at http://arxiv.org/abs/1701.03897

The following paper has been submitted and is currently under review:

Inequalities for the Gaussian measure of convex sets. Available at http://arxiv.org/abs/1309.1707

The following papers are in preparation:

Why does residual risk become relatively more important the more diversified the portfolio is? (with S. Satchell)

Optimisation-based representations for a class of reaction-diffusion equations. (with D. Driver)

Spectral term structure models. (with S. Cheng)

I have presented my research at the following seminars and conferences:

Tokyo Metropolitan University Workshop on Finance, August 2017.

Workshop on Mathematics of Quantitative Finance, Oberwolfach Research Institute for Mathematics, February 2017.

London Mathematical Finance Seminar Series, December 2016.

Meeting on Rough Volatility, Imperial College London, October 2016.