Academic Research Monitor

Where does Volatility Targeting work?

Equities

Global
Quantitative

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Looking at two different facets of volatility

The first ARM for 2017 looks at the importance of volatility-targeting for equity factor investing and on the impact of changes in aggregate volatility in the cross-section of stock returns.

Improving the performance of equity factor premia using volatility-targeting

The evidence on the importance of volatility-targeting an equity long-short momentum strategy has been strong (e.g. see our July 2013 ARM). But, can we argue the same for the rest of the equity factor premia? The first two papers that we review look at the impact of volatility-managing a broad spectrum of styles in the US, like value, size, quality, betting-against-beta and others. The main finding is that volatility-managed factors outperform their raw counterparties, with the result being more pronounced for the momentum and betting-against-beta factors. We extend the analysis by looking at other regions, namely Europe, Asia ex. Japan and Japan and find similar results.

Changes in aggregate volatility and the cross-section of stock returns

Do stocks with positive exposure to changes in aggregate volatility earn lower returns, as they provide a hedge during periods of heightened volatility? Conversely, are stocks with negative exposure to changes in aggregate volatility compensated by earning higher returns in equilibrium? The last paper that we review explores these questions and - contrary to earlier findings in the academic literature - finds that the changes in aggregate volatility (VIX) are not priced in the cross-section of stock returns over the period 2000 to 2015. In other words, the return differential between quintile portfolios, sorted by the sensitivity to changes in aggregate volatility, is small in magnitude and statistically insignificant.

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Introduction

In this issue of our Academic Research Monitor, we look at two different facets of volatility (see Figure 1).

Volatility-Targeting

On the one hand, we explore recent academic findings on the benefits of managing the volatility in equity factor investing. It is worth noting that volatility-targeting is a topic that we have extensively worked on in the past:

- *"Understanding Volatility-Targeting"* (October 2011)
- *"Beyond Volatility Targeting"* (June 2012)
- *"Extending Volatility Targeting"* (September 2013)
- ARM on Volatility Targeting Momentum (December 2015); pages 3-7

Aggregate volatility and the cross-section of stock returns

On the other hand, we look at recent academic advances on whether the sensitivity of stocks on changes in aggregate volatility is priced in the cross-section of stock returns. Put differently, the hypothesis is that stocks that exhibit a negative exposure to changes in market volatility (and therefore suffer a loss when market volatility rises, which, in turn, happens when the market is falling) should be compensated by a risk premium; but are they really? The latest academic findings say no (in contrast to earlier evidence).

Figure 1: Papers on various aspects of volatility

"Volatility Managed Portfolios" *Alan Moreira and Tyler Muir*	*Journal of Finance, forthcoming* SSRN working paper, October 2016
"Managing the risk of the 'Betting-Against-Beta' anomaly: Does it pay to Bet Against Beta?" *Pedro Barroso and Paulo Maio*	SSRN working paper, November 2016
"Is Aggregate Volatility a Priced Risk Factor?" *Stanley Peterburgsky*	SSRN working paper, September 2016

Source: UBS.

Paper #1: "Volatility Managed Portfolios"

by Alan Moreira and Tyler Muir

and

Paper #2: "Managing the risk of the 'Betting-Against-Beta' anomaly: Does it pay to Bet Against Beta?"

by Pedro Barroso and Paulo Maio

Volatility-targeting and momentum investing

One of the most successful mechanisms to improve the performance of equity cross-sectional momentum (long past winners, short past losers) is volatility-targeting, which works by avoiding the so called "*momentum crashes*".[1] Barroso and Santa-Clara (2015) and Daniel and Moskowitz (2016) are the typical academic references on the topic, and we reviewed both in our July 2013 ARM.

Extending the analysis to the cross-section of equity factor premia

The two new papers that we review in this issue of the ARM (Paper #1 by Alan Moreira and Tyler Muir, and Paper #2 by Pedro Barroso and Paulo Maio) aim to broaden the application of volatility-targeting across the entire cross-section of equity factors, and to investigate the conditions under which this risk management technique can improve the performance of the raw factors. Given the similarity in the methodology and the reported results, we provide a review of both papers.

The papers conduct their analysis for a number of factors. The common factors for the two papers are[2]: Market (RMRF), Size (SMB), Value (HML), Momentum (MOM), Profitability (RMW) and Investment (CMA); factor data are obtained from Kenneth French's website[3]. Additionally, the first paper looks at the Investment (I/A) and Return-on-Equity (ROE) factors of Hou, Xue and Zhang (2015) as well as at an FX carry factor (the only non-equity factor studied in both papers). Instead, the second paper considers the Betting-against-Beta (BAB) factor[4], using data from AQR's library[5]. Figure 2 reports the sample periods per factor and per paper.

Figure 2: Sample periods of analysis

Factor	Paper #1	Paper #2
RMRF	1926 – 2015	1963 – 2015
SMB	1926 – 2015	1963 – 2015
HML	1926 – 2015	1963 – 2015
MOM	1926 – 2015	1963 – 2015
RMW	1963 – 2015	1963 – 2015
CMA	1963 – 2015	1963 – 2015
BAB		1963 – 2015
I/A	1963 – 2015	
ROE	1963 – 2015	
FX Carry	1983 – 2015	

Source: UBS Quantitative Research. The sample periods for the various factors as reported in "*Volatility Managed Portfolios*" by A. Moreira & T. Muir (Paper #1), and "*Managing the Risk of the 'Betting-Against-Beta' Anomaly: Does It Pay to Bet Against Beta?*" by P. Barroso & P. Maio (Paper #2).

The general principle of volatility-targeting is to adjust the exposure to a long-short factor on a dynamic basis using a conditional forecast of future volatility, $\hat{\sigma}_t$:

$$r_{t+1}^{managed} = \frac{c}{(\hat{\sigma}_t)^k} \cdot r_{t+1}$$

There are two scalars in the above expression, namely k and c. The first (k) allows for different powers of conditional volatility to be used for the volatility-managed form of the factor (for more on this topic see *"Beyond Volatility Targeting"*, 18 June 2012). The most usual values are $k = 1$, in which case the conditional volatility is used (this is what is used in Paper #2), or $k = 2$, in which case the conditional variance is used to manage the exposure to the factor (this is what is used in Paper #1). The second scalar (c) is used in order to adjust the volatility of the volatility-managed strategy. When $k = 1$, then c is trivially interpreted as the *target volatility* for the volatility-managed strategy; the authors of Paper #2 (where

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[1] We have extensively published on volatility-targeting (also referred to a volatility-timing, constant-volatility, risk-control); see *"Understanding Volatility-Targeting"* (4 October 2011), *"Beyond Volatility Targeting"* (18 June 2012), *"Extending Volatility Targeting"* (3 Sept. 2013).
[2] These are the five factors from Fama and French (2016) – see our review of this paper in our February 2014 ARM – and the momentum factor of Carhart (1997).
[3] See: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[4] Paper #1 contains a very short analysis on the BAB factor for the period 1963-2015, with the findings being in line with those of Paper #2.
[5] See: https://www.aqr.com/library

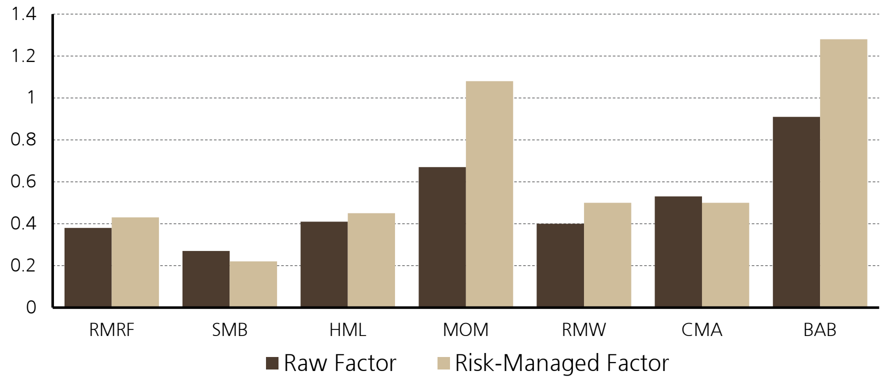
$k = 1$ is used), choose $c = 12\%$, i.e. they target an ex-ante annualised volatility of 12% for all the factors that they study. However, when $k \neq 1$, then the scalar c cannot be directly interpreted as a form of target risk. For this reason, the authors of Paper #1 (where $k = 2$ is used) pick the value of c ex-post in a way so that the unscaled and volatility-managed factors both have the same ex-post volatility.

Regarding the conditional forecast of future volatility, $\hat{\sigma}_t$, both papers use the realised volatility over the most recent month (estimated using daily intra-month returns) as a proxy. Their findings are generally robust to a number of alternatives.[6]

The winners of volatility-targeting: Momentum and Betting-against-Beta

The authors of the two papers apply their respective volatility-management framework to their respective factor universe and generally report similar results. Figure 3 reports the Sharpe ratio before and after applying the volatility-targeting mechanism from Paper #2. The evidence shows that volatility-targeting generally improves the performance of the raw factors except for size (SMB) and investment (CMA). However, it is visually obvious that the benefit of volatility-targeting is much stronger for the momentum and BAB factors.

Figure 3: Change in Sharpe ratio due to volatility-targeting



Source: *"Managing the Risk of the 'Betting-Against-Beta' Anomaly: Does It Pay to Bet Against Beta?"* by P. Barroso & P. Maio; the figure is constructed using data reported in Tables 1 and 3; reproduced with permission. The figure presents the Sharpe ratio of raw (buy and hold) long-short factors and of their risk-managed form using volatility-targeting. Sample period: January 1964 to December 2015.

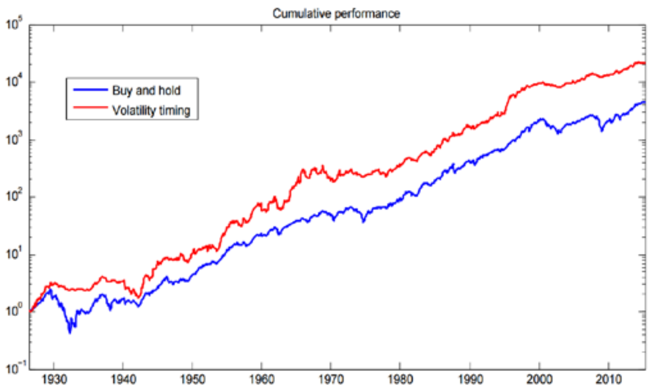
In the majority of cases, the risk-managed factors outperform the respective raw factors

The authors of Paper #1 do not report Sharpe ratios before and after applying their risk-management methodology, but instead look at the statistical significance of the alphas of the volatility-managed factors when regressed against the respective raw factor (as a reminder, both the raw and the volatility-managed form of the factor are scaled using the parameter c to have the same unconditional volatility). In line with the above results, the authors document statistically strong alphas for all factors (including the factors unique to their analysis, namely I/A, ROE, and FX Carry), except –as in Paper #2– for SMB and CMA. The largest (both in magnitude and statistical significance) alphas are documented for momentum, ROE and the market[7] itself. As ROE is generally related to Low-Risk[8], this finding is in line with the BAB result of Paper #2.

[6] The authors of Paper #1 alternatively use conditional variance forecasts using an AR(1) model; the authors of Paper #2 alternatively use six-month realised volatility estimates as well as conditional variance forecasts using a GARCH (1,1) model.
[7] The reason why the authors of Paper #2 fail to document a similarly strong performance improvement for the overall market (see Figure 3) is most probably due to their sample period (1963-2015). As shown in Figure 4, the largest performance benefit for the market is roughly accumulated in the years between early 1940's and mid 1960's.
[8] For more information on this, see our Monograph *"Investing in Quality"* (14 April 2014).

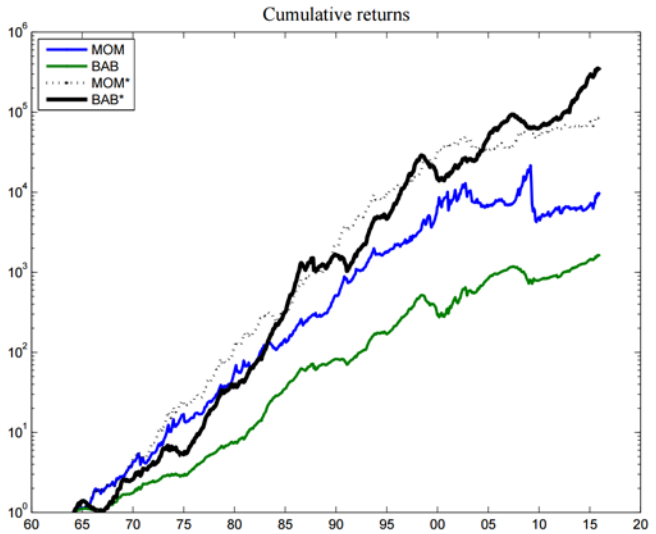
Figures 4 and 5 below present the performance of the market (from Paper #1) and of the momentum and the BAB factors (from Paper #2) before and after applying the volatility-management methodology. The outperformance of the volatility-managed strategies is obvious and consistent across time.

Figure 4: Volatility-managing the Market



Source: "*Volatility Managed Portfolios*" by A. Moreira & T. Muir; part of Figure 3, reproduced with permission. The figure presents the cumulative returns of the market, before and after applying a volatility-timing mechanism. Both strategies have been scaled so to have the same unconditional monthly volatility. Sample period: January 1926 to December 2015.

Figure 5: Volatility-managing the BAB and MOM factors



Source: "*Managing the Risk of the 'Betting-Against-Beta' Anomaly: Does It Pay to Bet Against Beta?*" by P. Barroso & P. Maio; Figure 1, reproduced with permission. The figure presents the cumulative gross returns of the MOM and BAB factors, before and after applying a volatility-targeting mechanism (MOM* and BAB*). Sample period: January 1964 to December 2015.

What drives the performance improvement?

In order to investigate the reasons why volatility-targeting improves the performance of the large majority of factors the authors of both papers conduct a volatility regime based analysis. In particular, they split the respective sample period of each factor across five buckets based on the realised volatility of the factor and report the average return, volatility and return-risk ratio of the raw factor over the subsequent month. Paper #1 presents results for the overall market, whereas Paper #2 focuses on momentum and BAB factors. Figures 6 and 7 present the respective results. The evidence is generally summarised in the following points:

a) Volatility is very persistent

- Factor volatility is largely persistent. Current volatility is tightly related to past volatility; in fact, there is a monotonic relationship between them. High volatility months are followed by more high volatility and low volatility months are followed by more low volatility. Importantly enough, the authors of the second paper, who focus primarily on the momentum and BAB factors, additionally show that if factor volatility is decomposed into a market risk and a specific risk component, then it is the latter that drives these results.

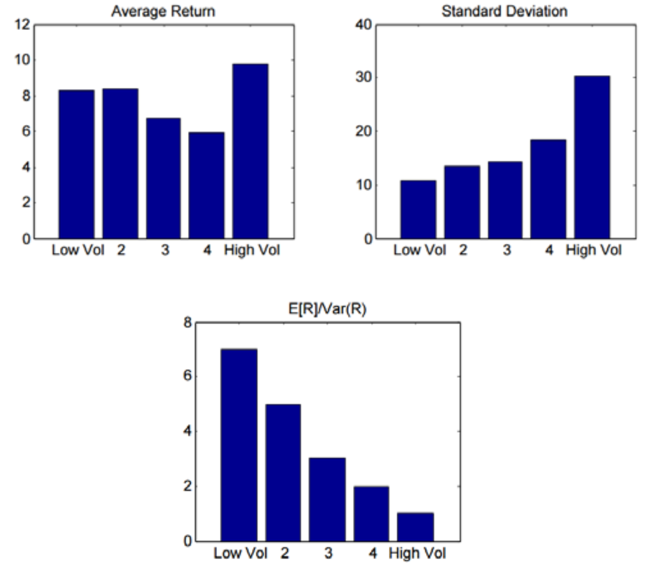
b) There is no significant risk-return trade-off on a monthly horizon

- There is a very weak (if not completely absent) risk-return trade-off, as lagged volatility does not have any significant impact on current return for either the market or the momentum and BAB factors. If anything, there is weak evidence that low volatility months are followed by slightly higher average returns. This evidence constitutes a significant challenge for general equilibrium models, where risk premia should rise when volatility is high.

➔ Volatility-targeting improves risk-adjusted returns

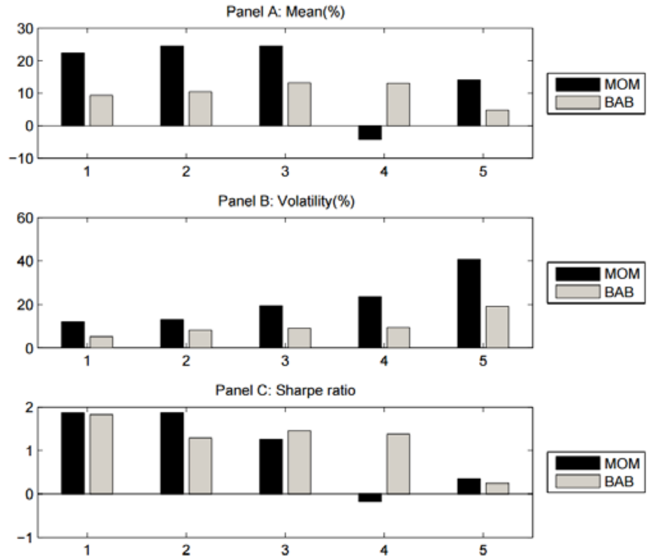
- Taking the above points together, the return-risk ratio (Paper #1 reports return over variance for the market –see Figure 6 below–, Paper #2 reports return-over-volatility for the momentum and BAB factors – see Figure 7 below) exhibits almost a monotonic behaviour with higher ratios observed after low factor volatility periods, whereas periods of higher factor volatility are typically associated to low future risk-adjusted performance.

Figure 6: Conditional performance of the Market



Source: "*Volatility Managed Portfolios*" by A. Moreira & T. Muir; part of Figure 1, reproduced with permission. The figure presents the average subsequent return, volatility and return/variance ratio for the market across five regimes determined by ranking all months of the sample period based on the realised volatility of the market. Sample period: January 1926 to December 2015.

Figure 7: Conditional performance of BAB and MOM



Source: "*Managing the Risk of the 'Betting-Against-Beta' Anomaly: Does It Pay to Bet Against Beta?*" by P. Barroso & P. Maio; Figure 3, reproduced with permission. The figure presents the average subsequent return, volatility and Sharpe ratio for the MOM and BAB factors, across five regimes determined by ranking all months of the sample period based on the realised volatility of the respective factor. Sample period: January 1964 to December 2015.

Spikes in volatility are not offset by proportional increases in expected returns

Put differently, the fact that high market/factor volatility periods are not compensated by higher subsequent market/factor returns, renders volatility-targeting a successful risk management mechanism for the overall market as well as for the momentum and the BAB factors (and most likely for the larger majority of the equity factors as already shown in Figure 3, albeit to a smaller degree).

Broadly speaking, all volatility-managed factors exhibit betas against the respective raw factor with values less than one. This is because they tend to reduce their exposure to the underlying factor when this becomes more volatile. In Paper #1 all betas of the volatility-managed factors range between 0.47 and 0.71. Additionally, it is shown that these betas fall even more during NBER recession periods; this is because factor volatilities tend to co-move with market volatility, hence causing further beta reduction when there are market-wide systemic shocks.

The authors of the first paper offer a number of additional analyses to support their findings. They show that their results survive conservative transaction costs, leverage constraints (that place a cap on the maximum allocation on the factor when volatility is low) and less frequent (than monthly) rebalancing. They also find that the results hold for portfolios of equity factors (and not just for single factors, as shown so far) as well as across a universe of 20 OECD stock market indices.

Theoretical dependence of outperformance of volatility-managed factors on the factor price of risk:

$$\alpha_{managed} \propto -cov\left(\frac{\mu_t}{\sigma_t^2}, \sigma_t^2\right)$$

As our final point, it is worth highlighting that Paper #1 contains a very interesting theoretical section at the end of the paper in an effort to explain the empirical benefits of volatility-targeting. Reviewing it is out of the scope of the ARM, but it is worth reporting one of the main findings. The authors show that the alpha of a volatility-managed factor (against the respective unscaled factor) is negatively related to the covariance between the factor return-risk trade-off (i.e. the factor price of risk, $\frac{\mu_t}{\sigma_t^2}$) and the factor variance (see the equation on your right). The empirically negative relationship between the factor return-variance trade-off and the factor variance (as shown in Figures 6 and 7) is therefore reflected as positive alpha for the volatility-managed factors (against their raw counterparties).

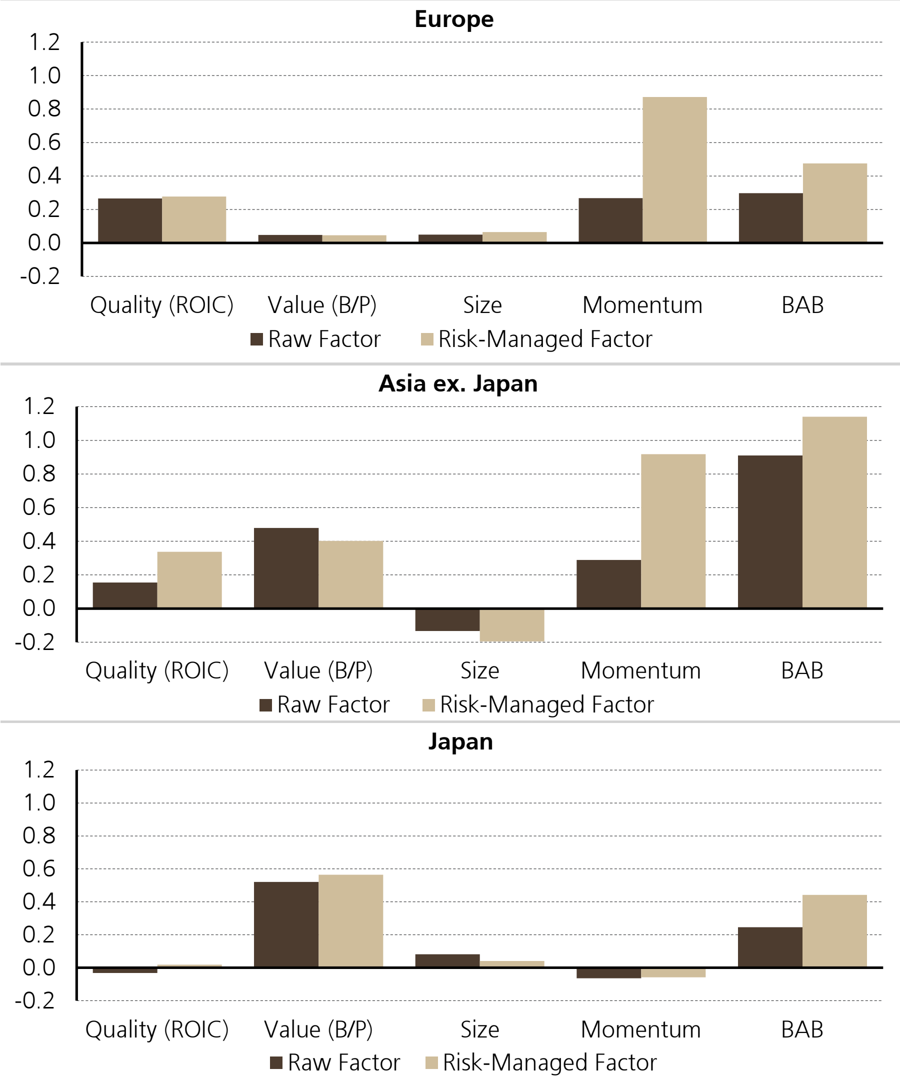
Extending the analysis to other regions

Do the results hold outside the US?

As we normally do in our ARM publications, we have replicated the methodology across three regions (Europe, Asia ex. Japan and Japan) and investigate whether volatility-managed factors outperform their raw counterparties on a risk-adjusted basis. The results are presented in Figure 8 below. The factors are constructed on a long-short basis as the spread return between the top and bottom thirds of the cross-section based on a number of ranking criteria: ROIC for Quality, Book-to-Price for Value, market capitalisation for Size, past 12-month return (excluding the most recent month) for Momentum and past 60-month beta for BAB. The BAB factors are additionally adjusted so as to achieve an ex-ante zero beta (using the betas of the long and the short side over the past month). Finally, the volatility of the factors (used for volatility-targeting) is estimated using the daily returns over the most recent month.

Our results are generally in line with the findings of the two papers that we reviewed in the previous pages. Importantly enough, the momentum and BAB factors are the strongest winners of volatility-targeting.

Figure 8: Sharpe ratio improvement due to volatility-targeting across regions



Source: UBS Quantitative Research. The figure presents the Sharpe ratio of raw (buy and hold) long-short factors and of their risk-managed form using volatility-targeting across three regions: Europe, Asia ex. Japan and Japan. The long-short factors are rebalanced on a monthly basis and represent the spread between top and bottom thirds of the universe. Sample period: March 1992 (March 1997 for BAB) to December 2016.

"Is aggregate volatility a priced risk factor?"

by Stanley Peterburgsky

This short paper is very much in the style of our work in the Academic Research Monitor – it takes an existing paper and asks whether the results hold out of sample. The result in this case appears to be "No".

Are the changes in aggregate volatility priced in the cross-section of stock returns?

In a 2006 paper, *"The Cross Section of Volatility and Expected Returns"* (Ang *et al.*), the authors find a relationship between a stock's sensitivity to changes in (market) volatility and future returns over the period 1986-2000. The approach is a simple one. Each month, they run the following regression on daily stock returns for each stock (the universe is of course the usual CRSP data with some filters):

$$R_t - R_{f,t} = \alpha + \beta \cdot \left(R_{M,t} - R_{f,t}\right) + d \cdot \Delta VIX_t + \varepsilon_t$$

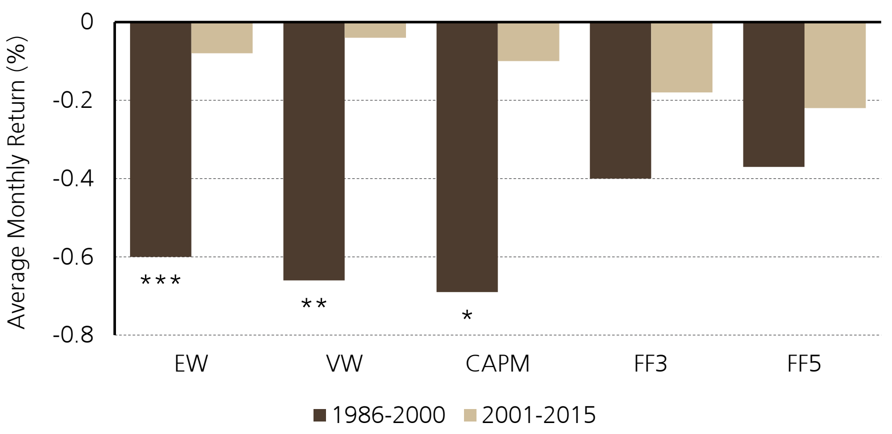
… yes over the period 1986-2000

where R_t is the daily return on the stock, $R_{f,t}$ is the daily risk free rate, $R_{M,t}$ is the market return and ΔVIX_t is the daily change in the VIX index. Then, they create portfolios of stocks by ranking on the d coefficient, which captures the sensitivity of the stocks to changes in implied market volatility. They find that stocks with low sensitivities to changes in the VIX in one month have high returns in the subsequent months. This seems reasonable – if volatility rises, then it is likely that the market has fallen. Stocks with a high d coefficient will fall by less than their beta would suggest, i.e. they act as a hedge, and hence people would be willing to accept a lower return on these names for this hedging property.

… but not over 2001-2015

The problem comes when the author of the current paper extends the analysis to the period 2001-2015. In this period, the returns to the five quintile portfolios are essentially identical. Figure 9 presents the return differential between the top (low d) and the bottom (high d) quintiles across 1986-2000 and 2001-2015 for equally-weighted (EW) portfolios, value-weighted (VW) portfolios, and their CAPM, Fama and French (1993) 3-factor and Fama and French (2016) 5-factor alphas.

Figure 9: Top versus bottom quintiles sorted by exposure to changes in VIX



Source: *"Is aggregate volatility a priced risk factor?"* by S. Peterburgsky; figure created using data from Table 2 of the paper. The Figure presents the average monthly return differential between the top (low d) and the bottom (high d) quintiles across 1986-2000 and 2001-2015 for equally-weighted (EW) portfolios, value-weighted (VW) portfolios, and their CAPM, Fama and French (1993) 3-factor and Fama and French (2016) 5-factor alphas. Statistical significance at 1%, 5% and 10% levels is denoted by ***, ** and * based on Newey and West (1987) standard errors.

Across the spectrum of specifications a similar pattern holds – significant returns or alphas in the first period; none in the second.

The author goes on to reproduce another result from Ang *et al.* (2006), which is running Fama and MacBeth (1973) regressions to estimate the price of aggregate volatility risk. Consistent with the earlier results, in the first period the price is significantly negative; in the second, it is negative but with a very low t-statistic. So again the out-of-sample results don't hold.

The author finally asks the question as to whether the results from the 1986-2000 period *"held based on rational expectations or due to mispricing"*. He doesn't, sadly, answer the question.

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