Academic Research Monitor
Low-Risk, Low-Volatility, Low-Correlation patterns

Equities

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Low-risk patterns are again under our spotlight

The amount of interest in low-risk investing instructs us to look again into the latest academic findings in this space. Where does the performance of low-beta stocks come from; their systemic risk (correlation) or their idiosyncratic risk? How is the performance of low-volatility stocks anyhow related to the profitability anomaly, the distress risk anomaly and the lottery-seeking behaviour? Can hedge funds benefit from the low-risk patterns? We review three recent academic papers and provide insights.

Is Low-Beta due to Low-Correlation or due to Low-Volatility?

A stock's beta is defined as the product of stock volatility and its correlation to the market. One can therefore ask: are the low-beta patterns due to low-correlation or low-volatility (strictly speaking, low-idiosyncratic volatility)? The first paper that we review looks at these dependences and finds that both effects are generally strong. As a result, the low-risk anomaly can be related to leverage constraints (the low-correlation part) as well as to lottery-seeking behaviour (the low-idiosyncratic volatility part).

Connecting Profitability, Distress, Lotteryness and Volatility

The second paper that we review establishes a link between profitability, distress risk, lottery-seeking behaviour and low-volatility patterns via an expected idiosyncratic skewness channel driven by growth options. Investors expressing preference for positively skewed upside potential specifically driven by corporate growth options should accept lower returns in equilibrium. This justifies the lower returns of higher distress risk, higher lotteryness, higher idiosyncratic volatility or lower profitability stocks; all these groups of stocks exhibit higher realised idiosyncratic skewness.

Do hedge funds take advantage of the low-risk patterns?

Hedge funds can generally employ leverage and are not evaluated with respect to a benchmark. However, the third paper that we review finds that hedge funds appear (at least on aggregate) to be betting against low-volatility stocks and on high-volatility stocks. This poses a challenge to leverage or benchmarking explanations of the low-risk anomaly. Instead, it promotes a lottery-seeking behaviour as an explanation for the low-risk patterns, given the typical hedge fund fee structure which charges an additional management fee if the performance exceeds some threshold.

Introduction

This issue of our Academic Research Monitor contains the reviews of three recent papers on the low-risk patterns (see Figure 1).[1]

The first paper looks at the low-risk anomaly and tries to disentangle the performance into a systematic (i.e. correlation) component and an idiosyncratic risk component. To put this differently, given that the beta of a stock is the product of its volatility and its correlation with the market, the question then becomes: are the low-beta patterns low-correlation patterns or low-volatility (strictly speaking low-idiosyncratic-volatility) patterns?

The second paper draws parallels between four different anomalies that all relate to low-risk patterns: profitability, distress, lotteryness and volatility. These are shown to be inter-connected via a growth options-driven expected idiosyncratic skewness channel. The growth options-related expected idiosyncratic skewness is shown to command a negative return premium, as investors show preference for positively skewed return profiles coming from future growth options, even if they come with lower average returns. A high-minus-low growth option-driven expected idiosyncratic skewness factor can explain the profitability of the various long-short factors based on profitability, distress, lotteryness and volatility.

Finally, the third paper explores the ability of low-risk factors to explain the variation of returns of aggregate hedge fund indices. The main finding is that hedge funds are (at least on aggregate) exposed to a low-risk factor, but with the opposite sign than possibly expected. As opposed to taking advantage of the low-risk patterns (given their ability to employ leverage and the lack of benchmarks), the evidence shows that – on aggregate – they bet against low-volatility stocks and favour high-volatility stocks instead.

Figure 1: Papers on Low-Risk Investing

"Betting Against Correlation: Testing Theories of the Low-Risk Effect" *Clifford Asness, Andrea Frazzini, Niels Joachim Gormsen and Lasse Heje Pedersen*	SSRN working paper, January 2017
"Seemingly unrelated stock market anomalies: Profitability, Distress, Lotteryness and Volatility" *Turan Bali, Luca Del Viva, Neophytos Lambertides and Lenos Trigeorgis*	SSRN working paper, May 2017
"Are Hedge Funds on the Other Side of the Low-Volatility Trade?" *David Blitz*	SSRN working paper, May 2017

Source: UBS.

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[1] We have covered low-risk patterns in the ARM a couple of times in the recent past; please see the February 2016 ARM and the November 2016 ARM. Additionally, please see our recent work on the dependence of low-risk investing on interest rate changes.

"Betting Against Correlation: Testing Theories of the Low-Risk Effect"

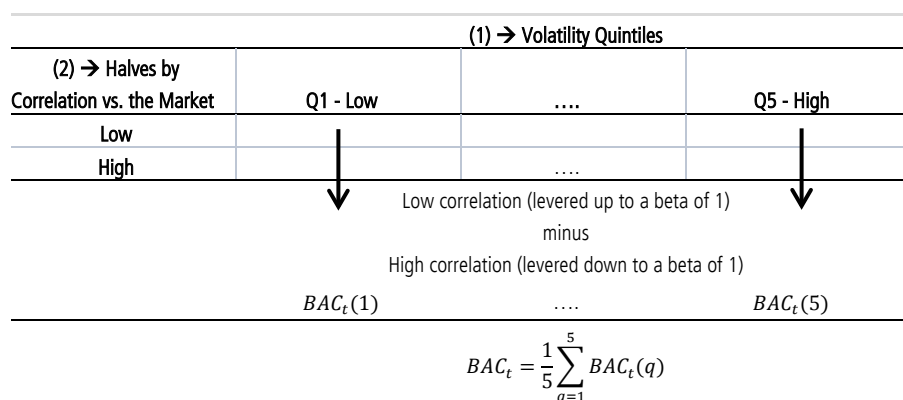**by Clifford Asness, Andrea Frazzini, Niels Gormsen & Lasse Pedersen**

The fact that stocks with low risk outperform on a risk-adjusted basis the stocks with high risk, contrary to the high-risk/high-return theoretical underpinnings, is a very well established empirical finding that dates back to Black, Jensen and Scholes (1972). The term "low-risk" is broad and encompasses the notions of low systemic risk (i.e. beta) as well as of low volatility (either total or idiosyncratic); see the idiosyncratic volatility anomaly by Ang, Hodrick, Xing and Zhang (2006, 2009) and the betting-against-beta anomaly by Frazzini and Pedersen (2014).

In an effort to rationalise the empirical irregularity of low-risk patterns, academics have suggested a range of potential explanations that can be grouped into two broad categories: (1) if "risk" is proxied by market beta (i.e. systematic risk), then the rational explanation suggests that features of financial intermediation, such as leverage constraints and benchmarking, are driving the low-risk effects; (2) if "risk" is proxied by idiosyncratic volatility, then the low-risk effects can be driven by behavioural biases related to seeking stocks with lottery features. This very recent paper by Clifford Asness, Andrea Frazzini, Niels Gormsen and Lasse Pedersen aims to shed light onto these dependences. Are low-beta effects due to low-volatility or low-correlation with the market? Is it leverage constraints or excess lottery demand that drives low-risk patterns?

In order to empirically study these questions, the authors construct a number of factors that isolate exposure to correlation (hence capturing systematic risk) and exposure to stocks with lottery features (hence capturing idiosyncratic risk). For their empirical analysis, they use US stocks (1963-2015) and stocks from 24 countries (1990-2015). The global (non-US) portfolios are formed as market-capitalisation weighted portfolios of country-specific strategies. The data are collected from CRSP and the XpressFeed Global Database.

Starting from systematic risk, the aim is to decompose the Frazzini and Pedersen (2014) Betting-against-Beta (BAB) strategy into Betting-Against-Correlation (BAC) and Betting-Against-Volatility (BAV) strategies. The methodology that the authors use for the BAC strategy is illustrated in Figure 2 below.

Figure 2: Construction of the Betting-Against-Correlation factor

(2) → Halves by Correlation vs. the Market	(1) → Volatility Quintiles		
	Q1 - Low	….	Q5 - High
Low			
High		….	

Low correlation (levered up to a beta of 1)

minus

High correlation (levered down to a beta of 1)

$BAC_t(1)$ …. $BAC_t(5)$

$$BAC_t = \frac{1}{5}\sum_{q=1}^{5} BAC_t(q)$$

Source: UBS Quantitative Research. The diagram explains how to construct a Betting-Against-Correlation (BAC) factor using a dependent double-sort methodology.

The procedure entails a dependent double sort, first by historical volatility (estimated using a one-year rolling window of daily returns) into quintiles, and

Beta = Correlation * Volatility

If low-beta outperforms, is it due to the correlation or the volatility?

Leverage constraints

-OR-

Excess lottery demand?

Low-risk from the perspective of systematic risk:

- **Betting against beta**

- **Betting against correlation**

- **Betting against volatility**

then by correlation with the market (estimated using a five-year window of three-day overlapping returns) into low and high. For each volatility quintile a beta-neutralised low minus high correlation portfolio is constructed (this is achieved by levering up the low correlation portfolio to an ex-ante beta of one and by levering down the high correlation portfolio to an ex-ante beta of one). Each low and high correlation sub-portfolio assumes rank-based weights (so stocks with higher ranks for the high correlation portfolio and lower ranks for the lower correlation portfolio have larger weights). The final BAC portfolio is simply the equal-weighted portfolio of the five BAC sub-portfolios across volatility quintiles. The BAV factor is constructed with the exact same procedure, simply by reversing the order of ranking; first by correlation into quintiles and then by volatility into low and high. It becomes obvious that this above methodology renders the BAC strategy almost independent to volatility and the BAV strategy almost independent to correlation.

Looking at the behavioural aspect of the low-risk patterns and the idiosyncratic risk component of the explanation, the authors construct a number of factors that can capture (partly or solely) the demand for stocks with lottery-like returns. For all these factors, the construction follows the Fama and French (1993) 2x3 size adjusted methodology (the results remain robust to using the methodology outlined in Figure 2), presented in Figure 3 below (the authors use independent sorting for the US and dependent sorting outside the US). Three ranking criteria are used: (1) idiosyncratic volatility (IVOL), estimated using the residuals of a Fama and French (1993) regression framework (US factors for the US universe; Asness and Frazzini (2013) factors for the global universe), (2) the largest maximum return over the past month (MAX) and (3) the ratio of the average of the five largest returns over the past month to the volatility of the stock (SMAX: scaled MAX).

Low-risk from the perspective of idiosyncratic risk and lottery demand:

- **Idiosyncratic volatility**

- **MAX past daily return**

- **Scaled MAX past daily return**

Figure 3: Overview of the Fama and French (1993) factor construction process

Market Capitalisation	Criterion of Interest (e.g. Idiosyncratic Volatility / MAX / Scaled MAX)		
	Low	Medium	High
Small	Low / Small (LS)		High / Small (HS)
Large	Low / Large (LL)		High / Large (HL)

$$Factor_t = \frac{1}{2}[LS_t + LL_t] - \frac{1}{2}[HS_t + HL_t]$$

Source: UBS Quantitative Research. The diagram reviews the Fama and French (1993) 2x3 double-sort factor construction methodology that is used in order to construct factors by IVOL, MAX and SMAX (Scaled MAX).

The IVOL anomaly (stocks with low idiosyncratic volatility outperforming stocks with high idiosyncratic volatility) was first studied by Ang et al. (2006, 2009), whereas the LMAX anomaly (stocks with the low maximum daily return over the past month outperform stocks with high maximum daily return over the past month) was first documented by Bali, Cakici and Whitelaw (2011); interestingly, the maximum daily return over the past month has been shown to be related to idiosyncratic skewness by Boyer, Mitton and Vorkink (2009). The SMAX criterion, which is effectively a risk-adjusted form of the MAX criterion, is suggested by the authors of the current paper that we review. The reason why the authors introduce the SMAX measure is because they want to capture lottery demand that is not mechanically related to volatility. The MAX measure can be high either because of a high return realisation or because of higher volatility. A risk-adjusted metric, like SMAX, can therefore identify large moves after controlling for volatility, hence capturing the shape of the return distribution, as the authors argue.

The empirical part of the analysis in the paper consists of a number of experiments aiming to identify whether low-risk patterns are primarily due to leverage constraints, as captured by the BAC strategy, or due to behaviourally-driven lottery

demand, as captured by the SMAX strategy. The actual finding is that <u>both</u> effects play a significant role in the low-risk patterns, and neither of the two subsumes the other. The results are relatively stronger for leverage constraints (and the BAC factor), especially outside the US (where the results of SMAX generally lack strong statistical significance). In the remainder of our review, we summarise some of the most important results that lead to this finding.

First, the authors show that the BAB and LMAX strategies have no statistically strong alpha, when regressed against their respective components, BAC and BAV or SMAX and total volatility (TV) respectively, both in the US as well as across global equity markets. This effectively means that BAB gets its alpha from betting against high volatility and high correlation with the market and that LMAX gets its alpha from betting against high volatility and high Scaled MAX return. This finding therefore supports that BAC and SMAX factors can – to a certain extent – isolate the systematic and idiosyncratic aspects of low-risk patterns.

Then, the authors look at the alphas of these two strategies, BAC and SMAX, against the Fama and French (1993, 2016) three- and five-factor models. They find strong alphas for both factors in the US. Across global equity markets, it is only the BAC strategy that exhibits statistical significant alphas. The SMAX strategy has statistically strong three-factor alpha, but once the authors control for the profitability (RMW) and the investment (CMA) factors, the statistical significance is lost due to the strong exposure to the profitability factor. The regression analysis generates two more important points: (1) the SMAX strategy is strongly exposed to a short-term reversal strategy; this is quite intuitive, as the SMAX strategy takes a long position on stocks with high returns on their best performing days over the past month; (2) the BAC strategy is strongly and positively exposed to the size factor (so, low correlation stocks across volatility quintiles tend to be small stocks) whereas the BAV strategy is strongly and negatively exposed to the size factor (so, low volatility stocks across correlation quintiles tend to be big stocks).

Following these results, the authors then look at the economic drivers of BAC and SMAX strategies. To test for leverage constraints, they construct a margin debt variable (amount of margin debt held by customers at NYSE member organisations divided by the market capitalisation of NYSE stocks). To test for irrational lottery demand, they use the investor sentiment index of Baker and Wurgler (2006, 2007). They find that BAB and BAC strategies outperform following periods when leverage constraints are high and during periods when leverage constraints decrease on a contemporaneous basis. Interestingly enough, the profitability of these factors is not related to market sentiment. Conversely, there is some weak evidence that the SMAX, LMAX and IVOL strategies outperform following periods when investor sentiment is high, but neither strategy is related to margin debt. These results are quite insightful, as it becomes clear that leverage constraints only affect systemic risk, whereas investor sentiment only affects idiosyncratic risk.

The last piece of evidence relates to the turnover of the various strategies and the respective alpha decay if rebalancing takes place less frequently than monthly. The analysis shows that the SMAX, LMAX and IVOL strategies (all of which use information from the last month before portfolio formation) turn over their respective portfolios five to six times more than the BAB, BAC, BAV strategies do. More importantly, the outperformance of the SMAX, LMAX and IVOL strategies is mainly due to high turnover and their alpha falls strongly after the holding month in event time. Conversely, the BAB alpha continues to grow for even up to 12 months after portfolio formation.

"Seemingly unrelated stock market anomalies: Profitability, Distress, Lotteryness and Volatility"

by Turan Bali, Luca Del Viva, Neophytos Lambertides & Lenos Trigeorgis

Stocks with higher profitability outperform their peers. Distressed firms underperform their peers. Stocks with lottery features underperform their peers. Stocks with low idiosyncratic volatility outperform peers. These are four statistically strong empirical observations that seem to go against the higher-risk-higher-return paradigm of modern finance theory. Is it possible to reconcile all these market anomalies using one unifying underlying mechanism? The recent paper by Turan Bali, Luca Del Viva, Neophytos Lambertides and Lenos Trigeorgis provides strong empirical evidence that an underlying channel of expected idiosyncratic skewness derived from growth options of a firm can explain all these "*seemingly unrelated stock market anomalies*" as the title suggests.

The main hypothesis of the authors is that "*if investors prefer stocks with embedded real options and have preference for more positive idiosyncratic skewness, then high idiosyncratic skewness offered by firms with such real options might entice investors to accept lower expected returns*". In other words, stocks with idiosyncratic upside potential due to corporate growth options should come at a premium and therefore exhibit lower returns in equilibrium. How are the four asset pricing anomalies under consideration related to growth-driven idiosyncratic skewness? High distress risk, high lotteryness or high idiosyncratic volatility firms are expected by their very nature to involve real options and therefore to exhibit higher idiosyncratic skewness in their distribution of returns. Conversely, high profitability firms are more likely to have realised past growth opportunities and therefore to exhibit lower future idiosyncratic upside potential. These relationships are documented by their authors as explained below in our detailed review.

For their empirical analysis the authors use a dataset that contains all stocks with records in the merged CRSP/Compustat database between 1983 and 2015, **excluding financials and utilities** (12,709 firms in total).

The four criteria associated with the anomalies under consideration are estimated as follows (for further details on the estimation, please consult the actual paper):

- **Profitability:** measured using return-on-equity (ROE), defined as the ratio between operating cash-flows and lagged shareholders' equity.
- **Distress risk:** measured using the negative of Merton's distance to default.
- **Lotteryness:** measured using the largest daily return over the last month.
- **Idiosyncratic volatility:** measured using the standard deviation of the residuals of a regression of daily stock excess returns on market excess returns and squared market excess returns over the last 5 years of daily observations.

These four characteristics are related to the expected idiosyncratic skewness specifically attributed to corporate growth options. The authors estimate the growth options as well as the historical idiosyncratic skewness as follows:

- **Growth options:** measured as the difference between the firm's current value and the perpetual discounted stream of expected operating cash flows under a no-further-growth policy. Put differently, the growth options measure captures the residual future-oriented growth potential.
- **Idiosyncratic skewness:** measured using the skewness of the residuals of a regression of daily stock excess returns on market excess returns and squared market excess returns over the last 5 years of daily observations.

The rationale: higher upside potential driven by corporate growth options should come at a premium

For the estimation of the expected idiosyncratic skewness of each firm, the authors run a cross-sectional regression at each month-end. The vector of realised idiosyncratic skewness measures of all firms (estimated using the last 5 years of daily data) in the cross-section is regressed against lagged (by 5 years, so that there is no overlap) measures of growth option, profitability, distress risk, lotteryness, idiosyncratic volatility, idiosyncratic skewness and a good number of other control variables (X), including asset growth, turnover, book-to-price ratio and others:

$$is_{i,t} = \alpha + \beta_{GO} \cdot GO_{i,t-5Y} + \beta_{ROE} \cdot ROE_{i,t-5Y} + \beta_{DR} \cdot DR_{i,t-5Y} + \beta_{LOT} \cdot LOT_{i,t-5Y} +$$

$$+\beta_{iv} \cdot iv_{i,t-5Y} + \beta_{iv} \cdot is_{i,t-5Y} + \sum_{j} \beta_j \cdot X_{j,i,t-5Y} + \epsilon_{i,t}$$

The result of this regression over the entire sample period (which is equivalent to taking the time-series average of the cross-sectional regression estimates at each month-end) shows a statistically strong relationship between realised idiosyncratic skewness and lagged values of the four ranking criteria of the four anomalies under consideration and of growth options. In particular, higher values of growth options, distress risk, lotteryness and idiosyncratic volatility are associated with higher future idiosyncratic skewness. Conversely, higher levels of profitability are associated with lower future idiosyncratic skewness (in line with this finding, similar behaviour is documented for the asset growth variable). The results hold both at the univariate and at the multivariate regression setting; they also hold if instead of a cross-sectional regression analysis one conducts a portfolio analysis (forming decile portfolios at each month-end based on any of the ranking criteria and estimating average realised idiosyncratic skewness over the following 5 years).

Positive relationship between future realised idiosyncratic skewness and current…

- **Growth Options**
- **Distress Risk**
- **Lotteryness**
- **Idiosyncratic Volatility**

Negative relationship between future realised idiosyncratic skewness and current…

- **Profitability**
- **Asset Growth**

Having established the cross-sectional relationship between future idiosyncratic skewness and current levels of growth options, profitability, distress risk, lotteryness and idiosyncratic volatility, the authors then proceed with the estimation of *expected* **idiosyncratic skewness attributed to growth options**. In particular, after the estimation of the cross-sectional regression above at each month-end, the authors use the latest estimates of growth options for all firms, $GO_{i,t}$, along with the respective slope coefficient $\hat{\beta}_{GO}$ and generate the vector of expected idiosyncratic skewness that is solely due to the impact of growth options:

Estimating growth options-driven expected idiosyncratic skewness

$$E_t[is_i]_{GO} = \hat{\alpha} + \hat{\beta}_{GO} \cdot GO_{i,t} \qquad (1)$$

This is the important variable for the rest of the analysis and it is set against the ranking criteria of the various asset pricing market anomalies under consideration in terms of their ability to forecast (and explain) the cross-section of stock returns. In particular, the authors argue that, as long as growth option-driven expected idiosyncratic skewness is able to capture profitability and investment effects in future returns (in line with Fama and French, 2016), then this variable should assist in explaining stock returns above and beyond standard variables used in the asset pricing literature (size, book-to-price ratio, momentum, profitability etc.).

In cross-sectional regressions of future monthly stocks returns against lagged characteristics (size, book-to-price, 12-month momentum, ROE, asset growth and expected idiosyncratic skewness attributed to growth options), the expected idiosyncratic skewness variable is one of the strongest predictors of returns and subsumes the predictive power of all (but asset growth) variables that are included in the analysis. The slope coefficient is negative, which effectively means that larger expected idiosyncratic skewness is related to lower expected returns. This result is in line with the hypothesis of the authors that investors who express preference for

Stocks with higher growth options-driven expected idiosyncratic skewness are priced at a premium

positively skewed upside potential specifically driven by corporate growth options should be willing to accept lower returns in equilibrium. Importantly enough, the earlier analysis showed that stocks with higher realised idiosyncratic skewness are typically stocks with higher distress risk, higher lotteryness, higher idiosyncratic volatility or lower profitability. The links between the profitability of the respective asset pricing anomalies and the documented effects between future stock returns and expected idiosyncratic skewness should by now have become apparent.

The authors then look at the time-series patterns. They construct a high-minus-low growth option-driven expected idiosyncratic skewness factor and investigate whether this factor can explain the various anomalies in question, in particular high-minus-low profitability, low-minus-high distress risk, low-minus-high lotteryness, low-minus-high idiosyncratic volatility. Their findings are very strong. These four portfolios have statistically strong average excess returns as well as statistically strong five-factor (against market, size, value, momentum, liquidity factors) alphas. However, when additionally controlling for the skewness factor all alphas fall strongly in magnitude and lose completely any statistical strength. In fact, similarly constructed expected idiosyncratic skewness factors using equation (1) and other variables (as opposed to the growth options variable), for example ROE or idiosyncratic volatility, leave the five-factor alphas unaffected. As the authors put it "…*only future growth options-driven expected idiosyncratic skewness is both consistently priced in stock returns and is able to explain the above anomalous returns.*"

An idiosyncratic skewness factor to explain a number of asset pricing anomalies

In line with these results, the newly introduced skewness factor is shown to completely eliminate the five-factor alpha of various long-short profitability factors suggested in the literature like the one by Fama and French (2016) and the one by Hou, Xue and Zhang (2015). Conversely, these profitability factors cannot explain the returns of the skewness factor, whose alpha remains both economically and statistically strong irrespective of the factor model used to explain its returns.

The growth options-driven expected idiosyncratic skewness factor seems to be behind the performance of the profitability factor

The investment strategy that takes a long position on the decile with the lowest past year average growth options-driven expected idiosyncratic skewness and a short position on the largest past year average options-driven expected idiosyncratic skewness generates a statistically strong average return between 16% and 18% per annum (equal or market-cap weights respectively) and equally statistically strong alphas based on a number of factor models that the authors test. Interestingly, the performance is primarily driven by the outperformance of the basket of stocks with low options-driven expected idiosyncratic skewness.

As long as market volatility determines the value of corporate growth options, then the expected idiosyncratic skewness effects should become more pronounced during high-volatility regimes. In line with this observation, the authors find the spread between the low and the high decile baskets based on growth options-driven expected idiosyncratic skewness is much stronger (both in terms of economic and statistical significance) in high volatility periods. As a consequence, the negative relationship between growth options-driven expected idiosyncratic skewness and futures stock returns is stronger in high volatility periods.

Overall, we consider the findings of this paper of extreme interest for factor investing allocations. Four seemingly unrelated anomalies are inter-connected via a growth options-driven expected idiosyncratic skewness channel. The growth options-related expected idiosyncratic skewness is shown to command a negative return premium, as investors show preference for positively skewed return profiles coming from future growth options, even if they come with lower average returns.

"Are Hedge Funds on the Other Side of the Low-Volatility Trade?"
by David Blitz

As already explained quite extensively in the previous reviews, the low-volatility anomaly contradicts the long-standing principle in finance that risk should be compensated for with higher returns and has been generally associated to leverage aversion, short-selling restrictions and benchmark constraints. In his recent paper, David Blitz offers a different perspective on the existence of this anomaly by analysing aggregate hedge fund returns.

One might expect that, since hedge funds do not face the restrictions just mentioned (at least, not at the extent that more traditional investment schemes do), they can potentially benefit from exploiting the low-volatility phenomenon, for example by levering up on low-volatility stocks. What the author of this paper deduces, however, is that the behaviour of aggregate hedge fund returns is consistent with taking long positions on high-volatility stocks and short positions on low-volatility stocks. That is, it would seem that the hedge fund industry is on the other side of the low-volatility trade.

Aggregate hedge fund return behaviour points to a consistent preference for high-vol stocks.

The approach the author employs involves regressing a large group of hedge fund index returns on the return differential between low-volatility stocks and high-volatility stocks. The data on hedge fund returns are collected from Thomson Reuters Datastream and contain 20 various Hedge Fund Indices: 7 Hedge Fund Research (HFR) indices and 13 Credit-Suisse (CS) Hedge Fund indices. The former are equally weighted, the latter are weighted by asset size. All returns are in excess of the risk-free rate which is sourced from the Kenneth French website. The multivariate linear model that is used controls for a broad number of variables:

Hedge fund data includes 7 HFR indices and 13 CS indices representing various themes.

- US equity market excess returns (Mkt);
- Lagged US equity market excess returns (Mkt-1);
- Emerging market returns in excess of US market returns (Em-US);
- The term premium, expressed as the differential return between the Barclays US Treasury index and the risk-free rate (Term);
- The investment grade credit risk premium (IG-Tr);
- The high yield credit risk premium (HY-Tr);
- The return of a time-series multi-asset momentum strategy across commodities, bonds, equities and currencies (TSmom);
- The variance risk premium (VRP);
- The Fama and French (1993) size and value, and the Carhart (1997) momentum factors (SMB, HML and WML).

11 variables are included in the regressions to account for known explanatory factors.

In addition to the above variables, the author constructs a factor as the return differential between low volatility and high volatility stocks (LV-HV); the volatility is estimated using a rolling window of 36 months. The actual construction of the factor follows the Fama and French (1993) factor construction process (which was schematically presented already in this ARM in Figure 3):

- Classify all stocks in the CRSP database as small or large according to the usual NYSE median market capitalization threshold;

- Construct four value-weighted portfolios; two containing the 30% lowest volatile stocks within each size group and two consisting of the 30% highest volatility stocks within each size group;

- Subtracting the average (USD) return of the high volatile stock baskets from the average return of the low volatile stock baskets results in the LV-HV factor.

All data is taken at the monthly frequency and the period of analysis covers January 2000 until December 2016.

Once the data has been collated, the 20 hedge fund indices are separately regressed against the LV-HV factor, controlling for the 11 variables listed above; Figure 4 contains the results for the HFR indices. Over the entire sample period, two facts emerge. First, the LV-HV factor consistently belongs to one of the most statistically significant explanatory factors for hedge fund returns. Second, the sign of the coefficient for LV-HV is negative in all but two cases – for the cases where the coefficient is positive, the result is not statistically significant.

Figure 4: Regression Results for HFR hedge fund indices (Jan 2000 – Dec 2016)

	alpha	Mkt	Mkt-1	Em-US	Term	IG-Tr	HY-Tr	TSmom	VRP	SMB	HML	WML	LV-HV	R-sq
HFRI Fund Weighted Comp index														
coeff.	0.12%	0.21	0.04	0.11	0.01	0.14	0.02	0.04	0.05	0.01	0.02	0.06	-0.10	92.00%
t-stat.	**2.8**	**13.12**	**4.18**	**10.62**	0.27	**2.58**	0.56	**3.74**	1.27	0.49	1.16	**6.62**	**-7.75**	
HFRI Fund of Funds Comp index														
coeff.	-0.03%	0.13	0.05	0.09	-0.04	0.20	0.00	0.06	0.06	-0.01	0.01	0.08	-0.08	80.70%
t-stat.	-0.54	**6.56**	**4.81**	**6.9**	-0.77	**2.93**	0.00	**4.02**	1.14	-0.59	0.46	**7.54**	**-4.75**	
HFRI Emerging Markets index														
coeff.	0.14%	0.39	0.08	0.43	0.09	0.06	-0.01	-0.02	0.22	-0.07	0.06	0.08	-0.11	90.80%
t-stat.	1.75	**12.48**	**4.38**	**20.9**	1.17	0.52	-0.24	-0.92	**2.71**	**-2.12**	**2.13**	**4.52**	**-4.21**	
HFRI Equity Hedge index														
coeff.	0.07%	0.30	0.03	0.14	-0.04	0.21	-0.03	0.01	0.09	0.03	0.06	0.10	-0.14	91.60%
t-stat.	1.13	**13.74**	**2.38**	**9.4**	-0.83	**2.72**	-0.67	0.40	1.58	1.59	**2.80**	**8.10**	**-7.75**	
HFRI Event Driven index														
coeff.	0.18%	0.15	0.06	0.07	0.04	0.07	0.13	0.02	0.15	0.05	0.07	0.04	-0.07	85.10%
t-stat.	**3.01**	**6.94**	**4.51**	**4.63**	0.73	0.96	**3.26**	1.28	**2.63**	**2.13**	**3.14**	**3.20**	**-3.75**	
HFRI Macro index														
coeff.	0.04%	0.07	0.01	0.12	0.02	0.07	-0.08	0.21	-0.08	0.02	0.01	0.02	-0.07	55.70%
t-stat.	0.50	**2.43**	0.46	**5.89**	0.31	0.64	-1.34	**9.23**	-0.98	0.65	0.28	0.89	**-2.84**	
HFRI Relative Value index														
coeff.	0.23%	0.03	0.04	0.04	0.13	0.25	0.13	0.00	0.15	-0.04	0.04	0.04	-0.03	76.50%
t-stat.	**4.97**	1.59	**3.67**	**3.24**	**2.94**	**4.05**	**3.8**	-0.01	**3.33**	**-2.41**	**2.42**	**3.68**	-1.86	

Source: *"Are Hedge Funds on the Other Side of the Low Volatility Trade?"* by D. Blitz; Exhibit 1, reproduced with permission. The table reports the results from regressing HFR index returns on LV-HV factor as well as 11 control factors. Sample period: Jan. 2000 – Dec. 2016. Bold figures correspond to statistically significant results at 5%.

The first result is interesting and reveals a new explanatory variable for explaining hedge fund returns. The latter result contradicts the hypothesis that hedge funds systematically exploit the low volatility anomaly simply because they have the means to do so. In fact, what these results imply is that hedge funds, on aggregate, do the exact opposite. That is, take a long bet on high volatility stocks and short low volatility stocks.

Results reveal that LV-HV is a highly significant explanatory factor for describing hedge fund returns.

The evidence shows that the cases where the statistical significance of the LV-HV factor is greatest appear to be associated with hedge funds styles that invest directly in equities.

Regarding the control variables, their significance is generally in accordance with expectations. However, they differ from one fund to the other and depend, largely, on the particular hedge fund strategy. When carrying out the same regressions but excluding LV-HV, the author finds that those insignificant factors

remain insignificant, implying that LH-HV isn't simply creating noise and dissipating the explanatory power of those other variables.

Overall, the general conclusion is that hedge fund index returns are driven by traditional betas, momentum-based factors and a bet against the low-volatility anomaly. This remains true when carrying out the same regressions over the first and second half of the sample period.

Given the association between the low-volatility anomaly and low-beta anomaly (which we discussed in detail in the review of Bali *et. al* (2017) earlier in the current issue of the ARM), the author replicates the above analysis by replacing LV-HV with a low-minus-high 36-month beta factor (LB-HB). The factor, LB-HB, turns out to be highly correlated with LV-HV at 0.95 over the entire sample period. Therefore, one would expect the results from carrying out the above regressions to be very similar when replacing LV-HV with LB-HB. This isn't necessarily the case, however. What the author finds is that, whilst t-statistics for LB-HB are, on the whole, negative, the statistical significance of this factor and the respective R-squared levels are much lower. Again, all these results point to hedge fund returns being highly exposed to LV-HV.

In addition to the above, further robustness checks are carried out. To dispel any concerns relating to multicollinearity and the fact that both the LV-HV and LB-HB factors might be dominated by the high-risk components, the author repeats the regressions using market-neutral equivalents of the factors; a betting against volatility factor (BAV) and a betting against beta factor (BAB). These are constructed by borrowing cash at the risk-free rate to take a 130% long position in the LV and LB portfolios, then taking a 70% short position in the HV and HB portfolios, investing the remaining 30% at the risk-free rate. Another robustness check is motivated by the relationship between the low volatility anomaly and profitability, as documented in the works by Novy-Marx (2014), Fama and French (2016) and also by Bali et al. (2017), which we have already reviewed in the current issue of the ARM. To this end, the same set of regressions are estimated, but this time the LV-HV factor is replaced by profitability (RMW), which is correlated with LV-HV at 0.80. See Figure 5 overleaf for t-statistics relating to these factors.

The last robustness check that the author conducts relates to the possibility that the results are primarily driven by one leg of the LV-HV factor. For that reason, he repeats the analysis using a low-volatility minus medium-volatility factor (LV-MV) and a high-volatility minus medium-volatility factor (HV-MV), either separately or jointly in the regression framework. The findings suggest that hedge funds tend to bet against low volatility and at the same time bet on high volatility (the latter effect appears to be stronger).

In summary, the conclusion remains that hedge funds are predominantly exposed to volatility, but possibly in the opposite way from that initially expected; they bet against low-volatility stocks and in favour of high-volatility stocks. This could potentially pose a challenge to leverage or benchmarking explanations of the low-risk anomaly. Conversely, it could promote a lottery-seeking behaviour as an explanation for the low-risk patterns, given the hedge fund fee structure that charges an additional management fee if the performance exceeds some threshold. Whichever might actually be the case, one of the important findings of the paper is that a low minus high volatility factor appears to explain a significant amount of hedge fund returns, above and beyond conventional factors used in the literature.

Hedge fund index returns are mainly driven by classic betas, momentum-based factors and a bet against low-volatility.

Figure 5: T-statistics for LH-HV and related factors (Jan 2000-Dec 2016)

	LV-HV	BAV	LB-HB	BAB	RMW
HFR indices					
HFRI Fund Weighted Comp index	**-7.75**	**-7.79**	**-4.93**	**-4.92**	**-4.14**
HFRI Fund of Funds Comp index	**-4.75**	**-4.98**	**-2.67**	**-2.67**	**-2.56**
HFRI Event Driven index	**-4.21**	**-4.52**	**-3.69**	**-3.89**	-1.61
HFRI Emerging Markets index	**-7.75**	**-7.53**	**-5.27**	**-4.89**	**-3.35**
HFRI Equity Hedge index	**-3.75**	**-3.63**	-1.53	-1.39	**-2.65**
HFRI Macro index	**-2.84**	**-3.24**	-1.41	**-1.96**	**-2.54**
HFRI Relative Value index	-1.86	-1.56	-1.03	-0.52	0.09
CS indices					
CS Hedge Fund index	**-5.23**	**-5.55**	**-2.96**	**-3.15**	**-3.48**
CS Convertible Arbitrage index	**-3.06**	**-2.60**	-1.77	-1.23	-0.69
CS Dedicated Short Bias index	0.98	0.87	1.76	1.66	0.22
CS Distressed index	**-3.08**	**-3.10**	-1.17	-1.15	-1.57
CS Emerging Markets index	**-3.39**	**-3.81**	**-3.69**	**-4.10**	-1.09
CS Equity Market Neutral index	-0.77	-0.50	-0.54	-0.29	0.20
CS Event Driven index	**-3.97**	**-3.71**	**-1.99**	-1.61	-1.03
CS Fixed Income Arbitrage index	0.35	0.21	0.96	0.87	0.36
CS Global Macro index	-1.63	-1.87	-0.79	-1.20	-0.33
CS Long/Short Equity index	**-5.39**	**-5.76**	**-3.47**	**-3.60**	**-4.57**
CS Managed Futures index	1.09	0.98	1.34	1.05	0.76
CS Multi-Strategy index	**-2.52**	**-2.16**	-0.96	-0.47	-0.94
CS Risk Arbitrage index	**-2.43**	**-2.04**	-0.78	-0.45	-1.95

Source: *"Are Hedge Funds on the Other Side of the Low Volatility Trade?"* by D. Blitz; Exhibit 4, reproduced with permission. The table reports the t-statistics from regressing aggregate hedge fund returns on 11 control variables and either LV-HV or one of four related factors. The period under analysis covers January 2000-December 2016. Figures in bold correspond to statistically significant results at 5%.

References

Ang, A., Hodrick, R. J., Xing, Y., & Zhang, X. (2006). The cross-section of volatility and expected returns. *Journal of Finance, 61*(1), 259-299.

Ang, A., Hodrick, R. J., Xing, Y., & Zhang, X. (2009). High idiosyncratic volatility and low returns: International and further US evidence. *Journal of Financial Economics, 91*(1), 1-23.

Asness, C. S., Frazzini, A., Gormsen, N. J., & Pedersen, L. H. (2016). Betting Against Correlation: Testing Theories of the Low-Risk Effect. *Available at SSRN: 2913508*.

Bali, T. G., Cakici, N., & Whitelaw, R. F. (2011). Maxing out: Stocks as lotteries and the cross-section of expected returns. *Journal of Financial Economics, 99*(2), 427-446.

Bali, T. G., Del Viva, L., Lambertides, N., & Trigeorgis, L. (2017). Seemingly Unrelated Stock Market Anomalies: Profitability, Distress, Lotteryness and Volatility. *Available at SSRN: 2974452*.

Black, F., Jensen, M. C., & Scholes, M. (1972). The Capital Asset Pricing Model: Some Empirical Tests.

Blitz, D. (2017). Are Hedge Funds on the Other Side of the Low-Volatility Trade? *Available at SSRN: 2898034*.

Boyer, B., Mitton, T., & Vorkink, K. (2009). Expected idiosyncratic skewness. *Review of Financial Studies, 23*(1), 169-202.

Carhart, M. (1997) On Persistence in Mutual Fund Performance. *The Journal of Finance*, 52(1), 57-82.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics, 33*(1), 3-56.

Fama, E. F., & French, K. R. (2016). Dissecting anomalies with a five-factor model. *Review of Financial Studies, 29*(1), 69-103.

Frazzini, A., & Pedersen, L. H. (2014). Betting against beta. *Journal of Financial Economics, 111*(1), 1-25.

Hou, K., Xue, C., & Zhang, L. (2015). Digesting anomalies: An investment approach. *Review of Financial Studies, 28*(3), 650-705.

Novy-Marx, R. (2014). Understanding defensive equity. National Bureau of Economic Research.

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