Institution: The University of Manchester

Unit of Assessment: 18 (Economics and Econometrics)

Title of case study: Mathematical Behavioural Finance

1. Summary of the impact

Research undertaken at the University of Manchester (UoM) has contributed to the development of a new interdisciplinary field, 'Mathematical Behavioural Finance' (MBF), that deals with mathematical models of financial markets based on behavioural principles. These models go far beyond the conventional paradigm of fully rational utility maximization, and reflect a whole variety of patterns of market behaviour. A particular emphasis is on evolutionary aspects: growth, domination or just survival, especially in crisis environments.

Impacts can be seen in investment strategies based on MBF that have been successfully employed in large scale funds, since 2008, by Swiss and German corporate investors (AllMountain Capital AG and *Deutsche Bank*). These strategies have demonstrated high rates of return combined with relatively low volatility, coping exceptionally well with one of the most severe financial crises in recent history.

2. Underpinning research

In the early 2000s, a group of researchers combining expertise in Mathematics, Economics and Finance established a new line of mathematical research aimed at the evolutionary modelling of equilibrium and dynamics of financial markets. The models they created went beyond the traditional Walrasian methodology that currently serves as the basis for teaching and research in Financial Economics, opening up new horizons in Theoretical Finance. The key researchers within this group include: Professor Igor Evstigneev (UoM, 2001- ; Professor of Mathematical Economics, 2004-), alongside Professors Thorsten Hens (University of Zurich), Klaus Rainer Schenk-Hoppé (University of Leeds) and Rabah Amir (now, University of Arizona).

The researchers were inspired by the idea of replacing the conventional approach of General Equilibrium (GE) in Economic and Financial Theory, with a viable alternative that would more adequately reflect the modern financial world. In contrast with GE, these models would be suitable for quantitative practical recommendations as they do not rely upon unobservable agents' characteristics, such as individual utilities and beliefs, and thereby open an avenue for practical applications.

The basis for the successful investment strategies developed as a result of this research is a **synthesis of three general investment principles** known in Financial Economics:

(a) The **Kelly Rule** prescribing to maximize the expected logarithm of the portfolio return.
(b) The **Capital Asset Pricing Model (CAPM) strategy** involving investment in the market portfolio.
(c) The **allocation of wealth among assets** in the proportions of their fundamental values – the expectations of the flows of the discounted future dividends.

3. References to the research (all references available upon request)

These papers are published in leading journals, spanning Economic Theory, Mathematical Economics and Mathematical Finance.

Publication [A] (a preprint of the Swiss Finance Institute) was included in top-ten SSRN download list several times in 2010-11, on various subjects related to financial market modelling and game theory. The research has been collaborative, with each co-author contributing to every aspect of the research.

[A] (2011) Amir, R., Evstigneev, I.V., Hens, T. & Xu, L. "Evolutionary Finance and Dynamic Games" *Mathematics and Financial Economics* 5(3) 161-184 (REF 2014)

doi:10.1007/s11579-011-0053-2
[B] (2008) Evstigneev, I.V., Hens, T. & Schenk-Hoppé, K. R. "Globally Evolutionarily Stable Portfolio Rules" *Journal of Economic Theory* 140(1) 197-228 (RAE 2008) doi:10.1016/j.jet.2007.09.005
[C] (2006) Evstigneev, I.V., Hens, T. & Schenk-Hoppé, K. R. "Evolutionary Stable Stock Markets" *Economic Theory* 27(2) 449-468 (RAE 2008) doi:10.1007/s00199-005-0607-8
[D] (2005) Amir, R., Evstigneev, I.V., Hens, T. & Schenk-Hoppé, K. R. "Market selection and Survival of Investment Strategies" *Journal of Mathematical Economics* 41(1/2) 105-122 (Special Issue on Evolutionary Finance) doi:10.1016/j.jmateco.2003.10.006
[E] (2002) Evstigneev, I.V., Hens, T. & Schenk-Hoppé, K. R. "Market selection of financial trading strategies: Global stability" *Mathematical Finance* 12(4) 329-339 doi:10.1111/j.1467-9965.2002.tb00127.x

4. Details of the impact

Pathways to impact: During the last decade, Professor Evstigneev and colleagues have given numerous presentations at significant international conferences in the field, and published popular papers on the subject addressing broad audiences. They have also organised several workshops (e.g. Manchester, 2011, 2012, Bergen, 2011) with invited theoreticians and practitioners. A recent popular paper – that introduced to a wider audience some pertinent issues relating to MBF – was published by Thorsten Hens in *Finanz und Wirtschaft* (the Swiss counterpart of Financial Times) [1].

Theoretical results published in [A-E] have been successfully employed in investment practices within the Swiss and German financial systems. The evidence of the impact of the research on MBF is provided by the investment company **AllMountain Capital AG** (Switzerland) and ***Deutsche Bank*** (Germany).

Impact 1: AllMountain Capital AG. The results of the research were used in the development of investment strategies in the AllMountain Capital AG, and earlier, when building the Managed Futures trading team of Horizon21. The AllMountain Capital AG is a specialist in Managed Futures and systematic investment strategies, founded in 2010 as a spin-off from Horizon21. AllMountain Capital is a highly successful hedge fund with USD 100 million currently under management.

In 2008, after the investment company started using the mathematical results on Behavioural and Evolutionary Finance outlined within the research of Professor Evstigneev and colleagues, it achieved an average annual return of +12%, with an annualized volatility of 15%, coping well with the global financial crisis and the post-crisis situation. A partner at AllMountain Capital AG notes that *"For a systematic asset manager like ours, it is of utmost importance to be able to rely on solid, thorough academic work when it comes to formulating our investment strategies"*, and writes in support of this research:

> *"The research of Profs. Evstigneev, Hens, and Schenk-Hoppé in Evolutionary Finance had an impact on AllMountain Capital on various levels: It (i) enabled us to operationalize income strategies (Lambda star) in the context of an investment portfolio; (ii) afforded us crucial insights about the importance of a "better-than-average" market timing when applying technical trading strategies; and, (iii) determined the overarching focus we now apply to risk management when in intense competition with other market participants, as many strategies do return, on average, sub-par returns without a state-of-the-art risk management. The fresh ideas suggested by evolutionary finance turned out to be especially fruitful in crisis and post-crisis environments."* [2]

Impact 2: *Deutsche Bank*. Results from the outlined research provided a theoretical framework for the development of the 'Portfolio Total Return Index' (PTRI), used by *Deutsche Bank*. The portfolio total return index is a rule-based value index which is built up of several different asset classes. The index management and controlling requires a risk valuation of each subclass, with

this valuation was primarily undertaken in the manner described in the underpinning research.

Since 2008, DB has invested in the index with the DB X-trackers: Portfolio Total Return Index (WKN DBX0BT). The DB X-trackers PTRI holds more than EUR 84 million of assets under management, as of 10th July 2012. Since its launch, the PTRI has created a total return of approx. 50% with a volatility of about 9.2%. Within this time, the benchmark consisting of 60% Stoxx 50 Index and 40% REX-P Index only achieved a total return of approx. 17% with a volatility of about 12.4%. The Head of DB X-trackers, *Deutsche Bank*, alongside the CEO of *Institut für Vermögensaufbau* (Munich) note that *"the scientific results achieved by Igor V. Evstigneev* [and colleagues]… *in the area of 'Evolutionary Finance' have essentially contributed to the development of the Portfolio Total Return Index"* , further elaborating in their letter of support that this positive performance:

> *"…is significantly based on a successful risk management and therefore on the scientific work of Igor V. Evstigneev, Thorsten Hens and Klaus Reiner Schenk-Hoppé. For this reason we are following the future scientific developments in the area of Evolutionary Finance with great interest. Further we understand this area as a practice- related advancement of the classical Behavioral Finance approaches."* [3][4]

5. Sources to corroborate the impact (all claims referenced in the text)

[1] (2012) 'Wann Momentum, wann Value?' *Finanz und Wirtschaft (*4th July)
[2] Testimonial from Partner, AllMountain Capital AG, Switzerland (6th December 2011)
[3] Testimonial from Head of DB X-trackers, Managing Directory, *Deutsche Bank* (July 2012)
[4] Testimonial from Head of the Portfolio Total Return Index Committee / CEO, *Institut für Vermögensaufbau* (co-signatory [3])