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1 November 2019

ALTERNATIVE BETA MATTERS

Quarterly Newsletter - Q4 2019

Introduction

Welcome to CFM's Alternative Beta Matters Quarterly Newsletter.

Within this report we recap major developments in the Alternative Industry, together with a brief overview of Equity, Fixed Income/Credit, FX and Commodity markets as well as Trading Regulations and Data Science and Machine Learning news. All discussion is agnostic to particular approaches or techniques, and where alternative benchmark strategy results are presented, the exact methodology used is given. It also features our 'CFM Talks To' segment, an interview series in which we discuss topical issues with thought leaders from academia, the finance industry, and beyond.

We have included an extended academic abstract from a paper published during the quarter, and one whitepaper. Our hope is that these publications, which convey our views on topics related to Alternative Beta that have arisen in our many discussions with clients, can be used as a reference for our readers, and can stimulate conversations on these topical issues.

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Global Markets are having to navigate through oceans of uncertainty, with four key themes dominating throughout the quarter. First and foremost is the ongoing trade dispute between Washington and Beijing: an announcement of new tariffs by President Trump on 1 August was the catalyst for a broad equity market sell-off, with investors piling into safe-haven assets. The second theme is the growing unease about global economic growth prospects: macro indicators were disappointing, with notably both German manufacturing and Chinese GDP figures slipping. Third, a flurry of geopolitical and domestic political risk is reason for pause: an attack on Saudi Arabian oil infrastructure for instance. The fourth theme is the monetary policy easing of most key central banks, partly in response to the risk that each, and a combination of the above pose to sustained global growth. Amidst this bevy of risks, investors are justifiably edgy, with heightened volatility observed in global markets over Q3.

Notwithstanding the uncertainty in markets, alternative managers enjoyed a good quarter, with the benchmark HFRX Global Hedge Fund Index gaining 1.6% and making it the third consecutive quarter of positive performance in 2019 (and the best performance YTD since 2013). Most other global hedge fund indices also showed positive performance. One exception, however, was the HFRX Equity Market Neutral Index which lost 0.2%. Market neutral strategies fell victim to a momentum reversal that stole most of the headlines in September.

Amongst alternative risk premia strategies, performance was notably undermined by equity market neutral portfolios – especially during August. The Société Générale (SG) Multi Alternative Risk Premia Index[1] still managed to post a 2% positive return over the quarter.

The headline story, however, was the good performance of Commodity Trading Advisors (CTA) in 2019, which continued in Q3. The Société Générale CTA[2] Index posted a gain of 3.6% over the quarter, following the 2.8% it recorded in Q2. Other SG Prime Indices showed similar good performance: the SG Trend Index finished up 5.8% for the quarter – bringing the yearly returns to 13.7%, and indicative of trend following strategies' broad outperformance compared to other common CTA strategies such as Global Macro. A substantial portion of the gains for CTAs (especially for trend following programs), were from positioning in the fixed income market. Looking at the non-specific performance across asset classes with the application of a generic trender signal[3], performance within the interest rate asset class was the most consistent, with the majority of contracts showing positive performance. The returns across and within other main asset classes were less consistent, with wider spreads between the best and worst performers. Finally, the BarclayHedge CTA Index[4] (+1.2% over the quarter) registered similar performance.

The one year rolling average absolute correlation between all futures contracts, taken as an indicator of CTAs' ability to diversify, continued to fall further during Q3, and reached close to 16% at the end of September. The correlation, between bonds and equities (with the US 10-year and US benchmark indices taken as proxies), briefly slipped below <-50%, during the quarter, shortly after the global equity sell-off in early August. These levels were maintained after investor sentiment improved in September, with the rally in debt relaxing, while equities rallied.

Total return for Equity Market Neutral (EMN) and CTA hedge fund indices over the past year[5]

[1] The Société Générale Multi Alternative Risk Premia index is an equal-weighted index of funds, capturing the returns of managers employing multi risk premia investment strategies across multiple asset classes.

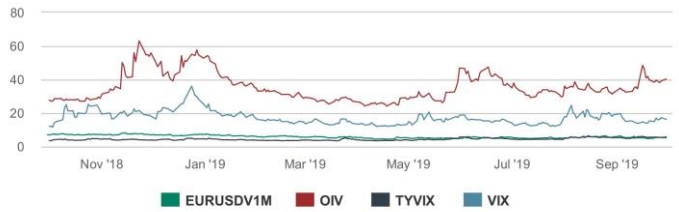
[2] The Société Générale CTA index is an equal-weighted index of the twenty largest (as measured by assets under management) trend following CTAs, who are recognised as such within the industry and are open to new investment. For construction methodology and a full list of constituents, see: https://cib.societegenerale.com/en/prime-services-indices/

[3] Our generic trender is calculated as described in our 'Two centuries of trend following' paper, which is available on our website: https://www.cfm.fr/insights/two-centuries-of-trend-following. The trend signal is the sign (either +1 or -1) of the difference of the last price and an exponential moving average of the past 5 months' prices, divided by the volatility: $S_n(t) = \frac{p(t-1)-\langle p\rangle_{n,t-1}}{\sigma_n(t-1)}$

[4] The BarclayHedge CTA Index provides monthly performance data for a large selection of managed future managers, going back to 1980. Constituents and methodology can be obtained on the BarclayHedge website: https://www.barclayhedge.com/research/indices/btop/

[5] The EMN index is that calculated by HFR, while the CTA index is calculated by Société Générale.

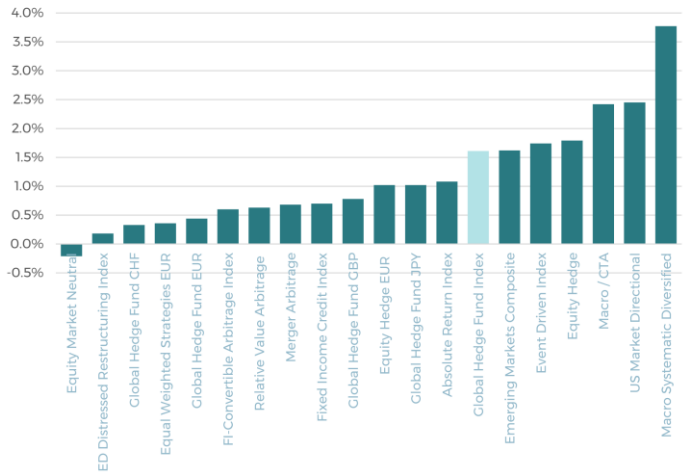
The principal implied volatility indices across four asset classes over the past year[6]



The log of the dollar risk weighted average daily volume across futures on the four asset classes over the past year[7]

The return of the generic trender[8] referenced in the text over the past year

HFRX Indices quarter performance



[6] For the EUR/USD exchange rate we use the Bloomberg defined EURUSDV1M ticker. The VIX, TYVIX, and OIV indices are calculated and published by the CBOE.

[7] We estimate effective FX volumes to be a factor of 5-10 more than this due to the extra liquidity available through the spot markets.

Equity indices

Distinctive monthly returns of global equities were observed, with mostly sideways movement in July; followed by a dramatic sell-off in August; and finally, a recovery in September (notwithstanding the well-documented momentum-reversal towards the end of the month).

July delivered positive, yet lacklustre returns. Global developed, market-cap weighted equity markets returned ~0.4% over the month, supported by, amongst others, global central banks' dovish pivot culminating in the first US Federal Reserve rate cut in eleven years at month-end. Quarterly earnings were broadly positive, with a majority of companies reporting growth that exceeded analyst expectations.

August got off to a rocky start as US President Trump announced plans to raise additional tariffs on Chinese imports: 10% on approximately $300bn worth of goods that have escaped subjugation to that point. Chinese authorities responded in kind by allowing the yuan to fall below 7 to the dollar – a key level unseen since the financial crisis. A tit-for-tat approach prompted the Trump administration to formally label China a currency manipulator. Equity markets fell by the most in 2019 on 5 August, with volatility duly picking up and remaining elevated for the remainder of the month. European equities underperformed their American counterparts. Weak economic data in Germany weighed on markets, notably manufacturing PMI figures that continued to slide with an economy seen to be on the brink of recession. The Eurostoxx 50 finished down -2.4% (in dollar terms), approximately 0.6% worse than the S&P 500.

September will probably be best remembered for the momentum reversal, which stole headlines as value stocks found strong bids in favour of those stocks having featured strong trend growth for most of 2019. Despite much speculation about the 'Momentum crash', consensus seemed to point to the abrupt U-turn in the then recent spurt of bond buying. As yields rose, and markets turned bullish, hitherto loaded up defensive stocks sold-off, especially Consumer staples. However, renewed optimism over a resumption of trade negotiations turned investors bullish, with the month starting off with a bang: the S&P 500 ended 1.3% higher on 5 September. A US Fed, who, as was widely expected, cut the federal funds target rate on 18 September, also supported global equities. European stocks, meanwhile, staged a comeback and were among

[8] Our generic trender is calculated as laid out in our 'Two centuries of trend following' paper, which is available on our website: https://www.cfm.fr/insights/two-centuries-of-trend-following. The trend signal is calculated as the difference of the last price and an exponential moving average of the past 5 months' prices, divided by the volatility: $S_n(t) = \frac{p(t-1) - (p)_{n,t-1}}{\sigma_n(t-1)}$. The instruments are equally risk weighted in the portfolio.

the best global performers. With the European Central Bank (ECB) having announced, on 12 September, an aggressive stimulus package, which included a reboot of its asset purchasing program, the Eurostoxx 50, and the broader Stoxx 600 gained 4.2% and 3.6% respectively (in Euro for the month.)

Meanwhile, looking forward, most closely watched Leading Economic Indicators (LEI) were either stable, or declined, with the OECD G7 Composite Leading Indicator having posted a 14th consecutive monthly drop in August. A lingering unease of slowing global growth (probably caused, or at least exacerbated by unsettled trade negotiations) prompted a shift to what traditionally is thought of as defensive sectors. As a consequence, in the US, the best quarterly performance came from Utilities and Consumer Staples. The worst performing sector was Energy – although this was in large part owing to the poor performance in August as worry about slowing growth and trade tensions peaked.

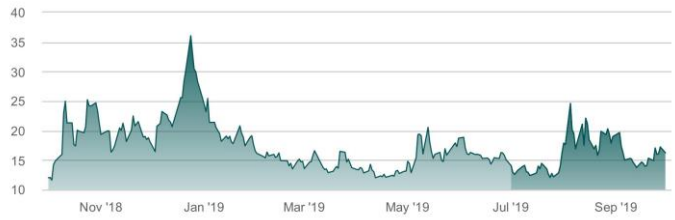
When applying our generic trender signal, the Nasdaq composite index delivered the most negative performance. The US Tech benchmark, after delivering good performance in July (+2.3%), suffered a dramatic reversal with a sell-off during the first weeks of August: the index lost 4.6% during the first two weeks as worries about a Chinese retaliation hit. Rising tariffs were feared to directly affect US consumers, with Tech companies likely the hardest hit. Contrarily, the Nikkei featured the best performance with our trender applied.

The Australian S&P/ASX 200 contract was the most overbought index, with a Relative Strength Index (RSI)[9] of 64 points on 8 July (very early on in the quarter on the back of strong gains in the previous quarter as one of the top performing indices in Q2). The Hang Seng Index, in a repeat of Q2, had the lowest RSI of 39 points, registered on 15 August.

Volatility spiked during August, with the VIX peaking at 24.6 points on 5 August – briefly after the announcement of intended tariffs. Realised 10, 30, and 50-day volatilities of the S&P 500 all trended higher until approximately mid-September, before dipping slowly towards levels prior to the collapse in August.

Finally, the CBOE Skew index[10], a widely tracked measure to gauge investors' sensitivity to skew risk, *i.e.* the likelihood of large 'outlier' returns in the S&P 500, was elevated through July (averaging ~125 points – a level closer to 100 indicating a normally perceived distribution of returns). Following the burst of volatility during the first week of August, the index drew down as markets anticipated a lower probability of additional large returns, ending the period at ~115 points.

CBOE VIX index



Stocks and equity factors

Factor-based investment strategies recorded a slightly negative quarter, with the HFRX Equity Market Neutral Index (HFRXEMN) down -0.2%.

In a reproduction of the Fama-French-Carhart factors, the Small Minus Big (SMB), or Size factor showed European small-cap equities ending flat over the period, but, in a repeat of Q2, outperformed their peers in the US and Japan.

There was a high level of volatility observed in the High Minus Low (HML) factor. All key regions presented with a similar pattern: a slow and steady downward drift through the quarter, until early September when Value securities rallied. The effect was most pronounced in European equities (but a strong surge in undervalued securities were also observed in the US). While Japanese value stocks also picked up, it was much less pronounced than in Europe or the US.

The rotation into Value stocks were largely triggered following the now so-called 'Momentum crash.' Looking at the performance of Momentum stocks in our reproduction of the Up Minus Down (UMD) factor, we observe a noticeable, and significant drawdown in all regions in early September. The most significant drawdown was registered in the US (from the peak reached at August month-end, to the trough level on 16 September), where Momentum stocks fell as much as 13%. European stocks suffered a similar drawdown, albeit slightly less dramatic than the US, with Japanese stocks the least affected. Broad consensus seems to point to the abrupt U-turn in the most recent spurt of bond buying. As yields rose, and markets turned bullish (as central banks ostensibly embarked on looser monetary policy, and trade

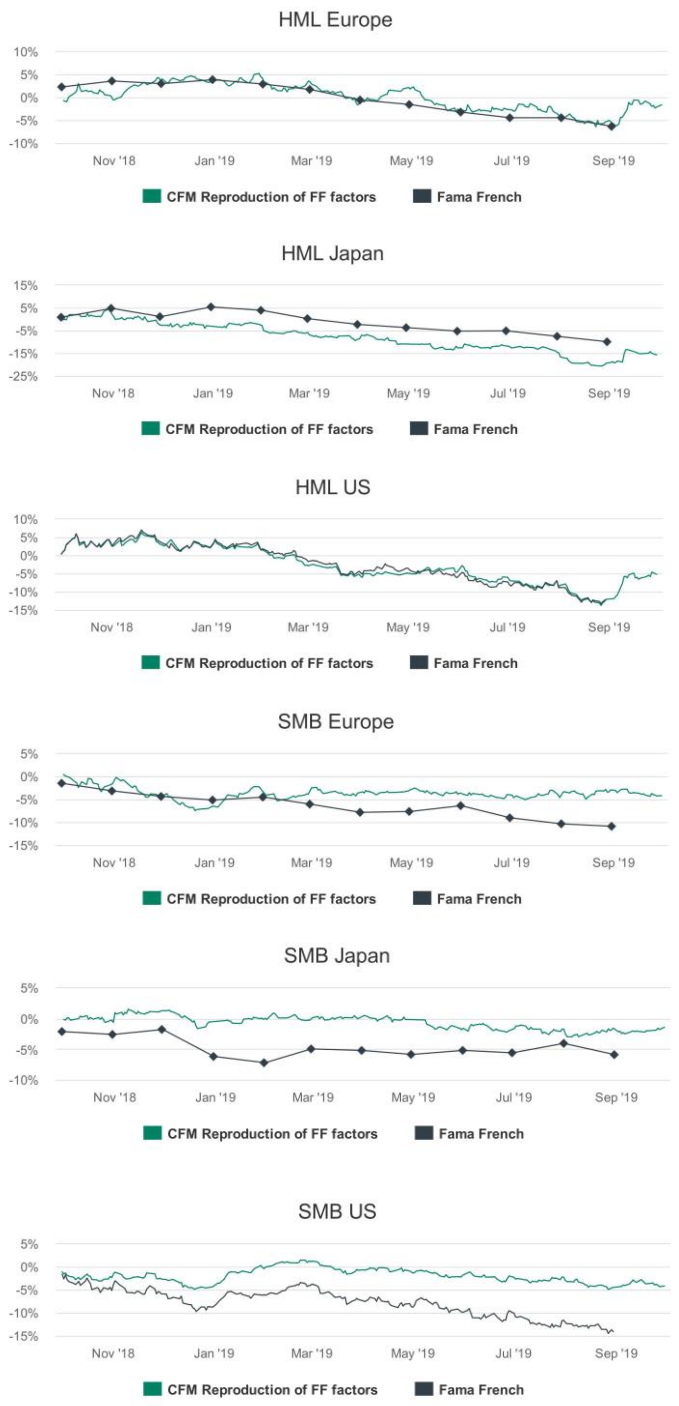
[9] Defined according to https://www.investopedia.com/terms/r/rsi.asp. The RSI varies between 0 and 100 with 70 implying an instrument is overbought and 30 implying the instrument is oversold.

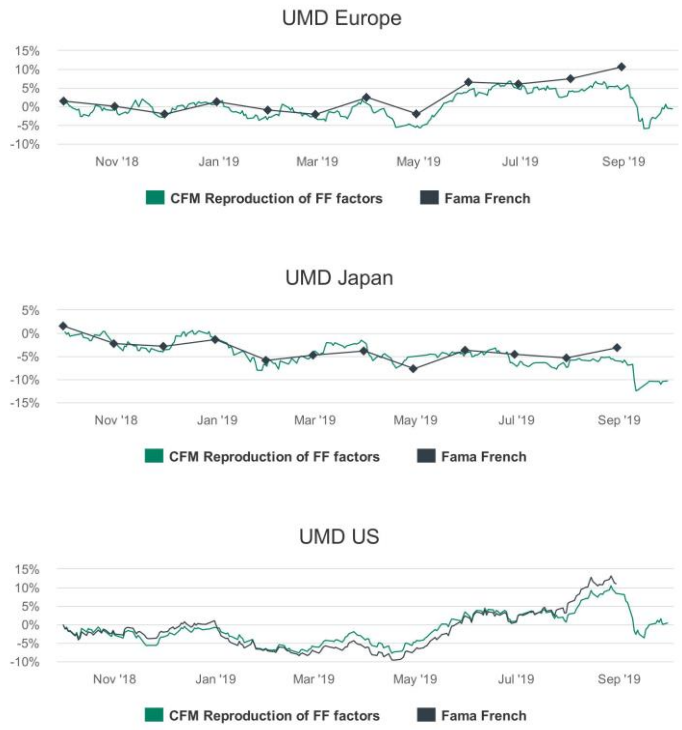
[10] For more information on the CBOE Skew Index, please refer to the official documentation and the methodology on the official website: http://www.cboe.com/products/vix-index-volatility/volatility-indicators/skew

worries receded), hitherto favoured defensive stocks sold-off, especially Consumer staples in the US.

Turning to the long only implementations of factors, Momentum Indices performed the worst over Q3, with negative gains in the low single digits (with most of the losses booked in September). Quality Indices along with Value indices, favoured during September, registered slight positive returns.

The Fama-French factors for the last year in Europe, Japan & US





High Minus Low (HML) corresponds to a market neutral (MN) portfolio long the high book to price stocks and short the low book to price stocks. Small Minus Big (SMB) corresponds to a MN portfolio long the small market cap stocks and short the large market cap stocks. Up Minus Down (UMD) corresponds to a MN portfolio long the historical winners and short the historical losers. In each case, the grey line is downloaded from Kenneth French's website, while the green line is the CFM reproduction of the Fama-French portfolios. The methodology can be attributed to Eugene Fama and Kenneth French and is not explicitly used in any CFM product.

Fixed income

Global markets have become highly sensitive to any update regarding the ongoing trade war. Markets exhibit significant swings and increased volatility in reaction to news about trade negotiations, often delivered in the form of tweets from the White House. It has even prompted the creation of the 'Volfefe Index' – a J.P. Morgan effort to quantify the influence of President Trump's tweets on interest rate markets. Taking aim at the infamous "covfefe" tweet of the President, the index attempts to quantify the fraction of implied volatility in the US Treasury market that stems from President Trump's tweets. The premise of such an index is not entirely trivial – there is some evidence that markets tend to exhibit more volatility on those days that the frequency of the President's tweets increase, especially related to trade.

Allowing credence to this proposition, it was then not completely unsurprising that bonds surged in August, following the announcement of new tariffs. Investors, skittish about the implications of an extended trade war and the likely spill-over effect on the global economy, ploughed into safe-haven assets, with the liquid US treasury market a prime benefactor. The US 10-year benchmark yield fell 12 basis points on 1 August, and continued to slide to below 1.5% at its trough on 3 September (a 44 basis point change from August). The Bloomberg Barclays Multiverse – the biggest and broadest global fixed income benchmark index – gained 1.83 % in August as global yields tumbled. With yields tumbling, volatility surged and implied volatility – the CBOE TYVIX acting as proxy – hit a high of 6.4 points on 15 August (from around 4.2 points at July month-end).

September saw a strong reversal in the fortunes of fixed income securities as trade tensions eased, and the prospect of a restart in trade negotiations (along with goodwill gestures from both sides), prompted a reinvigorated risk-on sentiment. The US 10-year climbed to nearly 1.9% by 13 September – the same levels prior to the August buying spree. By quarter-end, the US 10-year was, however, 36 basis points lower.

Elsewhere, European debt followed a similar pattern, driven by similar forces (albeit with its own idiosyncratic dynamics). Growing unease about the outlook for the Eurozone, especially given the deteriorating German economy, were at least in part responsible for prompting additional monetary policy from the ECB: A massive stimulus package was announced by Mario Draghi, outgoing President of the European Central Bank, on 12 September including rate cuts. The German Bund promptly fell 22 basis points over the quarter.

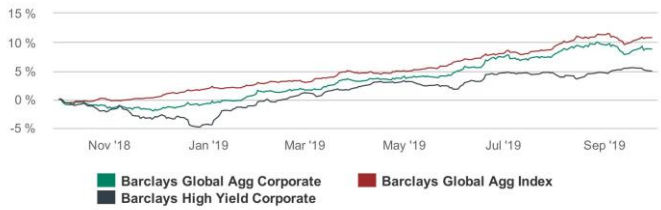
Policy makers are not only having to steer monetary policy in a still low inflation environment, with global growth uncertainty and multiple geopolitical risks, but are having to field intense criticism from the political class. The ECB decision on September was not widely welcomed, with notably German Bundesbank President Jens Weidmann saying shortly after the ECB announcement that "such a far-reaching package was not necessary".

There is also a measure of uncertainty about looser monetary policy amongst the policy makers themselves. Whilst the US Fed cut interest rates on two separate occasions in Q3 (25 basis points in July and the same again in September), the Fed, following its first dissent regarding monetary policy since 2017 at the June FOMC meeting, a second (at the July meeting) and a third (at the September meeting) followed.

When applying our generic trender, the UK 10-year Gilt was the best performing bond, while the Japanese 10-year was the worst performer (still positive). The lowest RSI of 48 points was reached on 16 September by the Canadian 10-year Bond, while the Euribor recorded the highest RSI of 74 points on 3 July (the Euribor languished in overbought territory from the end of Q2, before sliding towards neutral by mid-September). The highest RSI in sovereign paper was that of the German Bund, attained on 16 August following the surge in demand for safe-haven assets following the trade tariff announcement.

The benchmark Barclays Global Aggregate suite of indices offered positive returns: the Total Return Index (unhedged) returned 0.71% over the period (2.6% for the hedged version), while the sister Global Aggregate Corporate Total Return Index (unhedged) gained 1.2%. Corporate bonds (especially non-investment grade) underperformed, with the High Yield Total Return Index (unhedged) gaining 1.3%.

The return of Barclays Global Aggregate Bond Indices for the last year



Commodities

Gold, in similar fashion to the previous quarter, made headlines after staging yet another impressive rally. Given the uncertainty around trade negotiations (especially and directly following the announcement of President Trump of new tariffs in early August), along with ever gloomier economic growth prospects, the yellow metal contract surged 6.4% during August. The 3-month implied volatility jumped from a low of ~10 points at July month-end, to nearly 16 points three weeks later. A cocktail of its status as favoured safe-haven asset, along with falling interest rates as central banks turned towards looser monetary policies (lower real interest rates lowers the opportunity cost of holding bullion), ultimately pushed the metal to a 3.4% gain over the quarter.

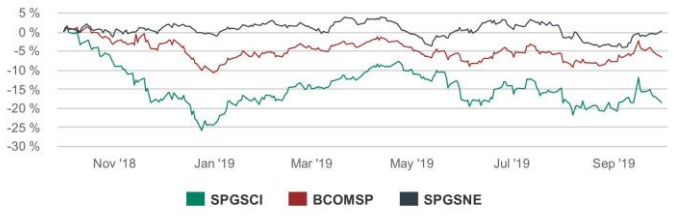
However, gold's cousin silver featured the best performance over the quarter. Driven by similar market forces as the yellow metal, the silver contract rose 10% in Q3 driven not only by the same safe-haven asset buying, but also by rising demand for the metal's core industrial usage. When our generic trender is applied, the metal was

the best performer in Q3. The consistent buying moreover pushed the RSI of silver to a peak of above 70 (on 5 September), also making it the most overbought commodity in Q3. Cotton, however, registered the lowest RSI: reaching 34 points and close to oversold territory on 6 August. The soft commodity came under pressure, predominantly as a revival in monsoon rains in India – the world's largest producer, prompted an upward revision of output expectations of 20-25%. Along with depressed global demand, the commodity lost 7.9% in Q3.

With the generic trender applied, Crude was the worst performer. A short position – on account of a consistent downward price pressure (Crude lost nearly 15% between April month-end and 13 September) – suffered losses as oil spiked following the attack on Saudi Arabia oil infrastructure over the weekend of 15 September. Fearing a significant disruption in supply, WTI Crude and Brent closed respectively 14.7% and 14.6% higher on the Monday. In the weeks following the attack, reports trickled in showing that the disruption would be mitigated in shorter order than originally expected. The CBOE/Nymex Oil Volatility Index jumped from moving within a range of between 32-38 points, to a peak of 49 points after the Saudi attack. The volatility sagged shortly thereafter, but remained elevated for the remainder of the period (bouncing around the 40 point threshold).

On aggregate, commodities settled lower, with the Bloomberg Commodity index falling just shy of 2.4% in Q3 (in dollar terms) in large part owing to the poor performance from energy markets. WTI and Brent (together constituting ~16% of the index) acted as a drag on the index, as did Copper. The industrial metal, frequently employed as a bellwether for demand and growth prospective (especially in China – the biggest importer of the industrial metal) lost 5.2% over the quarter. This followed on from a 7.8% drop in Q2 and is reflective of the unease about concern over global growth.

The one year return of the S&P GSCI, GSCI Non-Energy, and Bloomberg Commodity Spot indices



FX

The US dollar had its best quarter since Q2 2018. The greenback rallied 3.4% as per the DXY Dollar index, and the Fed's Trade-Weighted (or Broad) index hit an all-time high in September, ending 1.7% higher in Q3. The surge in the dollar came amidst and despite looser monetary policy by the Fed, with expectations for interest rates revised downward after the September meeting: the Fed's 'Dot-plot', FOMC members' expectation for future interest rates, revealed a lowering of the median year-end 2019 target rate to 1.875% (following the September meeting), down from the 2.375% median following the June meeting.

The euro constitutes the largest weighting in the DXY Index (57.6%), in part explaining the surge in the dollar index. The euro lost 4.2% against the greenback, on the combination of various drivers. First and foremost, the lacklustre outlook for the German economy has kept the euro under pressure. In response, the lowering of interest rates in the Eurozone by the ECB is making the euro an even more attractive funding currency for carry trades (borrowing the euro and selling it on the market in favour of other higher yielding currencies).

Further afield, the Japanese yen had a rollercoaster ride in Q3. After a choppy, but range bound July, the yen jumped 1.3% against the greenback on 1 August, following the surprise announcement of President Trump's intention to impose 10% of tariffs on $300bn worth of Chinese goods from 1 September. Beijing responded by allowing the yuan to weaken through the 7 yuan to the dollar mark a few days later as an ostensible response to the US tariff threat, and the US shortly after labelled China a currency manipulator. The yen gained nearly 2% in the first two weeks of August as investors sought out safe-haven assets. Implied volatility (1-month at-the-money) duly surged: from ~5 points on 31 July to 8.5 points by 23 August. The implied volatility of the yen outpaced those of all other major currencies. The yen's upward journey changed tack early in September, however, on renewed trade hopes.

The Canadian dollar featured heightened volatility given its particular sensitivity to the price of oil, but also was boosted by a favourable, domestic macroeconomic environment. For one, the GDP print for Q2 came in at 3.7% - much stronger than the 3% economists' forecast and acted as support for the loonie going into September. The Canadian dollar hit a yearly high against its southern neighbour in mid-July, having been supported by the theory that, given, amongst others, inflation in Canada is running above target, the Canadian central bank is likely

to buck the trend of looser monetary policy as witnessed in other major economies.

Meanwhile, emerging markets also struggled through a difficult quarter. The JP Morgan Emerging market currency index fell 4.1% - its worst quarterly performance since Q2 2018. Amongst the crowd of G7-21 currencies, it was the Chinese yuan that hawked most attention. After breaking though the 7 dollar level, it continued to slide and ultimately lost 3.9% against the dollar. At one point, and reflective of the heightened selling momentum, the 14-day RSI against the dollar fell below 30 – into oversold territory. Moreover, the CFETS (China Foreign Exchange Trade System) RMB Index, an index that tracks the yuan against the currencies of 24 strategic trading partners, fell 2.32% in August, and reached a level of 91.1 in early September – the lowest level since the gauge was introduced in 2015. When applying our generic trender, short positioning in the yuan was the best performer in the FX asset class.

A major disruption in emerging markets came on 12 August, when the prospect of a change in leadership in Argentina to a left-wing opponent in the Kirchner caste, sent the local S&P Merval index down 48% - the second largest daily price drop for any global bourse since 1950. Teetering on the brink of yet another financial crisis, investors fled, with the Argentine peso losing 14.5% on the same day, and continuing the sell-off to finish down 23% against the dollar in August. Cognisant of contagion potential, other emerging market currencies also tanked.

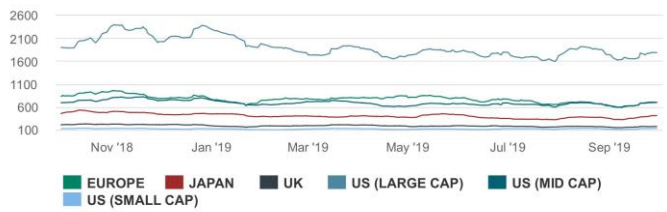
Trading news and regulation

We have been closely following the clampdown of American regulators on market data fees. These provide a primary source of profits for exchanges, with evermore investors needing to keep up with the movement of equity prices across a fragmented landscape of US equities. However, in a recent development, the SEC proposed an amendment to the 'Regulation National Market System' or 'Reg NMS', in order to make it more difficult to increase such fees. This move, while not unexpected, is certainly welcomed by both buy and sell-side clients whose market data budgets have skyrocketed over the past decade.

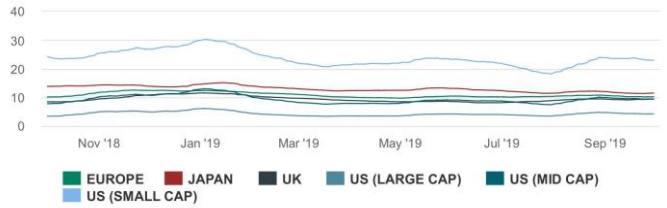
Another curious change in the landscape of trading-related commissions came in October. Charles Schwab, one of the largest American retail brokers, reduced its fees to zero. The move was quickly copied by several of its major competitors. As multiple articles point out, this does not mean that the service is free, simply that investors end up paying indirectly, much like in online services. The information about their order flow is monetised via a partnership between brokers and high-frequency traders. However, this practice continues to draw scrutiny from the SEC.

The European Securities and Markets Authority (ESMA), the EU's authority overseeing market stability, recently published a consultation paper on several new initiatives. The proposals would extend European market abuse regulation to FX markets, which remain quite loosely controlled. In particular, currency trading is still dominated by large dealers and is quite fragmented. More worryingly, a large part of the less sophisticated market participants still have their orders executed at benchmark rates defined by daily fixing prices, which may exhibit anomalous behaviour. Most recently two brokers were fined for artificially inflating trading volumes in the FX option market. We remain watchful of this space and closely follow the regulatory space as well as the ongoing definition of best practices.

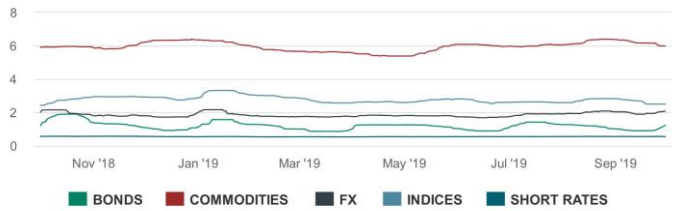
Average monthly dollar equity market volume in billion USD



Typical bid-ask spread in six major groups of equities in basis points



Average bid-ask spread on five future asset classes in basis points



Data Science & Machine Learning

CFM relies heavily on Information Technology, and in particular on vibrant and open tech communities and so-called 'open-source' computer libraries. These computer libraries are free to use, as their code (also called 'source' code) is open (i.e. readable by anybody). In an ongoing effort to support the community, we contribute by publishing and promoting social-media and blog posts, as well as open-source programs and libraries that are relevant to our business. We have, so as to institutionalise our contributions, recently introduced the #CFMTech hashtag on Twitter that now identifies our technical posts. The goal of these posts is to relay or publish technical information (in IT, data science, machine learning, etc.), that is curated by our in-house experts.

Beyond these succinct technical Twitter or LinkedIn posts, we also launched a blog: CFM Insights. Our first blog post explains how technology allows for the automatic creation of reports based on the leading programming notebook (Jupyter). We explain how to improve the management of successive versions ('version control'), and show custom input parameters for each automated notebook execution, before publication of the report.

In September we also released our first open-source creation: the Jupytab program. The name is a nod to the successful Jupytext program developed by CFM's Marc Wouts, which we helped to publish last year. Jupytab allows anybody to display plots with the leading data visualisation software Tableau, based on data obtained and transformed with the muscle of Jupyter notebooks and Python, a leading data science ecosystem. Our program creates a bridge between the best of two worlds: powerful data visualisation and powerful calculations. Anybody can download it, use it, and even contribute back to it!

Extended abstract

The case for long-only agnostic allocation portfolios

Paper by Pierre-Alain Reigneron, Vincent Nguyen, Stefano Ciliberti, Philip Seager and Jean-Philippe Bouchaud

Risk-Based Portfolios rely on a forecast-agnostic approach to investing, and they have risen in popularity since the global financial crisis. Their success reflects a growing disbelief in active managers' ability to deliver alpha, together with an increased emphasis on risk as a core component of investment policies.

These portfolios seek to efficiently capture some excess premium in one or multiple asset class(es) by factoring in risk-related quantities, without any explicit views on expected returns. In practice, many risk-based portfolio construction methods (in particular those relying on the inverse covariance matrix) are plagued by over-concentration and excess turnover.

Parsimoniously reliant on the covariance matrix, Agnostic Allocation Portfolios (AAPs) establish an efficient compromise in the risk-based space, between portfolios structurally blind to the correlation structure, and those based on the inverse of the covariance matrix of returns. Compared to previously documented risk-based portfolio construction methods, Agnostic Allocation Portfolios (AAPs) have less exposure to low-risk statistical factors which are a source of concentration and excessive trading.

AAPs offer similar to better risk-adjusted performance than standard alternatives such as the Maximum Diversification Portfolio or Minimum Variance Portfolio, especially for large pools of instruments. Additionally, the AAPs are much less concentrated than their optimisation-based competitors, and thus less exposed to idiosyncratic risk. Finally, AAPs are much less demanding in terms of portfolio turnover and transaction costs. At CFM we also focused on implementation efficiency: for all risk-based portfolios, concentration effects and excess trading can be substantially reduced by using adequately cleaned covariance matrices. We propose a cleaning method based on cross-validation.

With practical applications in mind, we make the code for the AAP optimisation and the covariance matrix cleaning method available in a Jupyter notebook.

Other news

- CFM was awarded the 'Best Offshore Manager Operating in Australia' at the Australian Alternative Investment Awards. See more details and pictures on the event website: https://www.hedgefundsrock.org.au/hfr-2019-awards
- Laurent Laloux, Chief Product Officer at CFM, was named as one of 'Tomorrow's Titans' in the annual Hedge Fund Journal report that identify those that are, or are set to become leading managers in their respective domains. See more details and the report on the Hedge Fund Journal's website: https://thehedgefundjournal.com/tomorrows-titans-2019-rising-hedge-fund-managers-of-the-future/
- Oliver Schupp, Head of Investor Relations for North America, spoke at the Alternative Investment Management Association (AIMA) Perspectives Seminar, in Santiago in September on the topic 'Man and Machine: An introduction to systematic strategies'. More information on the event can be seen here: https://www.aima.org/event/alternative-perspectives.html
- Philip Seager, Head of Strategies - Quantitative Investment Solutions, was a delegate at the annual AIMA Australia Forum, speaking on a panel entitled 'Trolling For Alpha - Finding An Edge With New Data, Technologies and Talent'. For more on this and other details of the event, please see the AIMA website: https://www.aima.org/events/flagship-aima-events/aima-australia-annual-forum/aima-australia-annual-forum-2019.html
- Philippe Jordan, Head of Investor Relations, spoke at the Absolute Return Conference in Sydney about seeing through the noise of financial market news. See details of the event, and a summary of what he and others discussed on the website of Investment Magazine: https://www.investmentmagazine.com.au/2019/10/hedge-fund-cfm-says-ignore-the-news/
- Charles-Albert Lehalle, CFM's Head of Data Analytics, took part in multiple roundtable discussions at the AI and Data Science in Trading conference in London in September. For more details, please see the event website: https://www.aidatatrading.co.uk/
- We hosted nearly a dozen of our popular 'Food for Systematic Thought', or FFSTs lunches in Q3. Please get in touch with your CFM representative for further details on upcoming events near you.
- Below is a selection of our recent papers:

> Confidence Collapse in a Multi-Household, Self-Reflexive DSGE Model arXiv:1907.07425 [pdf, other]

CFM Talks To

Robert Engle

We had the privilege of sitting down with Professor Robert Engle at his New York University office to discuss a range of contemporary topics, as well as some of his current research interests. Rob is currently the Michael Armellino Professor of Management and Financial Services, as well as Director of the Volatility Institute at the Leonard N. Stern School of Business. He is perhaps best known for his work on volatility modelling, for which, along with Clive Granger, he was awarded the Nobel Memorial Prize in Economics in 2003. His work has found wide application in the economics and finance professions, in particular the techniques he developed for more accurate risk forecasting.

Rob remains active and involved in the public discourse on economic and trade policy, as well as systemic risk. He also continues to teach, amongst others, in the NYU Stern MBA program. We asked Rob about his opinion around a set of three key themes: global economic uncertainty and geopolitical risk, his views on the US economy and current policy, as well as his new-fangled interest in climate change and risk. We also took the opportunity to get his take on some of the most talked about trends in asset management.

“To me, the evidence is not that conclusive that fiscal stimulus has been effective in the US, except for propelling the stock market.

CFM: *It might be appropriate to kick off with geopolitical risk, given that over the weekend (14 September) an attack on a Saudi Arabian oil refinery sent oil prices rallying and incited a surge in market volatility. This new threat – an apparent susceptibility of Saudi oil infrastructure – adds to an already long list of geopolitical risks. To what extent do you think markets are accurately pricing risk, and how might it be hedged?*

RE: In reading the literature on geopolitical risk you see lots of different ideas as to what it really is. And, clearly, when any portfolio underperforms, a ready answer is geopolitical risk. I have taken the view that by geopolitical risk, we mean geopolitical *events* that *move* markets.

We know that volatilities are to some extent predictable, and, if you investigate the history of volatilities of different countries and different asset classes, they typically peak at the same time. It then follows that volatility innovation is probably common across countries and asset classes. The drone strike on the Saudi refinery was completely unpredictable and affected all asset classes around the globe – not just commodities. And, as such, one can argue it was an innovation sprung from a geopolitical risk.

I have developed a statistical approach to assess how sensitive different countries and asset classes are to such a ‘common shock’. If a shock really is ‘common’ to all asset classes, every portfolio should be subject to the same shock. So, whilst there might be a ‘geopolitical risk premium’, one is still unable to predict when it’s going to happen, and whether it will affect all asset classes. It turns

out there is evidence that certain countries and asset classes are more sensitive to these common shocks than others.

And is it possible to hedge it?

An optimal portfolio – a Markowitz mean-variance-like portfolio for instance – is desirable because it features low volatility. But, what you would really like to know is that the volatility will stay low. So, if your preference is for a portfolio to be relatively unexposed to geopolitical risks, it is a different criteria, where a Markowitz portfolio might not be optimal. You might want to deviate from the Markowitz portfolio, or have another measure for optimisation other than just mean-variance efficiency – that is if you believe there to be a paradigm of heightened geopolitical risks.

CFM: *Following this chain of reasoning, one could argue, despite much punditry, that pinpointing a particular theme or type of geopolitical risk and how that might manifest in the markets is irrelevant? Is it how the common shock affects global market that matters?*

RE: Yes indeed. I can go back in time and identify the days where we observed the most volatility owing to a 'geopolitical risk': 9/11, or, the day right after the Brexit vote. These are clearly two totally different events – one a terrorist attack, the other part of a political process.

CFM: *Have you observed any geopolitical risks that produce unique persistence in volatility?*

RE: Geopolitical risks are themselves supposed to be innovations, and as such do not have any autocorrelation. The shock itself predicts an increase in volatility, for instance following some sort of a GARCH-model. (Readers can refer to the appendix in our whitepaper entitled *'Of Presidents and Heart Attacks – risk control as diversification through time'* for a dummy's guide to GARCH-models.) One observes the consequences of the shock persisting for some substantial amount of time, but the shocks themselves should be serially uncorrelated. At the same time they should be clustered and you'll find, taking a good example, more of these shocks during the 2007-2008 financial crisis.

CFM: *Robert Shiller, for one, has been arguing that the growing narrative of recession, is likely to be causative of a recession. Do you believe it likely that the more frequent geopolitical shocks are supporting the fear of a recession?*

RE: Specific to my framework, a recession that gradually materialises wouldn't trigger any heightened volatility risk, since there is no particular moment where the system is being shocked. Nonetheless, one of the geopolitical events that shows up in our metric was on 22 January 2008 – the day the Fed lowered interest rates 75 basis points without having a meeting. One thinks of this as an economic event, but the rate cut conveyed meaningful information about how serious the Fed thought the financial crisis was going to be – ultimately producing lots of volatility in financial markets all around the world.

CFM: *Your last comment is an appropriate segue into the topic of monetary policy – a theme that is garnering immense scrutiny amidst a cacophony of conflicting voices on the appropriate monetary policy path. Tomorrow (18 September) the Fed will in all likelihood cut interest rates a further 25 basis points. Do you think this is the right decision?*

RE: It depends on what they see in the Beige book. I suspect they are seeing stress in various areas, and have to balance what markets are expecting. But, I have to say, we have become too focused on the stock market as a way of measuring the performance of the economy. And the stock market is going up for a variety of other reasons – buybacks mostly, because of the big tax cut.

Based on what I observe, I am not sure I would lower rates. But I also think once we are at 2%, there is not much juice left in monetary stimulus. I would, however, certainly caution against negative interest rates.

> **"One of the effects of sustainable investing is that markets are prompted to figure out how to let companies make profitable investments that take time.**

CFM: *Your assessment rhymes with those of many others who question the efficacy of further monetary policy easing – especially as a remedial action to market externalities. In a run-up event to the G7 held in France earlier this year, François Villeroy de Galhau, Governor of the Banque de France, said that "monetary policy cannot repair the damage caused by protectionist uncertainties." Would you wager that the path of looser monetary policy is, in large part, a response to current trade uncertainties?*

RE: Yes. I think the US trade policy has hurt global growth, but, in particular, has hurt the US economy. And if you believe the economy is vulnerable to further downside

risks, a monetary or fiscal policy response is typically called upon. But, invariably, one first turns to monetary policy as it is more flexible, and, the US has probably exhausted what it could achieve with fiscal policy via the tax cut. And, so, there is a call upon monetary policy because there aren't many other options.

CFM: *Do you share the ECB, and its outgoing president Mario Draghi's view that fiscal policy, in the event of any further economic deterioration, should "assume a more prominent role in sustaining demand."*[11]

RE: I have spoken very disapprovingly about the austerity measures and rhetoric that have dominated European policy discussions. However, when I am asked about the US, I say there was a period – a very short amount of time ago – when the Tea Party was pushing for no debt, no tax increases – the small government idea. That has been turned upside down with the tax cut and the enormous growth in the deficit. I am not convinced the US economy, given that it has been engaged in substantial fiscal stimulus, needs monetary policy easing in addition. To me, the evidence is not that conclusive that fiscal stimulus has been effective in the US, except for propelling the stock market.

CFM: *Along with the discussion of monetary policy, is the fear amongst some that the cycle of cheap money is driving the growth of outstanding credit to risky levels. Are you monitoring the amount of credit swirling around in markets?*

RE: What I monitor is whether banks in the US, and roughly 70 other countries, seem to have enough capital given their outstanding debt, and the market value of their equity. This is akin to a stress-test and it is a measure we call 'SRISK'[12]. This is a measure of the amount of dollars a bank would need to raise in order to continue to function normally, if there is another financial shock like the 2007-2008 financial crisis, when the stock market fell by 40% over six months.

What we observe from this measure is that China and Japan feature as the two countries with the highest shortfall – and going up, but slowly. The US' shortfall, however, is low, but going up rapidly. The sum of the global shortfall is, alarmingly, as high as it was during the financial crisis - approximately $4 trillion. By my calculation, and in the model we estimated, as capital shortfall gets high, the likelihood of a financial crisis gets higher.

Now, there is reason to think that the debt in China is not as easy to ignite as in a capitalist market, because it is implicitly guaranteed by the state. Which begs the question: Is this private or public debt? I would argue a lot of it is public debt. But its market value is low, and the market cap of these banks is small compared to their liabilities. Consequently, it only takes a small change in their asset values to drive them into bankruptcy. But no one expects Chinese banks to go bankrupt. There is no need for the question of whether they are too-big-to-fail, because the state will simply bail them out.

But, on a related note, I think the effect of having these banks undercapitalised mean that they are not doing the business that banks are supposed to do, which is taking money from savers, and making loans to borrowers. And these borrowers are the people who should be willing to pay the most for the capital and those are the people that can't get it - instead it is going to state owned enterprises. The allocation system is not working properly and I think that is one of the main reasons they are slowing down.

CFM: *You noted that the shortfall of US banks is growing rapidly. Is this a worrisome trend, or is it likely just for temporary, idiosyncratic reasons?*

RE: I think the increase in US banks' shortfall is probably attributable to the steps taken towards deregulation. At the same time, the initial tax cut for these banks and the deregulation actually makes them look like they have got excess capital. I think it is dangerous in the US, but at the same time, the probability of a crisis here is still below 50%.

CFM: *In a recent interview Professor Anat Admati of Stanford University was speaking about banking regulation that you just mentioned. She argues for tougher regulation to reduce fragility in the banking system. But banks can't auto regulate, and regulators have been shown to be typically ill-equipped for the task. Do you have any notion (or proposal) of what effective regulation might look like? Especially in terms of capital requirements?*

RE: I don't have a quantitative number – it is in any event difficult to pinpoint. But, we are doing research on this topic and one of the things that we have seen, interestingly, is that there are quite a few countries in the world where the banks are *overcapitalised*. This is especially prevalent in emerging market countries, where not enough risk is being taken. It simply means that they are not making loans that should be made. Many of these banks might not be pushing at the margins in trying to find entrepreneurs that they can lend money to.

We use a total capital ratio of 8%, with some divergence amongst banks being over or undercapitalised with this as

[11] See account of the ECB monetary policy meeting: https://www.ecb.europa.eu/press/accounts/2019/html/ecb.mg190822~63660ecd81.en.html

[12] Please refer to the website of the NYU Stern Volatility institute and the SRISK page for further details: https://vlab.stern.nyu.edu/welcome/srisk

the midpoint level. Our work shows that this ratio is not far from what should be a reasonable measure.

CFM: *If I may move into some of the contemporary topics being discussed in the finance industry. A recent Financial Times article highlighted survey results showing that various CIOs and other decision makers identified climate change and AI as the two global trends most likely to transform the asset management industry.[13] Do you share this view?*

RE: I think AI will change all sorts of things. I am not so convinced it has much to offer for financial markets.

As for climate change, and ESG more generally – it is clearly a big driver of investment appetite, and I think asset management firms and hedge funds are falling all over themselves trying to figure out what products they can offer. It seems to me there are different motivations. If, for instance, a portfolio manager is to take into account any of a large assortment of ESG-like factors or metrics, a profibility is likely to take a hit in the short run. But, such investments are likely to pay-off in the long run. This is related to the concern that financial markets have a bias toward short-termism. So, it might be that one of the effects of sustainable investing is that markets are prompted to figure out how to let companies make profitable investments that take time.

> **“ The market doesn’t reveal itself very well about any climate change premium.**

CFM: *In this same FT article, the research not only suggests that AI and climate change are the two major trends, but ironically, that these are the issues asset managers are most ill-prepared to address. If you were managing money for investors, how might you go about integrating their demands?*

RE: That is a little unfair! I am not very optimistic that having ESG scores, especially the way that they are being compiled – taking weighted averages of these across a firm, then weighting the firms in your portfolio by this measure – gives you a portfolio with a very coherent purpose. That is partly why I did research on climate change, and how one may go about hedging for it.[14] The idea with the portfolio we created is that; what one would really like; the reason one might invest in the ‘E’ part of climate change; is to hedge against the worst outcomes of climate change.

CFM: *The one thing I found striking about this research – given we touched upon short-termism earlier – is that the hedging is done on a relatively short timescale, whereas dramatic climate change effects are only likely to manifest over a longer timescale. How did your research marry this timeframe misalliance?*

RE: If you want to know which firms will be best positioned for a ‘bad’ climate outcome in 50 years, you will have to do a lot of crystal-ball-looking. There are many unknown unknowns: companies will change their lines of business, we will have technological innovation that we didn’t anticipate, etc. So it seems to me you can’t really expect a fund to figure that out. Instead, what you want to do as time goes by, is update your valuation using new information in a dynamic portfolio.

How do you do that?

We want to know when ‘bad’ news about the climate hits the wires, which stocks investors buy, and which ones they sell. The reasoning goes that investors are likely to buy those firms that are best positioned to withstand a ‘bad’ climate scenario, and they are going to sell the ones that are likely going to be hurt. They should, in all likelihood, probably be selling, for example, stocks with high fossil fuel reserves and buying ones that offer a promising approach to mitigate climate change. That is what we are trying to figure out.

Nevertheless, the market doesn’t easily reveal any portfolio indicating a climate change premium, and the evidence is not significant as to what such a hedging portfolio may look like. However, if you create such a portfolio, and you suppose there is a significant event that galvanises investors’ views on climate change, this portfolio may become more revealing, and we will have a better idea of who the winners are likely to be. And if you are a pessimist about climate change, this is likely the portfolio you want; if you are an optimist, then you’ll probably play the other side.

CFM: *It is interesting that you frame the desire for such a hedging portfolio as optimist vs. pessimist, in that it speaks to a level of conviction one might harbour about climate change. It reminds me of a recent poll that showed the US being the most sceptical nation about climate change and its cause.[15] Following your reasoning,*

[13] Financial Times, 15 September, 2019 ‘AI and climate change transform investment sector’: https://www.ft.com/content/fa8885f6-ad69-3dd0-a437-6aeb23c753ad

[14] See the paper by Engle et al. ‘Hedging Climate Change News’: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3317570

[15] See the YouGov pole results here: https://yougov.co.uk/topics/science/articles-reports/2019/09/15/international-poll-most-expect-feel-impact-climate

an investor in Europe is therefore likely to act in a meaningfully different way than his or her average counterpart in the US.

RE: Right. This will probably speak to how, for example, a fossil fuel firm is priced. A European investor might assign a lower value than a US investor, and if one follows this reasoning, it is likely that US investors might accumulate a bigger share of the fossil fuel industry than European funds.

What is important, however, is to ask: How do you value a fossil fuel company over the next 50 years? And that depends a lot on what you think is likely to happen. If there is a risk that fossil reserves are going to become stranded assets – do you want to hold or short that risk? If you want to hold that risk, it is probably akin to earning a risk premium.

CFM: *In your paper, you made a very important distinction between 'physical' and 'regulatory' risk, and to me this is particularly relevant given the competing views about regulation and any likely regulatory responses. How, in the current climate of protectionist and nationalistic rhetoric, do you think we square this with what is an inherently global problem, calling for multilateral action?*

RE: I think that is the most salient feature of what we are living through right now. Most of my colleagues and I here in the US think the government should respond, regardless of whether they believe climate change is manmade or not. They should be able to act and adapt to its consequences.

I also think there is energy in the US around the idea of the private sector picking up the slack, but I don't believe they can to the extent that it is needed – at least not until prices are rationalised. One cannot expect the private sector to embark on massive infrastructure projects such as, for example, sea-walls or early warning systems – these are all collective public goods and would require at least some government involvement.

CFM: *This is in line with a growing call to action amongst business leaders and CEOs of large asset managers to take ownership of the challenge. One could argue this is a slippery slope as it usurps the authority and responsibility of governments and policy makers. There is a difference between investment convictions of how funds should be invested, versus doing so in response to a lack of regulation or government failings.*

RE: The best we can hope for, and the best I think we should expect from the private sector is that they make wise investments from a present discounted value point of view. In other words, if there is, for example, energy saving technology that firms could use, but it takes ten years to realise, markets should be more patient in seeing those opportunities realised.

- Find details of Professor Engle's research, a list of upcoming conferences, and other news on his faculty website: https://www.stern.nyu.edu/faculty/bio/robert-engle
- Refer to the website of 'V-Lab' for analysis and documentation of the Systemic Risk (SRISK) tool, along with a host of other quantitative analysis: https://vlab.stern.nyu.edu/

Professor Engle spoke with André Breedt, Research Associate in the Paris office of CFM.

Disclaimer

Whitepaper

Of presidents and heart attacks - Risk control as diversification through time

Executive summary

In this short note we briefly introduce "risk" (for those readers unfamiliar with the concept and how it is defined); show conceptually how we are able to forecast and control it (for those concerned about risk in their portfolio and how it may be mitigated); and highlight, through a set of historic events, how even a risk-controlled portfolio remains at the mercy of idiosyncratic events.

Introduction

In common parlance, risk is simply the possibility of loss. Losses may stem, predominantly, from two sources: uncertainty about the *1) direction* of expected returns, and the *2) magnitude* of returns. While the former (alpha) is difficult to harvest and maintain, the latter (volatility) displays certain features that facilitate the forecasting, and thus controlling of the magnitude of investment moves.[16]

The question of risk and volatility has occupied some of the most celebrated minds in finance and economics for the better part of 70 years. Most of the seminal work still cited today reads like a who's who of Nobel Prize winning economists: Markowitz, Sharpe, and Engle to name but a few, all toiled to understand the nature of risk, and sought appropriate models to measure and forecast it.

The use of volatility as a short-hand for risk, notwithstanding its now ubiquitous acceptance, provokes much criticism.[17] Still, as volatility is easier to quantify and exhibits features we can leverage to adjust exposure to further hikes in market stress, it can readily be used to design a risk-controlled portfolio.

Therefore choosing and assigning a quantifiable proxy for the size of market moves is important to control volatility, and deliver a more predictable return profile. This note will focus on volatility and why the adoption of a systematic, volatility-controlled protocol is desirable, and even necessary.

What is risk? And how is it commonly measured?

Risk has become synonymous with volatility, and is most commonly measured as the standard deviation,[18] i.e. the degree of deviation from the mean of a price return series over a given period, ordinarily annualised and printed in percentage.[19]

Equating risk with volatility is not a new idea. Already in his 1952 seminal paper, Harry Markowitz, the father of Modern Portfolio Theory, associated risk with *variance*[20] in the value of a portfolio, stating that one should consider "variance of return an *undesirable* thing". Markowitz also discussed risk in its relation to the correlation of assets, namely that combining two correlated assets intuitively increases risk relative to the combination of two anti-correlated assets. Sitting in between these two extremes, the combination of uncorrelated assets reduces risk more than returns and thus provides an improvement in risk adjusted returns. This observation is at the heart of what Harry Markowitz described as "the only free lunch in finance".

Some features and characteristics of volatility

In finance jargon, it is well understood that volatility is said to exhibit '*autocorrelation*',[21] or '*clustering*' – that is to say that high (low) volatility in the past, is likely to be followed by high (low) volatility in the future.[22] It is thus is a measurement of the relationship between a time series, and a lagged version of itself.

Measured between -1 (perfectly negatively correlated) and +1 (perfectly positively correlated), it measures by how much volatility levels persist.[23] To illustrate this persistent

[16] There are many other kinds of 'risk' that can manifest over the holding period of any investment: one need simply flip through any 'Key Investor Information Document' (KIID) or 'Product Disclosure Statement' (PDS) to take note of the myriad of various risks to which a portfolio is exposed: drawdown, currency, tax, liquidity, counterparty, etc. to name but a few.

[17] Perhaps most famously from Warren Buffet who berated the use of volatility as a risk measure in his 2014 letter to shareholders, calling it, amongst others, "*far* from synonymous with risk": https://www.berkshirehathaway.com/letters/2014ltr.pdf

[18] Standard deviation is a statistical measure of the dispersion of a set of numbers around an average. See for instance: https://en.wikipedia.org/wiki/Standard_deviation

[19] A criticism levelled at the typical calculation of volatility, is the agnostic treatment of positive and negative price changes (since both the positive and negative returns are squared). However, when one wants to forecast risk, this can be remedied by, for instance, constraining a risk estimation model by only taking negative price changes into account – often called 'downside risk measures'.

[20] Variance is the squared difference between an observation and the mean of all the observations in the same time series, the standard deviation (volatility) is the square root of the variance.

[21] Also sometimes referred to as 'serial correlation'.

[22] This feature was first documented by Benoit Mandelbrot in his 1963 paper, 'The Variation of Certain Speculative Prices'. The Journal of Business, 1963, vol. 36, 394.

[23] Please see our discussion note "Is there a 'new normal' in Volatility Markets?... Probably not!" in which we illustrate the fluctuating, yet consistent autocorrelation characteristic of both implied and realised volatility in equity markets. The paper is available on our website.

feature of volatility, in Figure 1 we plot the monthly realised volatility of the Dow Jones Industrial Average, and show how a month of high (low) volatility is followed by a month with high (low) volatility.

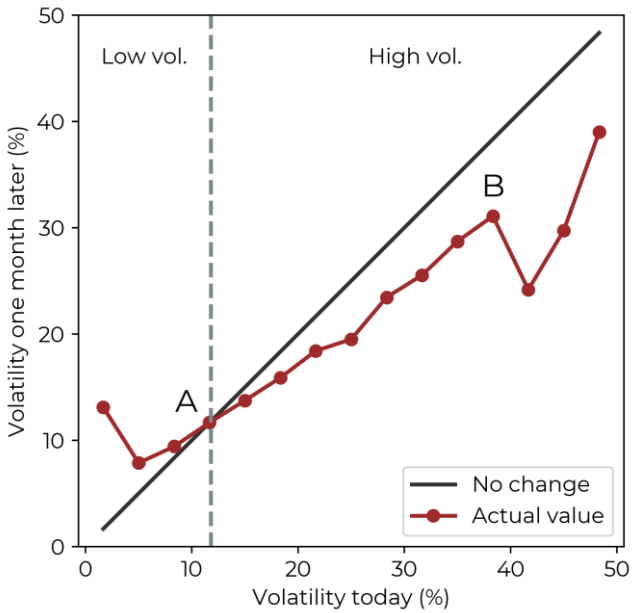


Figure 1: We plot the monthly volatility calculated as the annualised daily realised volatility using a 22-day (1-month) standard deviation moving average. High (low) volatility in a preceding month ('volatility today' on the x-axis), is typically followed by high (low) volatility in the succeeding month ('volatility one month later' on the y-axis). Point B for example shows that a month with volatility of ~38%, is followed by a month where the monthly volatility is ~30%. Point A is the average, annualised monthly realised volatility of the Dow since 1910: 11%.

Autocorrelation of volatility is observable, and measurable at both security, and portfolio level. However, the volatility of a single security is habitually higher than that of a portfolio with multiple (uncorrelated) securities. This is as a result of diversification (due to the way risk combines among uncorrelated instruments as mentioned above). The addition of securities in a portfolio thus reduces the overall volatility of the portfolio as illustrated in Figure 2.

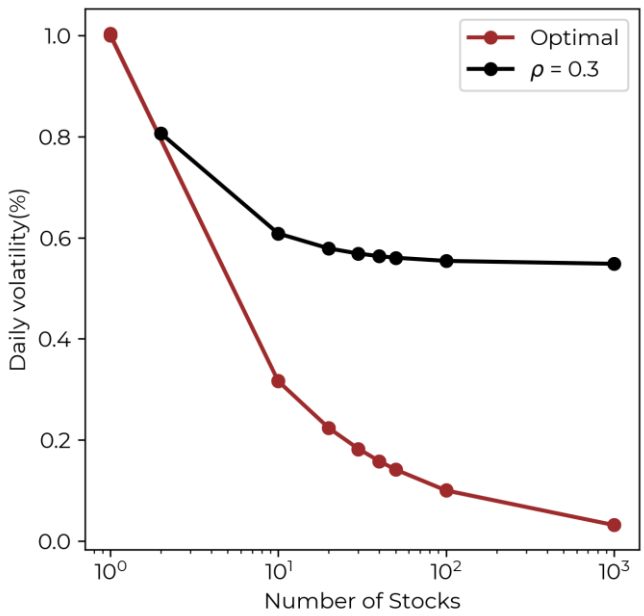


Figure 2: *A representation of how the volatility (y-axis) of a portfolio decreases with the addition of an increasing number of securities in a portfolio (x-axis in log-scale). We assume zero correlation between stocks and normally distributed returns (the red curve marked optimal). For the sake of simplicity, each stock is assumed to have a daily volatility of 1%, with the addition of each new stock also assumed to have the same 1% daily volatility. The volatility of a portfolio of N assets – given the assumption that the securities are uncorrelated – decreases at the rate of* $\frac{1}{\sqrt{N}}$ *If, however, as is the case in financial markets, securities exhibit varying degrees of correlation among themselves, the rate of decrease in volatility is slower. This is indicated by the black curve, marked* $\rho = 0.3$*, i.e. assuming a ~30% average correlation between securities in the market. Correlations between stocks exhibit such an effect and therefore stock market indices quickly no longer feel the benefits of diversification beyond a given threshold of N.*

Another feature of volatility is its tendency to spike unexpectedly (see for instance Figure 3). Whilst some spikes in volatility are easily attributable to an idiosyncratic or exceptional event, it is often less evident why volatility in the market increases so suddenly. Higher volatility in equities is also most commonly associated with negative return shocks, that is, a *negative* and *asymmetric* relationship exists between volatility and returns – the so called *Leverage Effect*. This ties in with the negative *skewness* observed in equity markets. Whilst interested readers can refer to a more technical explanation of skewness and different moments of the return distribution, for the purposes of this note, it suffices to say stock returns are characterised by a mix of regular, but small positive returns, dotted with less frequent, but large negative returns.

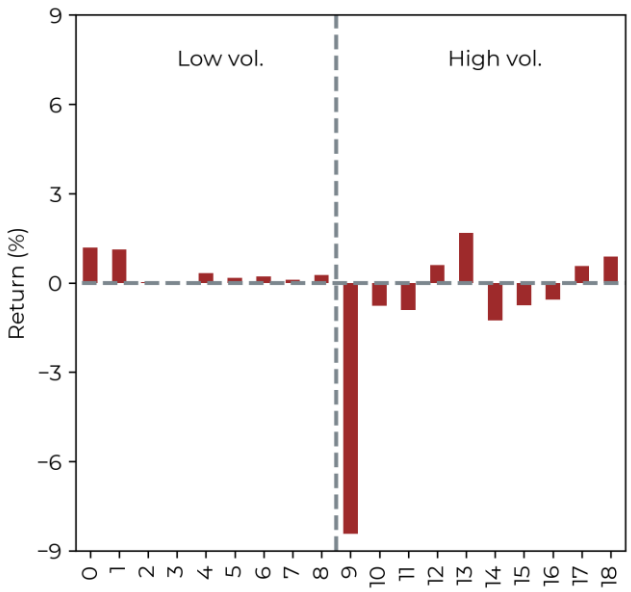


Figure 3: The daily price returns for Coca-Cola (constituent of the Dow Jones Industrial Average Index) during February 2019. Volatility was muted for the first half of the month, but a sell-off on February 14 (day 9 in the plot) following a warning issued by the company that sales growth was likely to slow in 2019, lead to a -8.4% drop in the stock price. Although this is one anecdotal example of a pronounced spike in volatility, followed by a period of higher volatility, it is a common observation in equity markets.

Why does one control for risk?

Prospect theory shows that given a set of choices, investors prefer less risk – they are for the most part said to be risk-averse.[24] Investors are as such inclined to select more certainty about the outcome of an investment, even if it entails lower returns. That is to say, they prefer returns with fewer severe negative returns (fat-left-tailed returns).

Since investors are behaviourally more risk-averse, increased volatility and drawdowns in the short-term can prove very trying for some. This often leads to irrational – or even imprudent – investment decisions. Some might, in addition, require certainty of returns as and when financial risk thresholds are breached. Others might also require a limit in downside risk.

In order to address these behavioural traits it is natural to want to control the risk of an investment or a portfolio of investments. If risk can fluctuate, then inevitably there are periods of high volatility. One may be aware that these periods will exist, but living through them is a different matter! If these periods of high risk also coincide with periods of negative performance then one is in the realm of the most difficult to bear returns: those with the dreaded fat-left-tail! Risk control thus is a remedy for reducing fat tails but also, in general, an improver of risk-adjusted returns, once the biggest moves are smoothed out.

How does one control for risk?

As any Finance 101 student will instinctively tell you, diversification. It is one of the key tenets of finance and allows investors to avoid what is commonly termed 'unsystematic risk', or diversifiable risk - those risks that are not commonly shared across all industries or asset classes.

As investors spread risk exposure over various asset classes (or within a given asset class[25]), the risk of the portfolio is diluted.

Cross sectional diversification, while effective in reducing risk, is not sufficient to protect against fluctuations *across time* – see Figure 4. And while diversification across sectors is a good hedge, it moreover does not mitigate against systemic risk – those risks that affect multiple sectors. Typical examples are political instability, or geopolitical events which trigger volatility in all corners of the market.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dow Jones Index	**7.2**	**3.7**	**0.1**	**2.6**	**-6.7**	**7.2**	**-1.7**	**2.0**	**0.5**
Communication Services	0.3	2.9	0.6	9.3	-3.5	5.4	-0.7	1.0	-0.6
Consumer Discretionary	6.2	3.2	1.0	4.0	-4.2	7.7	1.5	4.0	3.8
Consumer Staples	4.3	-0.3	0.9	-0.7	-2.2	7.5	2.1	2.0	3.6
Energy	4.4	2.6	1.0	-2.8	-6.7	8.8	-2.1	-4.0	1.9
Financials	8.4	2.5	-0.7	6.2	-4.8	7.0	1.2	-2.1	2.0
Health Care	2.9	-0.2	0.3	-3.5	-0.2	4.3	-4.3	-2.8	-2.0
Industrials	9.6	7.1	-3.1	-1.9	-11.9	8.0	-1.5	-1.3	4.3
Information Technology	6.2	6.6	4.2	2.1	-8.4	8.6	3.5	-4.8	4.1

Figure 4: *Individual securities (or sectors at an aggregated level) exhibit different levels of return, and have historically displayed different sensitivities to, for example, economic or business cycles. Here we show a map of the average returns per sector of the Dow Jones, per month for 2019 up until the end of Q3. The squares in green show the top two performing sectors for each month, with the bottom two performing sectors for each month in red. There is clear, inconsistent performance across sectors over time – making the argument for sector diversification.*

[24] We have shown in prior work that in reality investors are rather loss-averse and actually quite like to experience large and sharp gains in a P&L, a result that explains the premium received by insurance sellers. Curious readers are directed to our discussion note "Risk Premium Investing. A tale of two tails" available on the CFM website.

[25] Investors might choose to diversify their risk across various sectors in an equity portfolio for example, or, distribute their risk exposure across regions between developed and emerging markets.

However, just diversifying across the rows (sectors) is not sufficient. The resulting reduction in volatility may improve portfolio performance but will not be enough to avoid periodic exposure to heightened levels of market volatility (when correlations between securities increase, and where diversification across the columns (time) is required).

While many investors might even be unaware, when they allocate exposure, for instance, between developed and emerging markets, or equities and bonds, they are in effect taking correlation differentials into account. As explained earlier, during periods of high market stress – especially owing to systemic risk, the correlation between financial instruments within the same asset class tends to increase, and move towards 1. The benefits of diversification subsequently get eroded, since most of the price movements of the individual securities are in the same direction.

However, one may mitigate any expected market volatility by scaling down one's position to avoid periods of heightened volatility. If one can forecast future risk, one can scale positions, investing more (less) when volatility expectations are low (high). This rescaling of positions is, in practice, only possible in a world of partially financed futures. Real money positioning in any asset leads to a fixed notional sizing which is naturally capped (at the level of assets of the investment) and sometimes not easily adjusted due to illiquidity. Such effects are avoided through the use of futures[26] and has in more recent years given rise to the Risk Parity industry.

Can one forecast risk?

As any market participant will attest, forecasting any *direction* in financial time series is difficult. 'Forecasting' volatility, however, is easier.

This is because of the clustering feature of volatility discussed earlier: higher or lower volatility periods tend to persist. Luckily, for the purpose of risk control we are not so much interested in the *direction* of change, but rather the *magnitude* (and, being agnostic as to the sign of the change).

There are various models that can be employed to estimate risk, perhaps none more commonly used than the family of 'ARCH' models (see the appendix for a brief explainer). One can also devise an expectation of future volatility from option prices. This is commonly referred to as 'implied' volatility (implied from the prices of options).[27]

[26] See Appendix for a discussion of this point.

[27] Most readers will be familiar with the VIX Index, which implies the market view of market volatility of the S&P 500 over the next 30 days from S&P 500 options.

A test case – controlling the risk of the Dow Jones Industrial Average

Since we can forecast volatility (albeit imperfectly), we can distribute risk more evenly through time by exposing a portfolio less when moves are large (or expected to be large), and more when moves are small (or expected to be small).

While a myriad of techniques to control for risk exist[28], we will demonstrate the results by using a rolling standard deviation technique:

$$\sigma_t = \sqrt{std(\{r_{t'}^2\}_{t'=t-22D}^{t'})}$$

Where σ is volatility, r corresponds to returns and t is time measured in days.

By scaling one's position based on realised volatility ($pos_t \propto \frac{1}{\sigma}$), we can improve the Sharpe ratio of being long the Dow Jones by ~25% since 1910. In Figure 5, we plot the cumulated performance of the Dow Jones with and without adjusting for fluctuating risk.

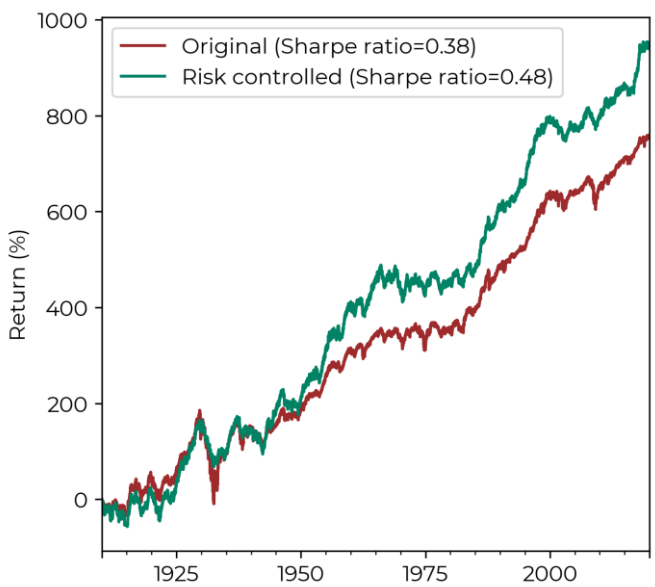


Figure 5: *The original, and risk-controlled total cumulative returns of the Dow Jones. By employing the simple rolling standard deviation to estimate, and consequently scale the exposure to achieve the same long term risk, the Sharpe ratio is increased by ~25% over the more than 100-year sample period.*

[28] Common examples include Moving Average, Exponentially Weighted Moving Average, Historical Mean, ARCH, etc. – all with their own benefits and drawbacks.

Another benefit of applying a risk control protocol is the mitigation of extreme returns in the tails of the return distribution. In Figure 6 below, the original (long only, no risk control) and risk controlled price change distribution is plotted and one observes a more normally distributed return stream after the risk control is applied.

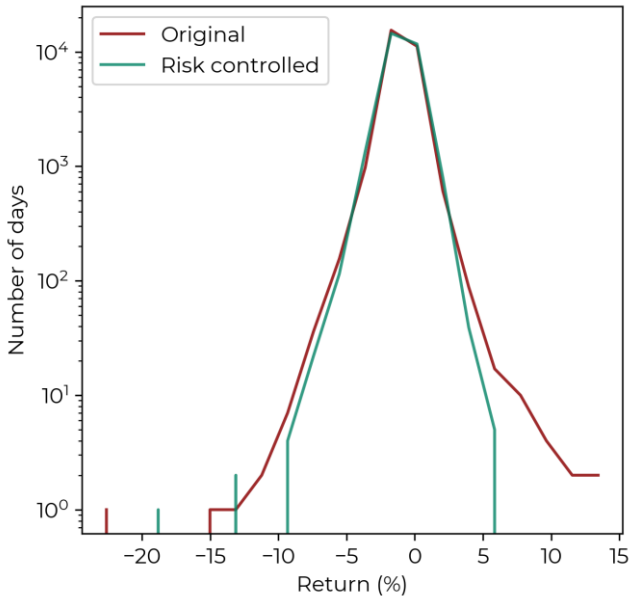


Figure 6: *The return distribution of both the original, as well as the risk-controlled index. The distribution of the risk-controlled returns shows a more normal and less fat-tailed return distribution. The frequency (Number of Days) is in log scale.*

Finally, as is shown in Figures 7.a and 7.b, the average daily price returns as well as the daily PnL volatility respectively of the risk controlled investment is more stable in time than that of the original, uncontrolled investment.

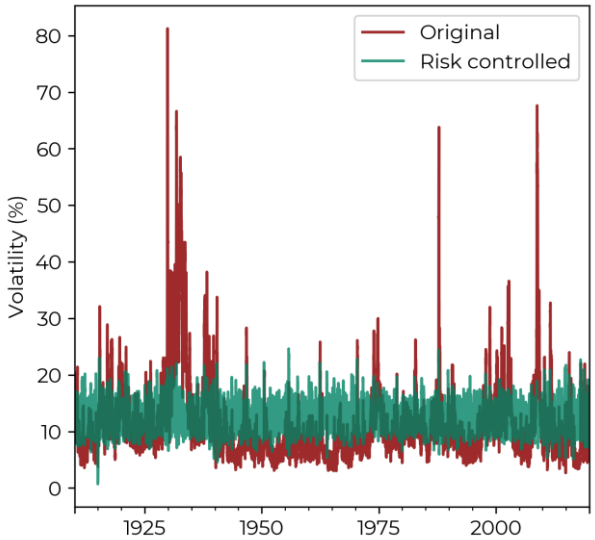


Figure 7.a: *A comparative 1-month moving average of daily volatility of the PnL (converted to annualised units) of both the original (in red) and the risk controlled (in green) investment. The PnL of the risk controlled investment is much more monotonic, while the original, uncontrolled investment features many more volatility spikes.*

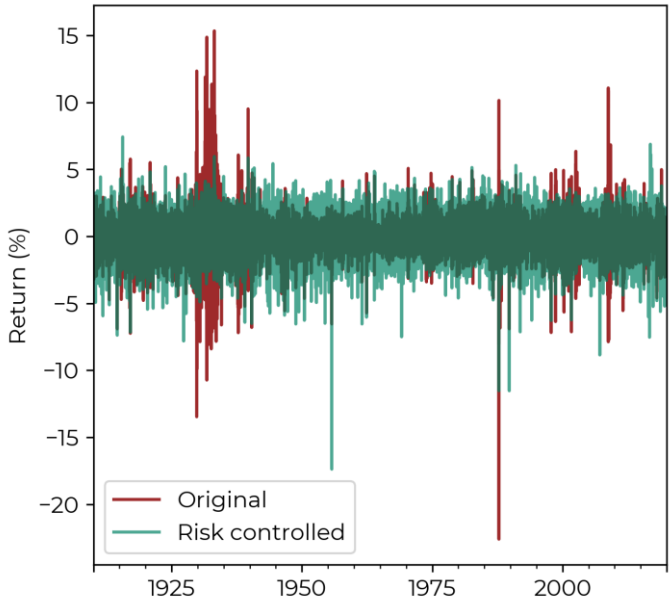


Figure 7.b: The daily price returns in percentage of both the index, and the risk-controlled version. Similar to the above, the daily price changes of the risk controlled time series features much less outsized returns – both positive and negative.

Can one perfectly control for risk?

While every effort can be made to reduce a fat-tailed return distribution, and preserve capital with disciplined systematic risk management, markets are inherently fickle.

Anticipating the idiosyncratic behaviour of markets is nigh on impossible, with the seemingly random nature of market returns well documented, if not always well understood. Proponents of the Efficient Market Hypothesis (EMH) hold that market prices reflect, at any given point in time, all the information available and relevant to any given security. If this were to be true, it should follow that only 'new' information should trigger a 'revaluation' of any given security. However, markets show too much volatility – especially in the absence of any discernible news – to be justified. Seminal work by Robert Shiller – another Nobel Prize winning economist – has shown that the volatility of

stock prices is far greater than is plausibly explained by any rational view of future earnings and dividends.[29]

Another feature of financial market returns is the 'fat-tailed' distribution of returns. Fat tails simply refer to those returns that are far beyond those plausibly expected for a normal distribution. Most readers will be familiar with the 'Black Swan' analogy – the rare, *mostly* unpredictable events that trigger a sell-off and cause bursts of volatility. Accordingly, most risk control models are incapable of predicting, and as such, controlling for these events. To illustrate this phenomenon, see the below sets of tables showing the highest positive and negative returns for a risk control strategy (and the corresponding market price change) and the causes thereof.

Highest negative *risk-controlled* returns				
Date	Price Return	Sigma	Risk Controlled Return	Volatility
26/09/1955	**-6.5%**	**-18.1**	**-17.4%**	**5.7%**
13/10/1989	-6.9%	-12.0	-11.5%	9.1%
19/10/1987	-22.6%	-12.0	-11.5%	30.0%
27/02/2007	-3.3%	-9.2	-8.9%	5.7%
25/04/1927	-2.2%	-8.1	-7.8%	4.2%
Highest negative *absolute* returns				
19/10/1987	**-22.6%**	**-12.0**	**-11.5%**	**30.0%**
28/10/1929	-13.5%	-4.7	-4.5%	45.5%
05/10/1931	-10.7%	-3.1	-2.9%	55.8%
12/08/1932	-8.4%	-2.5	-2.4%	53.0%
15/10/2008	-7.9%	-1.8	-1.7%	70.7%

Table 1. We rank the highest negative risk controlled returns, and show the corresponding returns of the index (which are the returns if an investor was simply holding the index). We furthermore isolate and rank only the single highest negative returns for each year, the second highest negative return for each year is ignored. The highest daily negative risk-controlled return (top table) was on 26 September 1955, where the negative risk-controlled protocol returns would have exceeded those of simply holding the index, on account of using leverage. Using the rolling standard deviation as risk estimate would have dictated higher exposure given the relatively low volatility at the time. Volatility is calculated as the 22-day rolling standard deviation.

Key events:

26 September 1955: The NYSE lost 6.6% after President Eisenhower suffered a heart attack – see Figure 8 below.

13 October 1989: A failed leverage buyout attempt for the parent company of United Airlines, owing to an inability to obtain credit, prompted traders to dump 'take-over' related and blue-chip stocks. A fear that the junk-bond market party was coming to an end (up till then fuelling much of the take-over activity) sent investors chasing for the exits. At the time, many publications hinted (and feared) similarities to the event that caused the highest negative absolute return in our example, asking, as the New York Times did: "Is It 1987 Again?"

19 October 1987: Black Monday. Probably one of the most infamous market melt-downs in post WWII history. The Dow Jones crashed 22.6% - the single largest daily percentage loss in the history of the index. While the exact catalyst is still debated, and the extent to which nascent computer-generated algorithmic trading contributed disputed, it is commonly accepted that a variety of issues contributed and escalated the sell-off. For comparison, the perhaps equally – if not more – infamous black Tuesday of 1929 (October '29) 'only' had a 11.7% drop. This sell-off was however preceded by an even bigger 12.8% decline the day before: the less famous Monday (October '28).

Highest positive *risk-controlled* returns				
Date	Price Return	Sigma	Risk Controlled Return	Volatility
16/08/1915	**3.7%**	**7.7**	**7.4%**	**7.6%**
07/11/2016	2.1%	7.1	6.9%	4.6%
15/03/1933	15.3%	6.2	6.0%	39.3%
05/09/1939	9.5%	6.1	5.9%	24.8%
12/06/1944	1.4%	5.6	5.4%	4.0%
Highest positive *absolute* returns				
15/03/1933	**15.3%**	**6.2**	**6.0%**	**39.3%**
06/10/1931	14.9%	3.6	3.5%	65.4%
30/10/1929	12.3%	2.7	2.6%	72.4%
21/09/1932	11.4%	3.7	3.5%	49.2%
13/10/2008	11.1%	3.3	3.2%	53.5%

Table 2. Contrary to Table 1 above, here we rank the highest positive risk controlled and absolute returns – again ranking only the single highest positive returns for each year.

Key events:

16 August 1915: Global markets tanked after the onset of World War I in 1914. A later boon in market prices is commonly ascribed to the opportunities that American firms were presented by selling industrial and related goods and materials to Europe, with the Dow Jones staging a strong rally right throughout 1915. Whilst there is no readily available trigger that explains the return on this day, amidst a low volatility period, with the use of leverage, the returns of the risk controlled protocol would have exceeded those of the market.[30]

15 March 1933: On March 4, 1933, freshly inaugurated President Roosevelt declared a nationwide bank holiday so that lawmakers could address the worryingly increase in bank runs. A few days later, on March 9, the US Congress passed the 'Emergency Banking Relief Act' allowing each of the twelve regional Reserve Banks in the Federal Reserve System to issue additional currency on good assets. Effectively creating a deposit insurance scheme, the law had the desired effect – on 13 March, the first day of business after the bank holiday, Americans were seen standing in line to make deposits, and markets responded favourably. After being shuttered for nearly two week, the Dow jumped 15.3% - remaining, at the time of writing, the single largest daily percentage change in the history of the index.

[29] Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends? The American Economic Review, vol. 71, No. 3, June 1981, pp. 421-436. Our own research has yielded similar results. Interested readers can see our paper, entitled 'Stock price jumps: news and volume play a minor role' available on our website.

[30] In a real trading setup one might choose to limit the size of notional positions as a safeguard against unnaturally low volatility environments.

EISENHOWER IS IMPROVING; CHANCE OF FULL RECOVERY CALLED 'REASONABLY GOOD'

DOCTOR IS HOPEFUL

Says President May Resume Some Work in Two Weeks

Transcript of news conference is printed on Page 21.

By RUSSELL BAKER
Special to The New York Times.

DENVER, Tuesday, Sept. 27 —Barring complications, President Eisenhower should be well enough within the next two weeks to resume some personal control of the nation's affairs, a noted heart specialist said yesterday.

Dr. Paul Dudley White of Boston, the specialist, examined the President yesterday morning. He told General Eisenhower that his chances for complete recovery were "reasonably good."

He cautioned, however, that the two-week period following an attack of coronary thrombosis, such as President Eisenhower suffered Saturday morning, was a critical one in which complicating setbacks might occur.

If no setback developed in this period, he said, the President should be able, for example, to confer briefly with John Foster Dulles, Secretary of State, and read official documents.

Progress Is Satisfactory

Dr. White found the President in satisfactory condition in the morning and said his morale was "wonderful." His optimistic analysis was echoed in the 4 P. M. (7 P. M. New York time) medical bulletin. That reported General Eisenhower had spent "a very comfortable day" and had eaten a lunch of meat, vegetables, fresh fruit cocktail and milk.

Just after 9 P. M., the attending physicians reported:

"This has been a comfortable day for the President. His satisfactory progress as previously reported has continued throughout the day."

Associated Press Wirephoto

REPORT ON PRESIDENT'S CONDITION: Dr. Paul Dudley White, left, Boston heart specialist, and Maj. Gen. Howard Snyder, President Eisenhower's personal physician, as they addressed press conference yesterday in Denver.

Stock Prices Off Sharply; Loss Is Put at $14 Billion

By BURTON CRANE

In a collapse ascribed to the illness of President Eisenhower, the stock market yesterday suffered its heaviest dollar loss in history. With most leaders losing 4 to 8 points a share, and one as much as 33¼, the value of New York Stock Exchange stocks lost approximately $14,000,000,000, half their 1955 gain. The entire loss for the month of October, 1929, was $16,000,000,000.

At the close of trading, prices were rising moderately on declin-

CABINET MEETING CALLED BY NIXON

Figure 8: By employing this generic risk control strategy, the highest negative relative return would have occurred on September 26, 1955 – the Monday after the weekend that US President Eisenhower suffered a heart-attack. Following news that the President suffered a heart attack, the New York Stock Exchange tumbled 6.6%. As can be seen in this newspaper clipping, the NYSE lost $14bn on the day – a loss that was triggered by an event that was perfectly unpredictable, and, given the low volatility at the time (leading to a levered position), offered substantial losses. September 26 was, as was reported at the time, "the heaviest dollar loss in history" for the NYSE.

Conclusion

We have shown how employing a risk control protocol can increase the Sharpe ratio, reduce the fat-tailed return distribution, and thus improve on the skewness and kurtosis. By controlling for risk, we provide a 'smoother' PnL profile for clients, with risk control being thought of as 'diversification in time', in the same way that investors diversify across asset classes. We have also shown, that despite employing a risk control protocol, investors remain vulnerable to idiosyncratic moves in the markets.

Yet, forecasting volatility is still challenging. We have illustrated a simple risk-control model using a moving average of squared returns. There are, however, more sophisticated tools and techniques, such as machine learning, that can be deployed to forecast risk, but, a discussion of such techniques is beyond the scope of this text.

It is also important to note that risk control is generally assured over the timescale of the trading strategy. If one is employing a longer term strategy on the timescale of several months, say, then risk is generally controlled on that timescale. Controlling for risk on the timescale of days, in this instance, is costly (in execution costs) and futile given the slow nature of the trading strategy. On shorter timescales, therefore, one expects risk fluctuations that, as long as moves are not too extreme, are harmless in being able to provide a constant level of risk on the strategy timescale.

Risk control is an essential part of any investor's tool kit, for systematic and non-systematic managers alike. In our experience a poorly implemented risk control engine can change one's view of the utility of a given trading strategy in a portfolio. The quality of the implementation of the risk overlay is thus of utmost importance in performing research on trading strategies.

Appendix

Why the use of futures markets is crucial in delivering risk controlled returns

It seems obvious that if a stock yields say a 10% return for a 10% volatility then a $100 investment in said stock also has these same investment characteristics of 10% return and 10% volatility. So far so good! Now, what about if we instead get $100 of exposure to the stock through a futures contract? A future on the stock has a notional size, say $100 for the sake of simplicity, and earns and loses money based on the fluctuations of that notional size in the underlying stock. The investor, in theory, puts nothing down to 'buy' the future but, nonetheless, loses the $100 if the stock price collapses to zero. In reality the investor does deposit some cash in a margin account and this margin covers the potential loss for the holder of the future.

The FCM (Futures Clearing Merchant) requires this cash outlay to protect herself from the client not being able to cover potential losses. In the case of a future on a well-diversified equity index future such as the S&P 500 in the US this margin deposit would normally be of the order of 15% of the notional size of the future. In the case of our $100 future on a stock therefore we would be required to deposit 15 cents with the FCM and would be able to hold 85 cents in any investment we like – let's say we deposit it in an interest yielding bank account. We therefore have 85 cents yielding the risk free rate (the 15 cents may also be

yielding the risk free rate at the FCM) plus the P&L of the stock corresponding to a $100 of investment. Because we are receiving interest on our $100 this then is removed from the P&L of the future as it is marked to market all the way to expiry (rolled futures provide excess returns rather than total returns) such that the total of $100 risk free rate plus the P&L plus the negative financing drag is equal to just holding $100 in the stock itself.

So, why go through all this detail? Because futures give us a perfect framework within which we can apply risk control to an investment. As described in the above text we would like to invest for a fluctuating notional sizing as $pos \propto \frac{1}{\sigma}$ where σ refers to our risk estimate. Because of the need to adjust our positioning we need access to an instrument that allows for a position that is sometimes higher and sometimes lower than $100 based on the most recent volatility estimate. Let's say for example that our estimate of volatility drops (increases) from 10% to 7.5% (12.5%). We then need to increase (decrease) our notional position from $100 to $125 ($75). This can be done with futures by simply adding (subtracting) notional size from the position with the addition (subtraction) of cash from the client margin account. One can safely increase notional sizing by 25% without requiring more than the $100 we actually have. This is the foundation of the Risk Parity industry that provides risk controlled exposure to bonds, equity indices, commodities etc. based on very liquid derivatives markets and provides improved levels of fat-tail control and risk adjusted returns, for the reasons discussed in this note.

A dummy's guide to GARCH

One can find many explainers of GARCH on the Internet and our intention here is not to reinvent the wheel. Instead we would like to provide some intuition behind the motivations for GARCH modelling of volatility. The classic way to write GARCH is as the following:

$$\sigma_t^2 = \gamma\sigma_0^2 + \alpha\sigma_{t-1}^2 + \beta\eta_{t-1}^2$$

For a random process where the returns, $\eta_t = \sigma_t\epsilon_t$. The ϵ here is a bell shaped random number and the index t corresponds to time, let's say days.

So, already we've probably lost you! Instead of the above equation we should consider what the GARCH model is trying to do. The main feature of volatility that we would like to model is the autocorrelation or persistence and this is what GARCH is capturing. If we set $\gamma = 0$ and $\alpha = 1 - \beta$ we obtain the following:

$$\sigma_t^2 = (1-\beta)\sigma_{t-1}^2 + \beta\eta_{t-1}^2$$

Now this may or may not look familiar but this equation is simply stating that volatility (or more precisely volatility squared or variance) is explained by an Exponentially weighted Moving Average (EMA) of squared price returns. This then produces in the volatility estimate an autocorrelation on the timescale of the EMA as approximately $\tau_{EMA} \sim 1/\beta$. So, if $\beta = 0.001$, for example, then the autocorrelation timescale would be approximately $\tau_{EMA} \sim \frac{1}{0.001} = 1000$ business days or approximately 4 years.

Indeed, this is the model we chose above to build our volatility forecast albeit with a timescale for the EMA of 22 days. Our volatility forecast model is a particular form of GARCH that captures short-term autocorrelation or persistence in a reasonably efficient way. This suffices for the purposes of this short note but clearly one can go further using more elaborate techniques to model the dynamics of volatility that are beyond the scope of this discussion.

Disclaimer

CFM has pioneered and applied an academic and scientific approach to financial markets, creating award winning strategies and a market leading investment management firm.

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