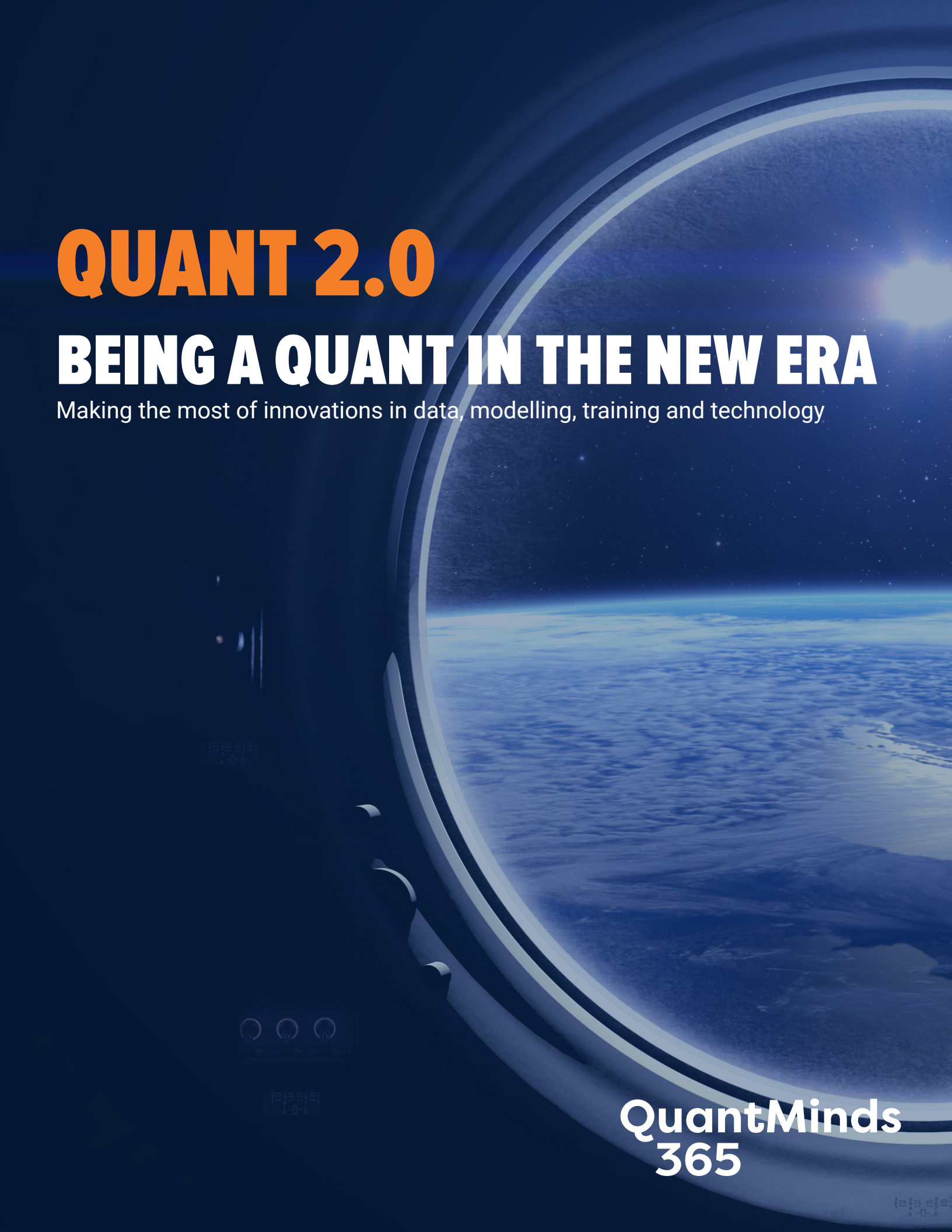


QUANT 2.0

BEING A QUANT IN THE NEW ERA

Making the most of innovations in data, modelling, training and technology

QuantMinds 365

QUANTMINDS

Ed Stapley
Editor, QuantMinds International

Ana-Luiza Olanescu
Editor, QuantMinds Americas

Charlie Burgess
Digital Content Editor

Georgia Hood
Business Development Manager

CONTRIBUTORS

Manlio Trovato
Head of Quantitative Research, Lloyds Banking Group

Marcos Lopez de Prado
Research fellow, Cornell University

David Leinweber
Founder Centre for Innovation Financial Technology, Lawrence Berkeley Laboratory

Horst Simon
Deputy Lab Director for Research, Lawrence Berkeley National Laboratory

Alejandro Perdomo-Ortiz
Quantum Machine Learning Lead and Founder, NASA, USRA Quantum AI Lab/ Qubtera LLC

Jessica James
Managing Director, Senior Quantitative Researcher, Commerzbank AG

Dr. Svetlana Borovkova
Associate Professor of Quantitative Finance, Vrije Universiteit Amsterdam and Head of Quantitative Modelling, Probability and Partners

Jeanine Kwong
Global Head of Equity Risk, Manulife

Laura Ballotta
Reader in Financial Mathematics, Cass Business School

Liming Brotcke
Quantitative Manager, Model Risk Oversight, Federal Reserve Bank of Chicago

Artur Sepp
Director And Senior Quant, Julius Baer Group

INTRODUCTION

This year's QuantMinds conference represented a microcosm of the shifting mindset and focus of quants, old and new, buy-side and sell-side, who are actively working on applications of AI and innovation to tackle traditional and new quantitative problems. There is now an evolution of technology driving quant finance, no more clearly evident in the significant amount of work on Machine Learning applications, as well as the serious consideration to blockchain and quantum computing.

Topics and techniques aside, it is the culture of the quant finance industry which continues to rise up the priority list for many. Whilst this cultural change is slower than the rapid technology developments we are seeing, it is pertinent to all leaders in the field. Just a few of the cultural challenges include: what to teach the next generation of quants, how to manage teams effectively, how to future proof talent and develop soft skills, business nous and strategic thinking in addition to mathematical and quantitative learnings. Crucially there is then the question of diversifying quant teams including the integration of more females into the sector at all levels of seniority.

The world of business and finance is evolving quickly and quants, no longer operating in siloed exotic environments, will need to adapt with it.

We hope you enjoy it.

The QuantMinds team

CONTENTS

P2 Managing quant minds

P4 Breakthroughs in technology shaping quant finance

P5 Where are all the women in quant finance?

P6 What should we be teaching the next generation of quants?

P8 Assessing risk profile of quant strategies: the convexity vs. skewness

MANAGING QUANT MINDS

QuantMinds 365

We live in the era of the algorithm. Complex mathematical models now price and execute an increasing array of complicated financial securities. Quantitative analysts, responsible for building and maintaining these models, are now relied upon not only generate profits, but to help companies reduce and manage their risk. It's a challenging line of work, and consequently quants can often command hefty salaries.

Those within quant leadership roles need to be able to justify that investment, building a story of why an executive committee should invest in building a quant team. Pricing and product development are not alone reason enough.

That's the view of Manlio Trovato, Head of Quantitative Research at Lloyds Banking Group, who was at QuantMinds International, to talk about how best to manage quant minds.

Those outside of the quant world – such as the members of the executive committee – want to know the why of quants, argued Trovato. "We all know what it is that we do, but we need to make sure everyone understands the why. That's the question that goes right to the heart of things from a management perspective," he stated.

So he set about providing an answer.

Quants exist to provide reliable, consistent and fair pricing, to respond to and delight clients with expanded offerings and value-added services. They exist to support the bank and their colleagues, they support the regulatory side with compliant pricing, capital, collateral requirements, risk calculations and robust platforms.

They also empower clients and colleagues alike through automation, automating those processes and tasks which can be model-driven. Quants are also a centre of service that unlock the potential of technology, working with colleagues to come up with new ideas. They seize on innovations to improve and outsmart the market.

The key then, for the quant manager, is to map every quant project to the needs of the business. For instance, mapping how FRTB projects, that are changing the way systems work and how business units work, rotate around a model and system capability in which quants are crucial in implementing.

Quants also build pricing models and maintain them, and these are required in order for clients to see prices and to interact with the institution. There is a need to be able to innovate for clients.

Looking ahead

The quant journey is ever evolving. From initial thinking about pricing theory, to new trends in both model and product sophistications, the role has evolved even further and with a much broader scope.

An increased regulatory landscape has driven quants into a higher regulatory focus, and this in turn has pushed quant groups to go across business units, as well as to review and revisit the tech stack.

In the future, argued Trovato, quants will spend even more time in safety and risk management, and delve even deeper into automation. In fact, quant and technology will become analogous: "I do see a lot more focus on professional software engineering and management of delivery, and a lot more quant tech synergies," he said.

In addition, Trovato saw a much less siloed approach to pricing / XVA specialists and less add-on tools, prototype delivery and less of a siloed approach between the modeller, the quant and the tech side.

Compliance, sustainability and managing complexity of automation and added value using analytical insight would continue to drive the future of quants.

What drives quants?

It's crucial that a manager understands what motivates quants, he argued.

"You can only get the best out of people when you understand what drives them."

"Quants are passionate. Passionate about maths, finance, technology, problem solving, research and they are passionate to learn.

Quants will be built into the fabric of the organisation, they won't be a unicorn group, but will become a whole FinQuan Tech package.

"They are now very much integrated into the financial world, working with traders, finance, risk and compliance, they have learned to understand it and work with it." Quants are also passionate about technology, and exploring new options with it, he added.

The job of the manager was to unlock that quant value. "They cost a lot, we want to get the best."

"My view is the unlocking is tied to a concept of a cross-skill and cross-team or group, removing the overlap and duplication."

The quant profile is going to contain a much broader skillset, encompassing proper software engineers to project managers. "You need someone to manage the delivery of technical quant solutions, and they have to have some insight in what we're doing conceptually in an organisation"

On the part of the organisation, there had to be a realisation that the solutions that quants deliver are part of a bigger picture. "There is a lot of value in looking at the whole picture, a bit like the way that quants started looking at pricing models and expanding that to other services," he explained.

Ultimately, concluded Trovato, quants will be built into the fabric of the organisation, they won't be a unicorn group, but will become a whole FinQuan Tech package.

BREAKTHROUGHS IN TECHNOLOGY SHAPING QUANT FINANCE

QuantMinds 365

During QuantMinds International in Lisbon this year, the hotly anticipated panel *New frontiers in Big Data, Machine Learning and supercomputing* attracted a larger audience and a lot of discussion. Catch up on the presentations for the insights from the leaders in the field.

Marcos Lopez de Prado, CEO, True Positive Technologies and Senior Lecturer, Cornell University, kicks off the panel with his thoughts on Machine Learning and its applications for the finance industry.

Horst Simon, Deputy Lab Director for Research at Lawrence Berkeley National Laboratory, discusses three ingredients for Machine Learning.

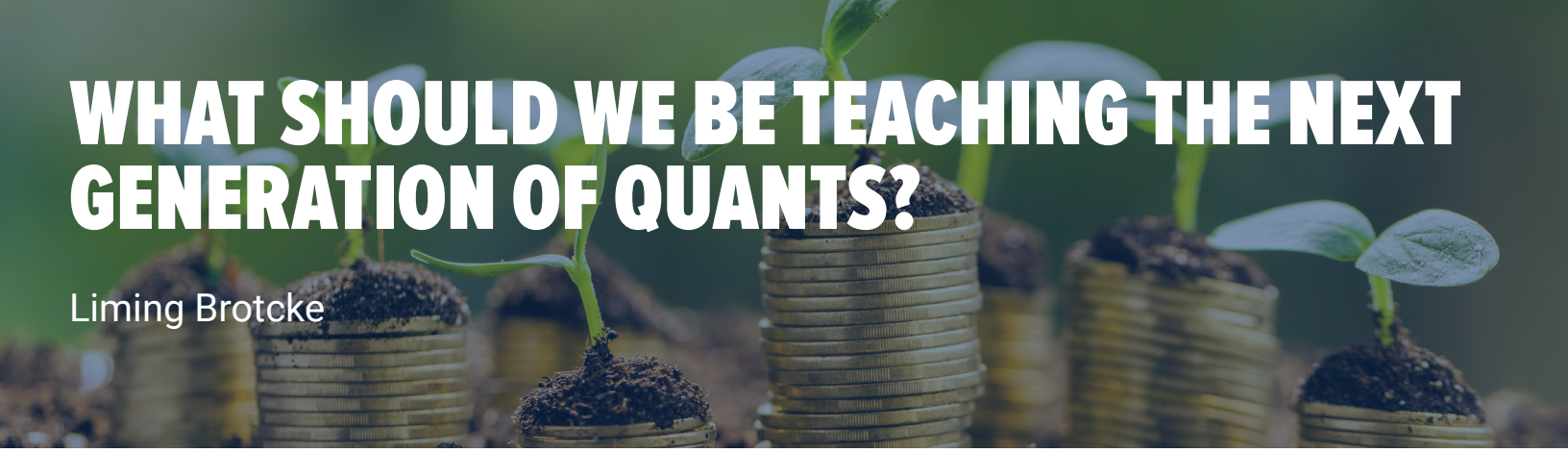
Alejandro Perdomo-Ortiz, Senior Research Scientist at Rigetti, presents his thoughts on why and how quantum computing will help solve the hardest problems for quants, and across other industries.

David Leinweber, Founder Center for Innovative Financial Technology at Lawrence Berkeley Laboratory, looks back at how technology has changed the market so far.

WHERE ARE ALL THE WOMEN IN QUANT FINANCE?

QuantMinds 365

In the first #QuantWomen digital panel, we welcome Jessica James Managing Director, Senior Quantitative Researcher at Commerzbank AG, Jeanine Kwong, Global Head of Equity Risk at Manulife, Svetlana Borovkova, Associate Professor Of Quantitative Finance at Vrije Universiteit Amsterdam and Laura Ballotta, Reader in Financial Mathematics at Cass Business School to discuss diversity and inclusion in quant finance, and the steps we need to take to readjust the balance and ensure more women enter and stay in the industry.



WHAT SHOULD WE BE TEACHING THE NEXT GENERATION OF QUANTS?

Liming Brotcke

Liming Brotcke is a quantitative manager of the Model Risk Oversight team at the Federal Reserve Bank of Chicago. She manages a team of model risk management specialists who conduct quantitative and qualitative review of a variety of models, and here discusses the fundamentals of what young quants will need to be successful.

The growing power and wide application of advanced modelling techniques, coupled with increasingly sophisticated algorithms and vast amounts of data, has made trading activities more complex and created a steady demand for quantitative analysts, otherwise known as quants. The increased speed of computers, dictated by Moore's Law, has correspondingly increased staff productivity and competition intensity. The complexity of derivative trading and its impact on liquidity and financial market stability also draws lots of attention from regulators.

Traditionally, a quant is expected to develop and implement mathematical/financial models that evaluate derivative prices and trade securities. Depending upon their activities, quants can be further grouped into several categories. Front office quants work directly with traders and create pricing and trading models for traders. They design algorithms that search for alpha, the elusive returns above those returned as a component of standard stock market fluctuations. Front office quants have a greater emphasis on providing real-time solutions to specific problems than detailed modelling. Model validating quants take responsibilities of implementing and validating models from the front office to ensure error-free calculation used in trading. Research quants focus on creation of innovative pricing models and trading strategies for the front office. Asset management banks employ investment quants that leverage either exclusively quantitative strategies or a combination of quantitative and fundamental methods.

There are also quant developers who are responsible for programming, script writing, code debugging and other technical issues. Statistical arbitrage quants working at hedge fund firms research the inefficiencies present in the market with the help of automatic trading algorithm. Finally, capital quants are tasked to forecast banks' credit exposure. In the United States, quants who don't work directly with traders are also referred as "middle office" or "back office" quants and typically work in risk management.

There are a variety of activities quants often engage, including bonds, commodities, credit, equity, foreign exchange, and hybrids. Business needs also differ among commercial banks, investment banks, hedge funds, technology service companies, and software issuers. Roughly speaking, the buy side (i.e. hedge funds and alike) is more statistics and algorithmic trading oriented whereas the sell side (i.e. investment banks and alike) is more like traditional derivatives pricing and all that follows.

Quant activities will encompass solid understanding of business needs, the underlying theory (mathematics, statistics, data science, etc.), available or developing technology, and the regulatory environment.

First, a solid mathematical background is a must. The ability to work with stochastic partial differential equations, linear algebra, stochastic calculus, and probability theory to solve problems and derive solutions is the most desirable skill set to have. As such, a doctoral degree in highly numerate fields such as mathematics, physics, engineering, economics with a focus on econometrics and time series, computational finance, and so on is preferred by most firms. In the last decade graduates with Master's degrees in mathematical finance, financial engineering, operations research, computational statistics, machine learning, and financial analysis gain sufficient popularity among employers as well. With the wider adoption of data science and machine learning in portfolio risk modelling and portfolio management there is also an increased demand for predictive analytics in the recent years.

Second, quants are expected to command adequate financial market knowledge. The supervisory view of model is that models are simplified representations of real-world relationships among observed characteristics, values, and events. Understanding the underlying problem is critical for a quant to succeed which requires a good grasp of how financial market works as a whole, as well as sufficient familiarity with individual products being involved such as commodities, interest rate, foreign exchange, and asset-backed securities,

aside from robust mathematical and analytical skills. Unlike the mathematical knowledge that can be learned in an academic setting, most quants acquire financial market knowledge by working with traders, portfolio managers, and other colleagues in risk management.

Third, software skills are also critical for quants to perform at a proficient level. C++ is the most important programming language and commonly used for high-frequency trading applications. Other statistical softwares include Matlab, SAS, S-PLUS/R, SQL, and Python. Advanced skills in Excel are also required, in particular when there is an integration of Java, .NET and VBA with Excel.

The most recent financial crisis has resulted in heightened attention on models developed and used for the financial market from regulatory agencies. The issuance of the BOG-FRB SR 11-7/OCC 2011-12 establishes supervisory expectations on key elements of model risk management including model development, implementation, and use, model validation, and model governance, policies and controls. More quants employed by banks have been involved in the control function often called model risk management or model validation unit, which validates the entire process of model development and implementation, approves or rejects the models before the front office can deploy them for production use. There are also specific expectations on financial institutions that leverage vendor models. The impact of such regulatory guideline is profound. For example, models cannot be used for business prior to validation and approval. For models already used in in production but with identified major deficiencies timely remediation plans and exception approval need to be in place. It is important for quants to add knowledge of regulatory requirements to their tool kit in the changing environment.

Maintaining large interconnected ecosystems of in-house and vendor built models will be necessary for banks as a going concern to meet regulatory requirements; correspondingly, the skill requirements will be ever diverse relying on people of varied educational and professional backgrounds. Lastly, developing communication skills will become more important in the future. Successful quants will have to communicate abstract mathematical constructs to end-users, senior management, business heads, and regulators.

ASSESSING RISK-PROFILE OF QUANT STRATEGIES: THE CONVEXITY VS SKEWNESS

Artur Sepp

All quantitative strategies have specific risk profiles characterized by the skewness of returns, performance in tail events, and cyclicality risk, when strategies perform only in certain market cycles. Artur Sepp, Director And Senior Quant at Julius Baer Group, has previously discussed the cyclicality risk of quantitative strategies and here looks at convexity vs. skewness.

This year at QuantMinds International, I presented my latest work on Machine Learning (ML) for volatility estimation and prediction. The goal of applying ML for systematic trading is to improve the risk-profile of quant strategies and reduce the risk of back-test over-fit. I would like to introduce my presentation by discussing the risk-profile of quantitative strategies using the two key risk metrics.

- **Skewness of realized returns.** The skewness serves as a static measure of the third order risk-profile of investment strategies. Strategies with the negative skewness typically include carry and mean-reversion strategies, in which frequent small gains are followed by infrequent large losses. Strategies with positive skewness tend to include trend-following and long volatility strategies, in which case strategies tend to produce infrequent large gains followed by a series of frequent small losses.

- **Convexity of realized returns with respect to the flagship index or benchmark.** I define the convexity as the beta coefficient of strategy returns to the square of returns on the benchmark. In this way, the convexity measures the dynamic risk of strategy performance in tails of the performance of the flagship index. On one hand, the strategies with negative convexity underperform considerably the index in stressed periods with large negative performance on the index and yet they tend to underperform the benchmark when it produces large positive gains. On the other hand, the strategies with positive convexity tend to outperform the benchmark in both negative and positive periods with strong emphasis on delivering positive performance in stressed periods.

The quantitative way to analyze the convexity profile of a quantitative investment strategy is to estimate the quadratic (parabolic) regression of returns on the strategy predicted by returns on the flagship or benchmark index and index returns squared:

$$StrategyReturns = Alpha + LinearBeta * IndexReturns + ConvexityBeta * IndexReturns^2$$

The estimate of the linear beta indicates the direct first-order exposure to the performance of the benchmark index. Market-neutral strategies have insignificant linear betas. The estimate of the convexity beta assesses the second-order exposure indicating how the strategy performs in markets with strong bias to either downside or to upside. The convex strategies benefit from extreme returns on the benchmark index while the concave strategies suffer in extreme markets. The alpha is the estimate of the excess return that the strategy can generate.

Illustrations using hedge fund indices

To illustrate the risk profile of different quantitative strategies, I apply hedge fund indices that show the aggregated performance of niche quant hedge funds (HF):

- **Short Vol HF index** is CBOE Eurekahedge Short Volatility Index measuring the equal-weighted performance of 13 hedge funds which have short exposures to the implied volatility.

- **Relative Value Vol HF index** is Relative Value Volatility Hedge Fund Index of 35 hedge funds that run volatility strategies with long, short, or neutral exposure using the relative value approach.

- **Long Vol HF index is Long Volatility Index** of 11 hedge funds that have net long exposures to the implied volatility.

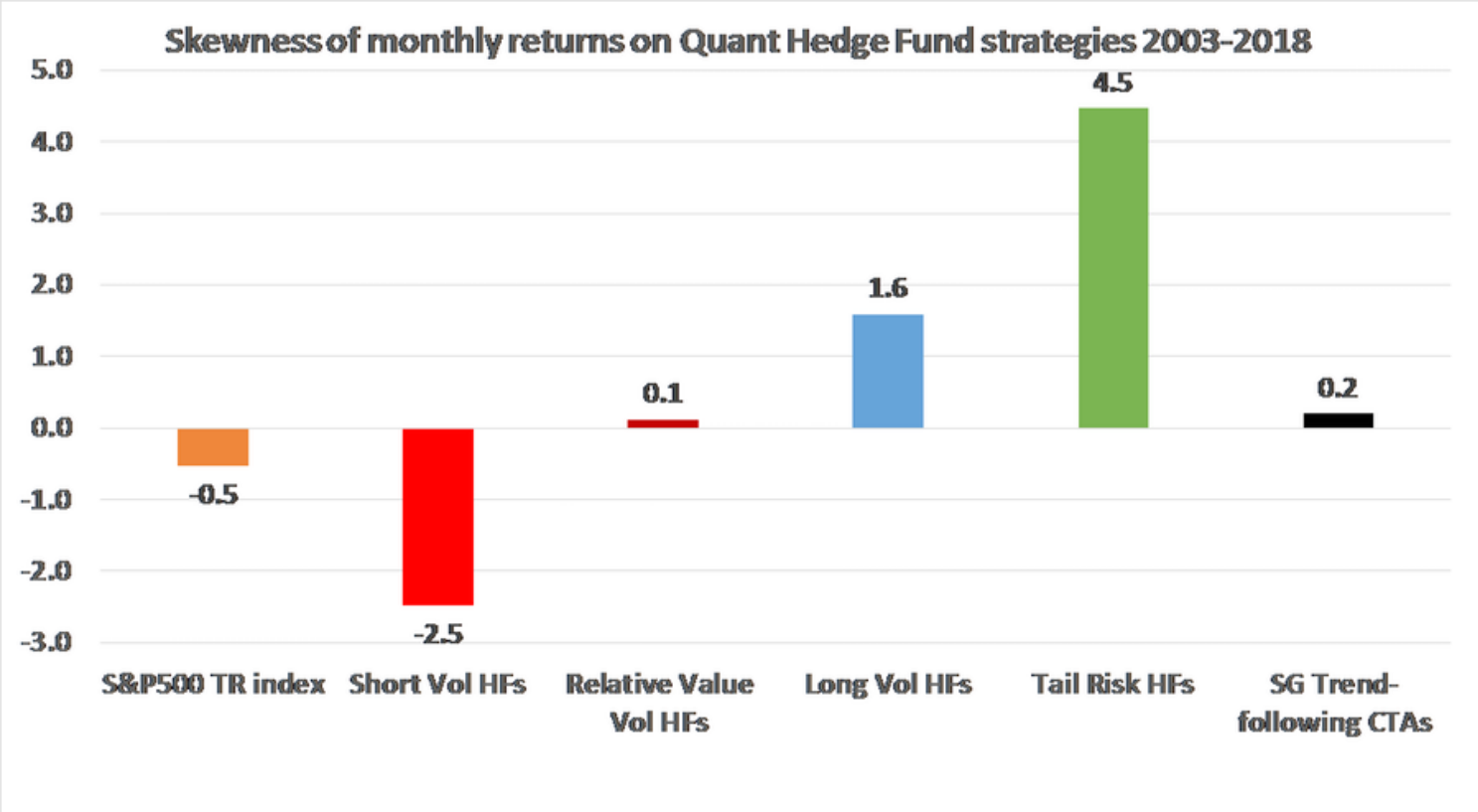
- **Tail Risk HF index is Tail Risk Hedge Fund Index** including 8 hedge funds that seek to generate significant upside during market stress periods.

- **SG Trend-following CTAs is SG Trend Index** (NEIXCTAT Index) consisting of 10 systematic trend-following commodity trading advisors (CTAs).

Both the CBOE HF and SG CTA indices are equal-weighted and reconstituted annually accounting for the survivorship

bias. CBOE HF indices are updated on monthly basis while the SG trend-following CTAs index is updated daily. The time series of monthly returns for the first three Eurekahedge HF indices are available from January 2005, the data for Tail Risk HF index and SG Trend-following CTAs are available from January 2008 and January 2000, respectively.

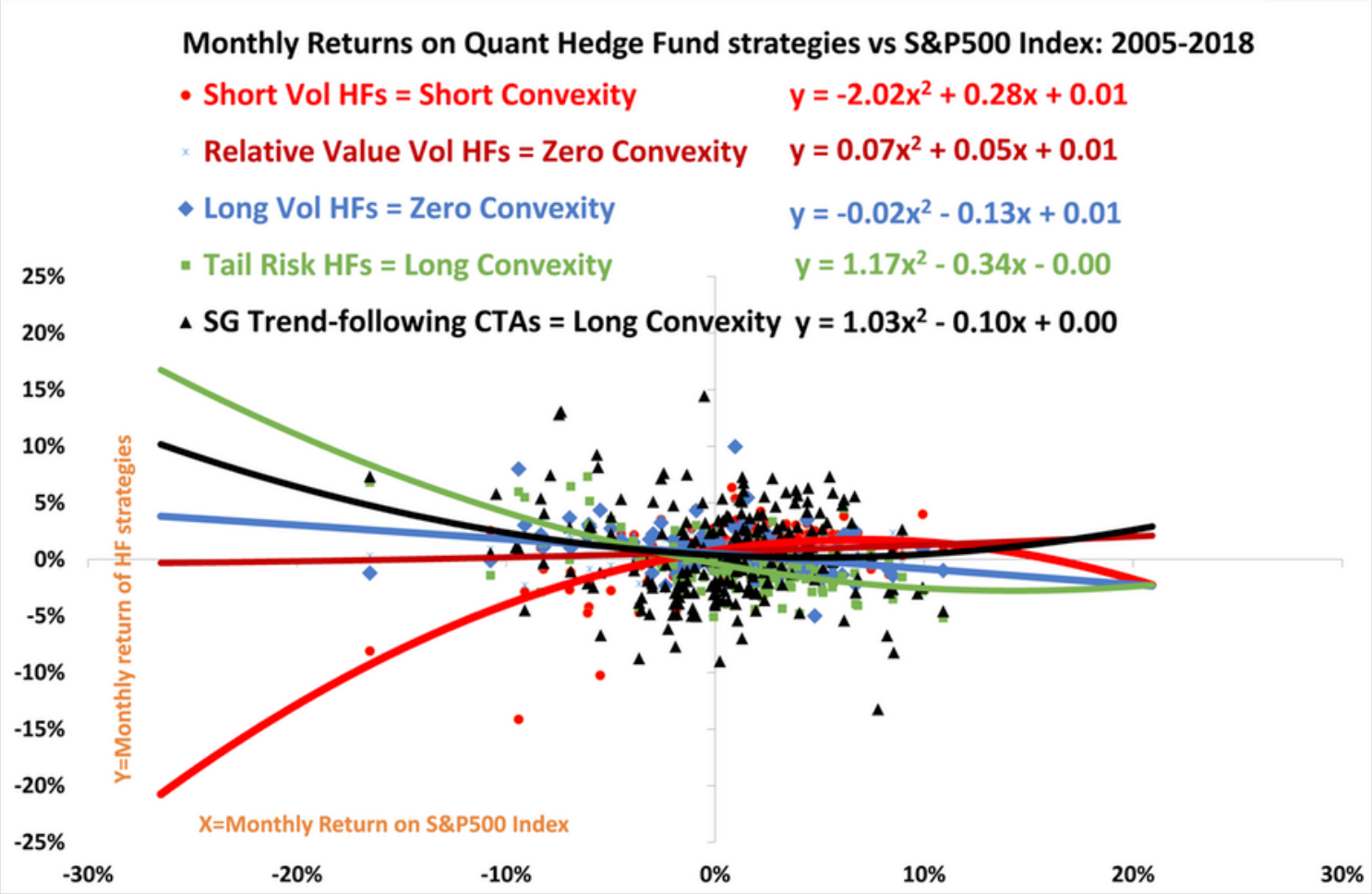
In the figure below, I show the realized skewness on the HF strategies. The short vol strategies are the most negatively skewed, which is a typical feature of this strategies. The positive performance over the stressed periods on short volatility strategies is seen as a compensation to bear the skewness risk of these strategies.



The relative value vol funds have insignificant skewness by combining short and long exposures to implied volatility, while the long volatility funds can generate positive skewness by maintaining the net long exposure to the implied volatility. The tail risk hedge funds have a strong positive skewness which come however at the expense of extended periods of losses during normal markets.

The trend-following CTAs do not appear to generate significant skewness for monthly returns, however, the skewness of quarterly returns becomes significant. I also point out because we have a limited number of monthly returns – about 200 observations – the sample volatility of the skewness estimate is relatively high of about 0.17.

In the figure overleaf, I show the realized convexity with respect to the S&P 500 index using monthly returns. The overall explanatory power of the regression is not strong, only about 10%, However, it provides the indication on the tail risk of quant strategies.



Short volatility HFs generate strong negative convexity losing during stress periods. Relative value and long vol HFs have an insignificant convexity profile. It is instructive that for long Vol HFs, the positive skewness does not produce positive convexity: while the long vol HFs are expected to produce infrequent large gains, the arrival of these gains is not expected to occur in the tail. In contrast tail risk HFs do produce both positive skewness and convexity, however at a cost of negative overall performance which can be seen from their negative alpha. Trend-following CTAs produce significant positive convexity even though they have insignificant positive skewness.

I specifically address the risk profile of trend-following in my recent blog and SSRN article.

JOIN THE CONVERSATION #QUANTMINDS