Institution: Maxwell Institute for Mathematical Sciences

Unit of Assessment: UoA 10 – Mathematical Sciences

Title of case study: Strengthening asset management by building diverse portfolios

Period when the underpinning research was undertaken: 2014 - date

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Sotirios Sabanis	Reader	Oct 2001 - date
Joerg Kalcsics	Reader	Sep 2015 - date
Jacek Gondzio	Professor	Oct 1998 - date
Sergio Garcia Quiles	Reader	Jun 2013 - date
Mathias Barkhagen	Research Associate	May 2017 – Nov 2018

Period when the claimed impact occurred: 2019 - date

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact

The research was carried out with Aberdeen Standard Investments (ASI), for the design and implementation of new diversification algorithms, within a new innovative framework called Dimensionality, which creates multi-asset portfolios with better performance under adverse market conditions. As a result, the Macro Systematic Dimensions Fund was launched in July 2019, and had USD33,608,897 under management as at 31 December 2019 [5.1]. According to ASI, funds using Dimensionality performed better in the financial turmoil of early 2020 than those using other common approaches, such as Risk Parity or Minimum Variance [5.4]. Direct beneficiaries of this work include ASI with the launch of a new product (fund) and their clients.

With ASI, the investment arm of the UK's second largest asset management firm, Standard Life Aberdeen, rolling out this product while simultaneously expanding education among institutional investors, [5.6], the UK's asset management sector has increased its global resilience to economic shock.

2. Underpinning research

The global financial crisis of 2008 led to heavy losses for most asset portfolios held by institutional investors, prompting investors to question their portfolio construction methodologies and understanding of the level of diversification which can be achieved. A common belief for a well-diversified portfolio is that the risk of the portfolio should not be concentrated to only a few risk factors and the tail risk of the portfolio should be controlled.

The research identified a new framework for portfolio diversification which goes beyond the classical mean-variance approach and portfolio allocation strategies such as risk parity, see [3.1]. It is based on a novel concept, devised during the collaboration with ASI, called portfolio dimensionality which connects diversification to the unpredictability and non-standard nature of portfolio returns and can typically be defined in terms of the ratio of risk measures which are homogenous functions of equal degree. Maximising portfolio dimensionality leads to highly non-

trivial optimization problems with objective functions which are typically non-convex and potentially have multiple local optima. Two complementary global optimization algorithms were developed. See [3.1].

1) For problems of moderate size/dimension, a deterministic Branch and Bound algorithm was developed. This algorithm is the work-horse of discrete optimization, although rarely used for solving continuous optimization problems. One of the reasons is that the efficiency of the algorithm crucially depends on the derivation of tight upper and lower bounds on the objective function over subsets of the solution space, which are often difficult to obtain for non-convex problems, as well as a suitable approach of subdividing the solution space. As our initial solution space is given as a simplex, the use of simplicial decomposition is chosen for the latter. Concerning the former, new continuous and combinatorial bounds were developed for the problem which turned out to be considerably tighter than the ones previously obtained and resulted in a significant reduction in the number of iterations that were needed to solve the problem to optimality (within a given error bound).

For problems of larger size/dimension, a stochastic global optimization algorithm based on Gradient Langevin Dynamics was developed. This relies on recent state-of-the-art work on Stochastic Gradient Langevin Dynamics [3.2] and on variants of the Unadjusted Langevin Algorithms [3.3] within the framework of nonconvex stochastic optimization. The theoretical underpinnings of these algorithms rely on the analysis of the Langevin stochastic differential equation and the properties of its numerical schemes, see [3.4].

3. References to the research

[3.1] Barkhagen, M, Fleming, B, Quiles, SG, Gondzio, J, Kalcsics, J, Kroeske, J, Sabanis, S & Staal, A 2019 'Optimising portfolio diversification and dimensionality' ArXiv. https://arxiv.org/abs/1906.00920

[3.2] Chau, NH, Moulines, É, Rásonyi, M, Sabanis, S & Zhang, Y 2019 'On stochastic gradient Langevin dynamics with dependent data streams: the fully non-convex case' ArXiv. https://arxiv.org/abs/1905.13142

[3.3] Brosse, N, Durmus, A, Moulines, É & Sabanis, S 2018, 'The Tamed Unadjusted Langevin Algorithm', Stochastic Processes and their Applications. Volume 129, Issue 10, October 2019, Pages 3638-3663 https://doi.org/10.1016/j.spa.2018.10.002

[3.4] Sabanis, S 2016, 'Euler approximations with varying coefficients: the case of superlinearly growing diffusion coefficients', Annals of Applied Probability, vol. 26, no. 4, pp. 2083-2105. https://doi.org/10.1214/15-AAP1140

4. Details of the impact

Standard Life Aberdeen PLC is a multinational investment company. It operates in asset management through its subsidiary ASI with equities, multi-asset, fixed income, real estate, and private market funds. Based on the outcomes of this research, a fund was launched in November 2019 by Aberdeen Standard Investments (ASI) under the name 'Standard Life Investments Global SICAV – Macro Systematic Dimensions Fund (Bloomberg ticker: SLMSDDU LX Equity)'. The fund was developed as a result of the joint research effort of ASI and the Maxwell Institute (MI) team, and was co-funded by ASI. The Macro Systematic Dimensions Fund was launched in July 2019, and had USD33,608,897 under management as at 31 December 2019 [5.1].
The holdings of the Fund are not selected with reference to a benchmark index, but the performance of the Fund is compared with the Secured Overnight Financing Rate ("SOFR") [5.2].

The investment team applies a systematic approach to portfolio construction. Their primary focus is to use evidence-based, data-driven quantitative approaches to identify investment ideas within four categories (i.e. equity and credit, interest and inflation rates, relative value and others, e.g. the volatility of investment markets). Such portfolios receive substantial investment from

institutional players, including large pension funds, as a way for them to achieve a healthy growth in their balance sheets. Their objective to invest in well-diversified (and thus resilient) portfolios, which can cope in times of financial turbulence, is of utmost priority for them. According to the Head of Macro Systematic Strategies Research at ASI "*The Multi-Asset Solutions team within Aberdeen Standard Investments considers this methodology to be a unique selling point, both as a diagnostic tool as well as a differentiated way to think about portfolio construction and diversification. The feedback from our clients has been very positive*" [5.3]. The importance of the aforementioned methodology as described above highlights the significance of this research for the company and its clients.

Moreover, and according to ASI, the research has helped the company to develop an investment philosophy which underpins other products (funds/segregated mandates/sub-exposures in existing funds) and, importantly, to differentiate from the competition. ASI confirmed "*The experience in early 2020 when financial markets experienced some of the most extreme and unusual behaviour since the great depression and the financial crisis of 2008, has re-enforced the interest in risk management, portfolio diversification and risk mitigation. For those funds that deployed the methodology developed during the collaborative research agreement, we have retrospectively compared the portfolio construction methodology with other common approaches, such as Risk Parity or Minimum Variance and found the Dimensionality approach to be superior*" [5.3].

The joint research article [3.1] was co-presented (by ASI and Sabanis) at one of the most prestigious conferences for industry and academia in Financial Mathematics, namely the SIAM Conference on Financial Mathematics & Engineering (FM19) which took place in Toronto [5.4]. The joint research efforts were highlighted by ASI at the CBOE (Chicago Board Options Exchange) Risk Management Conference which took place in Munich [5.5].

The fund was awarded the Fund Launch of The Year at the 5th annual EQDerivatives Awards (the event was postponed due to the current global health emergency). According to the award committee, "*Not only is The Macro Systematic Dimensions Fund unique compared to peers when you take into consideration the innovative portfolio construction methodology and strategy, it is also extremely relevant now as global institutional investors we have spoken to are increasingly seeking systematic strategies that integrate macro views given the backdrop of an evolving market landscape. What was also a key differentiating factor has been your own contribution to expanding education among institutional investors across the globe, not only in a practical context, but in academia also. What has also been very positive is the feedback we have received on the 'Dimensionality' methodology - it truly is unique and how it taps into four unconnected return streams*" [5.6]. Thus, the significance of this research is recognised by independent experts both in academia and also in industry.

5. Sources to corroborate the impact

[5.1] 2019 Standard Life Investments Global SICAV Audited Annual Report and Accounts, issued on 26 March 2020. Pages 276-285 refer to funds under management at 31 December 2019, https://www.aberdeenstandard.com/docs?editionId=3a93d563-06a6-4881-ba0c-5642a17fdc58

[5.2] ASI Key Investor Information for the Standard Life Investments Global SICAV Macro Systematic Dimensions Fund, https://www.aberdeenstandard.com/docs?editionId=c6ee80f7-a1c0-4204-9a4c-8a333d5f1e01

[5.3] Statement from Head of Macro Systematic Strategies Research at Aberdeen Standard Investments.

[5.4] UoE/ASI joint presentation https://meetings.siam.org/sess/dsp_programsess.cfm?SESSIONCODE=67304 at the SIAM Conference on Financial Mathematics & Engineering (FM19) https://www.siam.org/conferences/cm/conference/fm19

[5.5] ASI presentation (https://assets.website-files.com/5ab57ef41738f46d15802683/5d7fa010bda9c63725d1459f_Day%201%20Session%204%20Jens%20Kroeske_final.pptx) at the Cboe (Chicago Board Options Exchange) Risk Management Conference, September 2019, https://www.cboermceurope.com/

[5.6] Email from EQ Derivatives to quantitative investment director within the multi-asset macro systematic strategy & risk team at ASI confirming that the fund was awarded the Fund Launch of The Year at the 5th annual EQDerivatives Awards, https://armanios.co.uk/dev/eqd/events/5th-annual-eqderivatives-awards