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The Sensitivity of Low Vol Strategies to Interest Rates: Myth or Reality?

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- **Low vol equity strategies have experienced rapid growth over the past decade, attracting substantial assets under management globally, as a result of their performance during periods of market stress.**
- **Some investors have attributed the outperformance of low vol strategies to the benign interest rate environment over the past two decades and, thus, are concerned that a sharp change in the rates environment may have a negative effect on performance.**
- **We investigate whether interest rate exposure explains the low vol anomaly and find that despite their bond-like characteristics, low vol portfolios display little sensitivity to interest rates after the co-movements between low vol returns and standard equity factors are taken into account.**
- **In addition, when an investor already has an allocation towards investment and profitability factors, a long-only low vol strategy adds, on average, little diversification benefits.**
- **This is because the performance of low vol portfolios is driven by exposure to large, conservative and profitable companies, whereas high vol portfolios have exposure to small, unprofitable and growth companies. Once those are controlled for, the risk-adjusted alpha of a long-only low vol portfolio is no longer significant, and the alpha of a long-short low vol portfolio shrinks by half.**

Introduction

There is pervasive empirical evidence that investing in low risk stocks produces superior compound rates of return. Accordingly, low volatility equity investing has attracted increasing and significant assets under management globally. For instance, the seven largest low vol ETFs had about $82bn of assets under management (AUM) in February 2020, compared with $14bn only a few years ago, in December 2014.[1] The remarkable performance of low vol strategies during severe bear markets, including the 2007-8 financial crisis, helped boost their popularity.

Standard finance theory argues that investors bearing more *ex-ante* risk earn higher expected returns. For instance, the capital asset pricing model (CAPM) predicts that the relation between beta and return is linearly positive. Almost 50 years ago, Black (1972) challenged this conventional view and documented a disconnect between the theory and the empirical evidence. Haugen and Baker (1991) provided early evidence that low volatility stocks have higher risk-adjusted returns than portfolios with high volatility stocks, so strategies that overweight low beta stocks and underweight high beta stocks earned positive CAPM alphas. Over 1963-2019, low volatility and low beta portfolios have outperformed high beta and high volatility stocks, featuring higher returns, lower volatility and less severe drawdowns. This observation is often called the "low volatility" anomaly. The phenomenon is present not only in the US stock market, but also in international equity markets (see, eg, Blitz and van Vliet, 2007; Ang, Hodrick, Xing, and Zhang, 2009; Blitz, Pang and van Vliet, 2013).[2]

This paper contributes to the literature on low vol in equities along two dimensions. First, we investigate the interest rate risk of low vol strategies, given their bond-like characteristics. Second, we examine to what extent their performance can be explained by known drivers of cross-sectional variation in returns. We find that the correlation between portfolio returns and rate changes is time-varying, switching sign from negative to positive in the early 2000s. However, once the co-movements between low vol returns and the Fama-French five factors are taken into account, little, if any, sensitivity to interest rate risk remains.

We then provide a more systematic analysis of the risk exposures of the low vol portfolios by using standard equity risk factors. The performance of low vol portfolios is driven by exposure to large, conservative and profitable companies, whereas high vol portfolios have exposure to small, unprofitable and growth companies. Once those are controlled for, the risk-adjusted alpha of a low vol portfolio is no longer significant, and the alpha of a long-short low vol portfolio shrinks by half, though still remains significantly different from zero.

The following section looks at the performance of low vol portfolios. Then, we investigate the interest rate exposure of low vol strategies. Finally, we examine the drivers of low vol portfolio risk-adjusted returns.

Low Vol Portfolios Outperform High Vol Portfolios

The Performance of Low Vol Portfolios

Low volatility equity investing comes in many forms, such as low beta (Haugen and Baker, 1991), minimum variance portfolios (Clarke et al., 2006 and 2010), and betting against beta

[1] The top seven ETFs have the following Bloomberg tickers: USMV, SPLV, XMLV, XSLV, EFAV, EEMV and ACWV. The AUM of low vol mutual funds is potentially much larger than $82bn. Furthermore, other investors, such as pension funds and insurance companies, may implement low vol investment strategies in their portfolio managed in-house or through investment vehicles other than mutual funds and ETFs.

[2] The low vol anomaly is observed in other asset classes besides equities. For instance, Frazzini and Pedersen (2014) document beta anomalies for US Treasuries and US corporate bonds (sorted by maturity or rating). In contrast, Ng and Phelps (*2014*) find little evidence supporting the existence of a low-risk anomaly in corporate bonds.

(Frazzini and Pedersen, 2014). Most implementations share, however, similar characteristics and consist in forming a long-short portfolio that goes long stocks in the bottom low-risk decile and short stocks in the top high-risk decile. In this study, the low vol portfolios are constructed by ranking equities based on their idiosyncratic stock return variance (Ang et al., 2006, for additional details). The sorting variable is the variance of the residuals (*RVar*) and is defined as the variance of the regression residual of the daily Fama and French (1993) three-factor model, using 60 days (minimum 20) of lagged returns. Stocks are re-ranked at the beginning of each month on the basis of their estimated idiosyncratic volatility at the end of the previous month. These are then assigned to one of ten decile portfolios, and the constituents are value-weighted in each decile. The 10 low vol portfolio returns are available from Professor Ken French's data library. As a robustness check, we also consider three alternative construction methods of low vol portfolios. First, the portfolios are formed on univariate market beta (*Beta*) at the end of each June, where the estimated beta is based on the preceding five years (two minimum) of monthly returns. Second, the portfolios are formed monthly on the variance of daily returns (*Var*), estimated using 60 days (minimum 20) of lagged returns. Third, the Betting-Against-Beta method (*BAB*) introduced by Frazzini and Pedersen (2014) takes a leveraged long position in low-beta stocks and a deleveraged short position in high-beta stocks. Thus, by construction, BAB portfolios are roughly market neutral.

We focus on value-weighted returns instead of equally weighted returns because this ensures that the equity strategy is implementable and has a large capacity. As noted by Fama and French (2008), equally weighted portfolios comprise mostly microcaps (defined as stocks with market capitalization below the 20th percentile of the NYSE). These small stocks account roughly for 60% of the number of companies listed on NYSE, NASDAQ and AMEX, but represent only 3% of the total market capitalization. An implication is that equally weighted strategies disproportionally load on these stocks, which are expensive to trade and relatively illiquid.

Figure 1 provides several performance statistics of the market portfolio (first column) and the ten low vol portfolios, where D1 corresponds to the low vol portfolio and D10 to the high vol portfolio for the sample period July 1963-November 2019.[3] All portfolios display similar average returns of about 0.9% per month, except for the high vol portfolio, which has an average return of 0.36%. In other words, most of the low volatility anomaly is related to the poor performance of high volatility stocks, rather than the outperformance of low volatility stocks. Overall, our results confirm previous evidence that there is no clear relation between *ex-ante* volatility and average returns and corroborate the poor absolute performance of the most volatile portfolio. In contrast, the volatility increases monotonically from 3.5% (per month) for D1 to 8.4% for D10. Hence, low vol portfolios have bond-like characteristics, whereas high vol portfolios have more nonlinear option-like payoffs, characterized by extreme returns ranging between -33% and 33% per month. Compared with other well-known anomalies, such as size or value, cross-sectional differences in risk-adjusted performance for low vol portfolios are driven mostly by differences in risk, rather than by differences in expected returns. Of note, the Sharpe ratio of the low vol portfolio is 0.56 (annualized), higher than that of the overall market (based on the CRSP universe) of 0.43. Measures of downside risk, such as minimum monthly return and maximum drawdown, are also monotone. For instance, the maximum drawdown for the low vol portfolio is 44%, whereas that for the high vol portfolio is about 95%.

[3] We follow the extant literature (see, eg, Baker, Bradley and Wurgler, 2011) in starting our sample in the early 1960s, a common start date for studying low vol strategies. Whereas we could extend the sample further backward in time for constructing low vol portfolios, this would preclude the use of the Fama and French (2015) profitability and investment factors in the asset pricing tests, as those factors are only available after June 1963.

FIGURE 1

Performance of Low Vol Portfolios

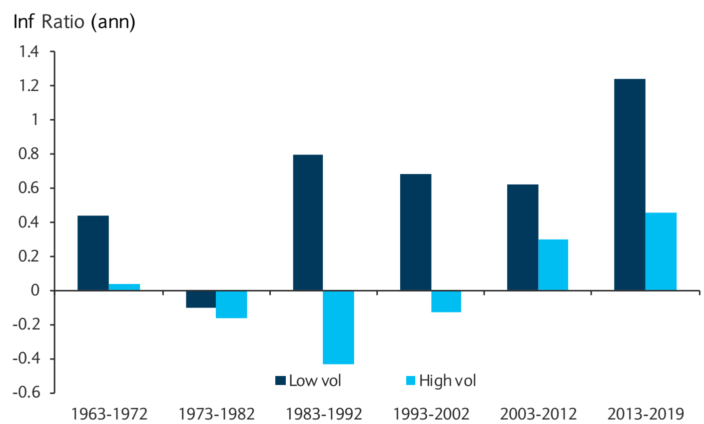
	Market	D1 Low Vol	D2	D3	D4	D5	D6	D7	D8	D9	D10 High Vol
Avg Ret (%/m)	0.92	0.95	0.99	0.92	1.03	1.03	1.19	1.01	1.18	0.94	0.34
Std Dev (%/m)	4.37	3.54	4.07	4.39	4.73	5.00	5.45	5.88	6.51	7.31	8.40
Sharpe Ratio (ann.)	0.43	0.56	0.52	0.43	0.48	0.45	0.52	0.37	0.43	0.27	-0.02
Min (%/m)	-22.64	-14.32	-20.93	-20.36	-24.51	-24.70	-26.90	-29.73	-30.27	-31.42	-32.67
Max (%/m)	16.61	13.91	17.81	17.88	20.70	16.40	21.98	21.19	30.89	31.19	33.03
Skewness	-0.52	-0.24	-0.32	-0.41	-0.31	-0.37	-0.34	-0.39	-0.29	-0.29	-0.15
Max Drawdown (%)	-50.39	-43.65	-41.35	-47.30	-56.44	-59.77	-56.14	-60.63	-68.53	-80.07	-94.62

Note: The sample period is July 1963-November 2019. The table reports the summary statistics of the performance of the overall market (based on the CRSP universe) and ten (decile) low vol portfolios. The volatility decile portfolios are formed on univariate sorting based on idiosyncratic variance. Portfolios are rebalanced monthly and ignore transaction costs, and returns are value-weighted. Source: Ken French data library, Barclays Research

So far, we have looked only at summary statistics. Figure 2 provides additional information about the time series properties of the performance by displaying the annualized information ratio for every ten-year period starting in July 1963 of the low vol (dark blue bars) and high vol (light blue bar) portfolios. We find that the low vol portfolio has an information ratio that is always higher than that of the high vol portfolio. Hence, the low vol portfolio offers a better risk-return profile than the high vol portfolio not only on average, but also in all sub-periods.

FIGURE 2

Information Ratio over Time



Note: The sample period is July 1963-November 2019, bracketed in 10-year periods. The figure displays the annualized information ratio for the low vol and high vol portfolios. The low volatility portfolio is formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value-weighted and ignore transaction costs. Returns and volatilities are annualized by multiplying them respectively by 12 and $\sqrt{12}$. The information ratio is the ratio between excess returns and volatility. Source: Ken French data library, Barclays Research

Explanations of the Low Vol Anomaly

Researchers and investors alike have offered several explanations for the low-risk anomaly (Blitz et al., 2014), though the underlying reasons can be broadly grouped in two camps: risk versus behavior. According to the risk-based explanation, the low-risk anomaly is not an anomaly, rather it is a reflection of omitted risk factors, as either beta or volatility are inadequate measures of risk. An alternative explanation is that the anomaly is the by-product of institutional or regulatory constraints, such as for leverage or shorting.[4] Other

[4] The intuition is as follows. When borrowing constraints prevent leverage, investors looking to increase their return have to tilt their portfolios towards high-beta stocks to harvest more of the equity risk premium. The additional demand for high-beta securities tends to increase their prices and, thus, to reduce their expected returns. In contrast, the decline in demand for low-beta stocks tends to reduce their prices and, thus, to increase their expected returns.

explanations, loosely placed in the behavioral camp, relax the assumption that investors care only about the mean and variance of returns. In particular, they might be overconfident about their stock picking skills, and this bias tends to create an excess demand for high-volatility securities where the rewards to security selection are larger than average. Asness et al. (2020) posits that leverage aversion is a big driver of the tendency of low-risk assets to perform better than those that are high-risk. Alternatively, investors might prefer positive skewness (ie, so-called lottery stocks) and end up overpaying for this (Bali et al., 2017). A related explanation is that mutual fund managers have strong incentives to overweight high-beta stocks due to their option-like payoffs (Karceski, 2002).

The Interest Rate Risk of Low Vol Portfolios

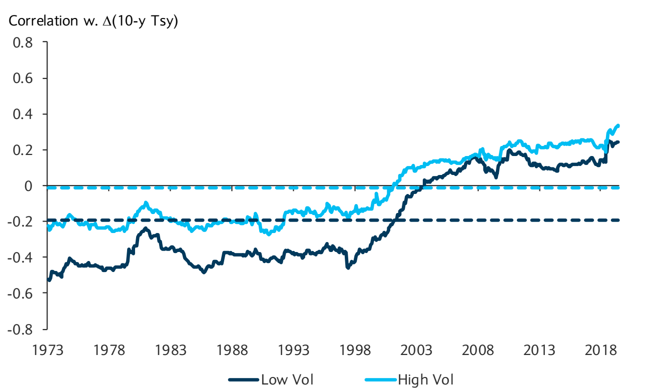
The Correlation between Low Vol Portfolio Returns and Changes in Interest Rates

Given the risk-return profile of low vol strategies, investors might consider those portfolios as good substitutes for bonds. One implication is that, similar to bonds, they may be sensitive to changes in interest rates. To assess empirically the interest rate exposure of such portfolios, we proceed in two steps. First, we look at the univariate relationship between low vol portfolio returns and interest rate changes. We consider both a parametric (assuming a linear relationship) and a non-parametric approach. Second, we look at the relationship between equity returns and interest rates after controlling for equity risk factors, such as the Fama-French three- or five-factor model. We find that after controlling for Fama-French five factors, the sensitivity of low vol portfolio returns to interest rate changes becomes about one-fifth the value of the coefficient in a simple regression.

Several important conclusions can be drawn from Figure 3, which displays the 10-year rolling correlation between portfolio returns and monthly changes in the 10y Treasury rate. Low vol portfolio returns are, on average, negatively correlated to interest rates with a value of about -20% for the sample 1963-2019. The correlation has varied considerably over time, ranging from a trough of -50% in 1973 to a peak of 33% at the end of the sample. The correlation between high vol portfolio returns and interest rate changes is, on average, zero.

FIGURE 3

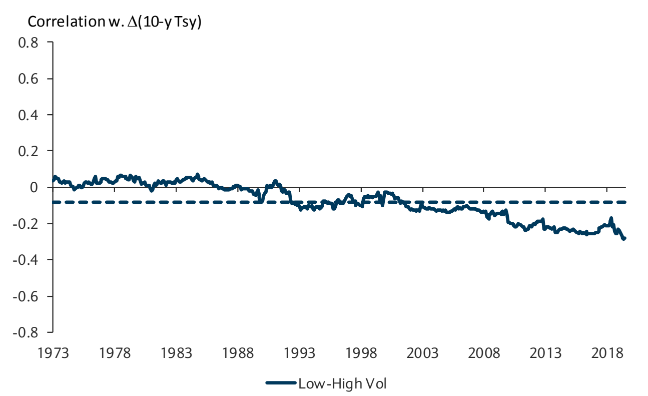
Correlation between Low or High Vol Portfolio Returns and Changes in the 10y Treasury Rate



Note: The sample period is July 1963-November 2019. The figure displays the rolling correlation between the low or high vol portfolio returns and monthly changes in the 10y Treasury rate. The rolling window is 10 years. Low and high vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. The dashed lines are the full-sample average correlations. Source: FRED, Ken French data library, Barclays Research

FIGURE 4

Correlation between Low-High Vol Portfolio Returns and Changes in the 10y Treasury Rate



Note: The sample period is July 1963-November 2019. The figure displays the rolling correlation between the low minus high vol portfolio returns and monthly changes in the 10y Treasury rate. The rolling window is 10 years. Low and high vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. The dashed line is the full-sample average correlation. Source: FRED, Ken French data library, Barclays Research

However, it also varies over time, ranging from -30% to 30%. Hence, different conclusions about the sensitivity of equity returns to interest rates can be drawn depending on the sample period.

Figure 4 plots the correlation between low minus high vol portfolio returns and changes in the 10y Treasury rate. On average, it is about -10% and ranges from about -30% to 10%. The time variation of the long-short low vol portfolio is smaller than either the low or high vol portfolio, suggesting that the top and bottom deciles hedge their interest rate exposure.

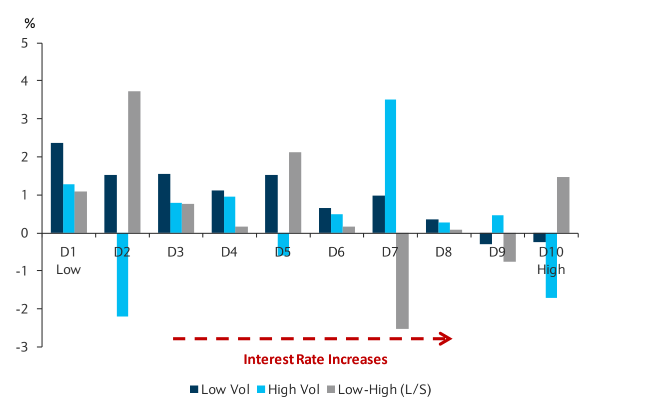
Correlation is appropriate when the relationship between portfolio returns and changes in the 10y Treasury rate is linear. In other words, the same relationship holds both for small and large changes in interest rates. We investigate this by using a non-parametric approach that does not require making any linearity assumption. Figure 5 shows the performance of low vol (dark blue), high vol (light blue) and low minus high vol (gray) portfolios broken into deciles based on 10y Treasury rate monthly changes for the sample 1963-2019. The first decile, "D1 Low," corresponds to the largest declines in interest rates, and the tenth, "D10 High," corresponds to the largest increases in interest rates, irrespective of the year in which the interest rate change occurred. The average returns for the low vol portfolio decline roughly monotonically with increases in interest rates. In contrast, the performance of the high vol portfolio does not seem to be related to changes in interest rates. As a consequence, the low minus high portfolio does not display a monotone relationship with interest rate changes.

To shed further light on the interest rate sensitivity of the low vol portfolios, Figure 6 splits the full sample into two non-overlapping subsamples: 1963-1999 (dark blue) and 2000-2019 (light blue). In the early period, the performance of low vol portfolios decreases as interest rate increases. For instance, the average return is 3.7% for the first decile and -0.4% for the tenth. However, the performance of low vol portfolios becomes positively related to interest rate changes in the post-2000 sample.

We also examine the performance of portfolio returns for every 10-year period. Within each, we look at the performance of low vol (D1 in Figure 7) and high vol (D10 in Figure 8) portfolios separately for months featuring interest rate decreases (dark blue bars) or

FIGURE 5

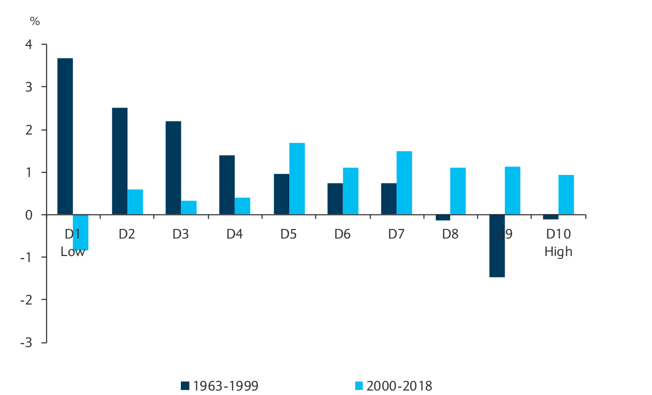
Low and High Vol Portfolio Returns by 10y Treasury Rate Changes Deciles



Note: The sample period is July 1963-November 2019. The figure displays the average monthly returns of the low, high, and low-high vol portfolios for ten deciles based on monthly changes in the 10y Treasury rate. The volatility portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. Source: FRED, Ken French data library, Barclays Research

FIGURE 6

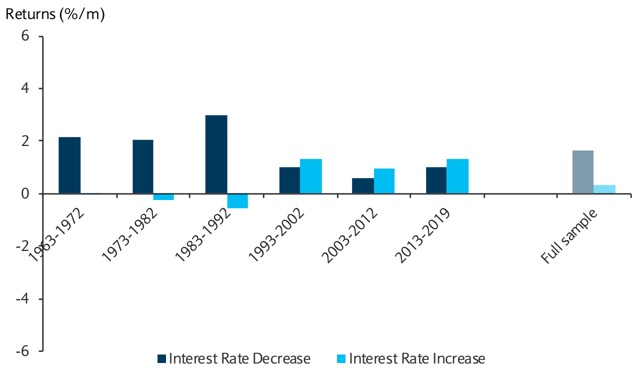
Low Vol Portfolio Returns by 10y Treasury Rate Changes Deciles in Subsamples



Note: The sample periods are July 1963-1999 (dark blue) and January 2000-2019 (light blue). The figure displays the average monthly returns of the low vol portfolios for ten deciles based on monthly changes in the 10y Treasury rate. The volatility portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. Source: FRED, Ken French data library, Barclays Research increases (light blue bars). Figure 7 shows that in the early period, the low vol portfolio produced higher returns when interest rates decreased. However, in the post-2000 period, the average returns were higher when interest rates increased. Figure 8 examines the average returns of high vol (D10) portfolios in periods of interest rate increases or decreases. In line with the findings of Figure 5, there is no clear relationship.

FIGURE 7

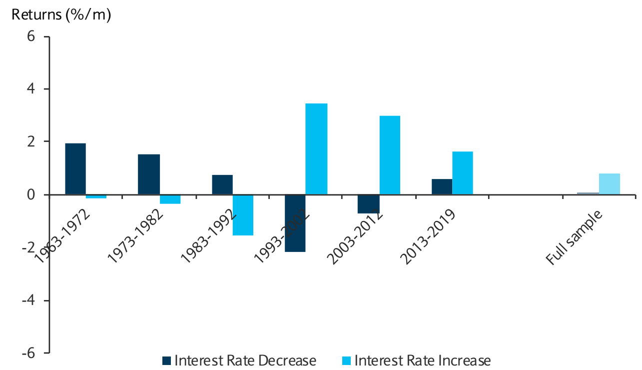
Low Vol Portfolio Returns by Interest Rate Increases and Declines



Note: The sample period is July 1963-November 2019, bracketed in 10-year periods. The figure displays the average monthly returns of the low vol portfolios for 10y Treasury rate increases and declines. The low volatility portfolio is formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. Source: FRED, Ken French data library, Barclays Research

FIGURE 8

High Vol Portfolio Returns by Interest Rate Increases and Declines



Note: The sample period is July 1963-November 2019, bracketed in 10-year periods. The figure displays the average monthly returns of the high vol portfolios for 10y Treasury rate increases and declines. The high volatility portfolio is formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. Source: FRED, Ken French data library, Barclays Research

Portfolio Returns and Interest Rates When Controlling for Risk Factors

Modern portfolio theory argues that an asset's return and risk characteristics should not be viewed alone, but should be assessed by how that asset affects the overall portfolio's return and risk profile. In this section, we investigate to what extent the performance of low vol stocks is related to changes in interest rates once we control for standard equity risk factors.[5] Specifically, we consider a number of widely accepted risk factors:

- The market excess return (**Mkt_Rf**): the return spread between the capitalization weighted stock market (based on the CRSP universe) and the risk-free rate (proxied by the one-month Treasury bill rate).
- The size factor (**SMB**): the return spread of small minus large stocks.
- The value factor (**HML**): the return spread of cheap minus expensive stocks.
- The investment factor (**CMA**): the return spread of firms that invest conservatively minus aggressively.
- The profitability factor (**RMW**): the return spread of the most profitable firms minus the least profitable.

[5] Karyda et al. (2014) construct a replicating portfolio of the low vol returns based on an equity and a bond market factor. The latter corresponds to the spread between the Barclays Treasury index return and the risk-free rate (so a sort of term premium). This paper, instead, focuses on estimating the sensitivity of low vol returns to *changes* in interest rates. Moreover, a number of differences remain between their paper and ours, such as a different construction method of the low vol portfolios, different sample periods (1963-2019 in this paper instead of 1990-2013), and different set of risk factors.

The market, size and value factors have been staples of modern asset pricing models in the literature since Fama and French (1993). On the other hand, the investment and profitability factors have been proposed more recently (Fama and French, 2015).[6]

To assess the sensitivity of low vol strategies to interest rates, we estimate the following four regressions:

Simple: $LV_{i,t} = \alpha + \gamma \, \Delta i10_t$

CAPM: $LV_{i,t} = \alpha + \gamma \, \Delta i10_t + \beta_{Mkt} \, Mkt\_Rf_t$

FF3: $LV_{i,t} = \alpha + \gamma \, \Delta i10_t + \beta_{Mkt} \, Mkt\_Rf_t + \beta_{SMB} \, SMB_t + \beta_{HML} \, HML_t$

FF5: $LV_{i,t} = \alpha + \gamma \, \Delta i10_t + \beta_{Mkt} \, Mkt\_Rf_t + \beta_{SMB} \, SMB_t + \beta_{HML} \, HML_t + \beta_{CMA} \, CMA_t + \beta_{RMW} \, RMW_t$

where $LV_{i,t}$ stands for the monthly return on the i^{th} portfolio decile formed on univariate sorting based on idiosyncratic variance and $\Delta i10_t$ stands for the monthly change in the 10y US Treasury rate. The long/short low vol portfolio returns corresponds to $LV_{1,t}$ - $LV_{10,t}$. The first equation is a simple regression; the second, third and fourth equation control, respectively, for the market factor (CAPM), and the Fama-French three- (FF3) and five-factor (FF5) models.

Figure 9 displays the 10-year rolling coefficient γ, which measures the sensitivity of low vol (D1) portfolio returns to changes in the 10y Treasury rates for the four models introduced above. We start by discussing the coefficient of the simple regression. In line with the results in Figure 3, the coefficient is negative until around 2000 and then becomes positive.[7] The coefficient has an average value of -3, which implies that a 10bp change in the 10y Treasury rate is associated, on average, with a decline of -0.3% in the monthly low vol portfolio returns. The regressor coefficients of the models conditional to other equity risk factors (light blue and gray lines) continue to display considerable time variation, though the magnitude is smaller than that of the unconditional model. For instance, the coefficient γ in the fourth equation ranges between -1.7 and 1.4, about one-fourth of the level of the unconditional model.

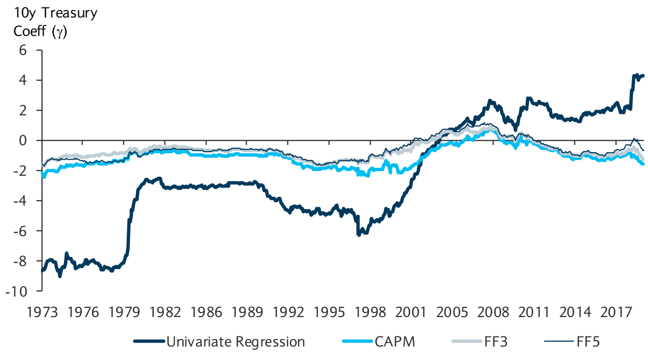
Figure 10 looks at whether the coefficient of the interest rate sensitivity is statistically significant. The dashed lines represent the 2.5% and 97.5% confidence interval. Specifically, when the solid lines are within the dashed lines, the coefficient is not statistically significantly different from zero. In other words, the difference between the solid line and zero might be due to chance. Although not statistically significant, the interest rate exposure of low vol portfolios might still be economically significant. To address this question, we look at the sign and magnitude of the estimated coefficient. First, the sign is negative for about half of the sample and positive for the other half. Thus, the sign is not consistent. Second, the magnitude of the interest rate exposure is small. For instance, a change of one standard deviation of the 10y Treasury rate (ie, 28bp for the sample 1963-2019) is associated with only 5% of the total volatility of the low vol portfolio excess returns. Furthermore, the adjusted R^2 of the Fama-French five-factor model increases marginally from 86.6% to 86.9% by including the change in the 10y Treasury rate. All in all, we conclude that the interest rate exposure does not explain much of the low vol anomaly.

[6] The data on the Fama-French five factors are provided by the Kenneth French data library (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html). We thank Professor French for making available a rich data library containing the time-series data for various risk portfolios.

[7] The relationship between the γ coefficient in the first regression and the correlation coefficient displayed in Figure 3 is as follows: $\gamma = \rho \times \sigma_Y / \sigma_X$, where ρ represents the correlation coefficient and σ_X represents the standard deviation of variable X. Hence, the sign of γ and ρ is the same, whereas the magnitude depends on the volatility of the low vol returns compared with the volatility of the 10y interest rate changes.

FIGURE 9

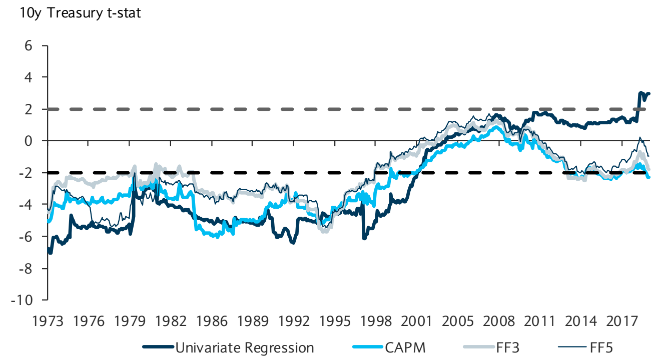
Low Vol (D1) Portfolio Sensitivity to the 10y Treasury Rate (regression coefficient)



Note: The sample period is July 1963-November 2019. The figure displays the regression coefficient of low vol portfolio returns on monthly changes in the10y Treasury rate, controlling for different risk models. The rolling window is 10 years. Low vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. Source: FRED, Ken French data library, Barclays Research

FIGURE 10

Low Vol (D1) Portfolio Sensitivity to the 10y Treasury Rate (t-stat)



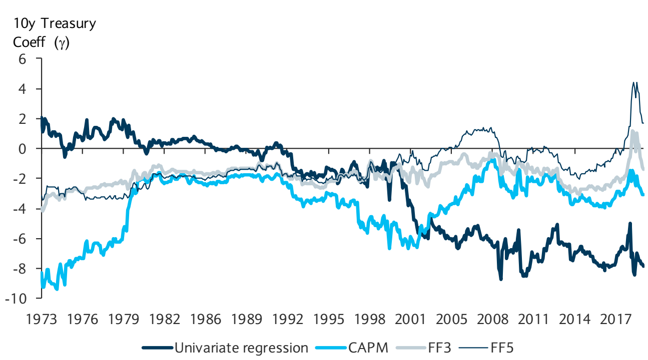
Note: The sample period is July 1963-November 2019. The figure displays the t statistics of the regression coefficient of low vol portfolio returns on changes in the 10y Treasury rates, controlling for different risk models. The rolling window is 10 years. Low vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. The dashed lines represent the 2.5% and 97.5% confidence interval. Source: FRED, Ken French data library, Barclays Research

Figure 11 displays the 10-year rolling regression coefficient of the long-short low vol (D1-D10) portfolio on monthly changes in the 10y Treasury rate, controlling for different risk models. By construction (see footnote 7), the dynamics of the rolling coefficient for the simple regression are similar to that of Figure 4. Similar to what we documented for the low vol portfolio, the absolute value of the regression coefficient of the 10y Treasury rate change becomes smaller once we control for Fama-French risk factors, and it is not statistically different from zero in the second half of the sample period.

We examine the robustness of these results along several dimensions. First, we consider different construction methods of the low vol portfolios by ranking stocks based on their market beta or the total variance, instead of residual variance. Second, we consider a rolling window of five years instead of ten. Third, we study equally weighted portfolio returns instead of value-weighted returns. The main results of the previous sections are robust to

FIGURE 11

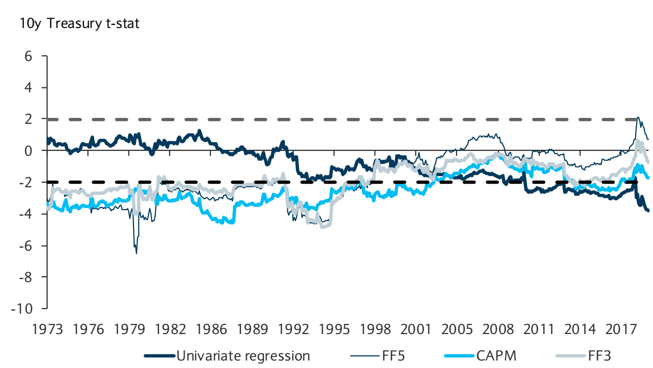
L/S Low Vol (D1-D10) Portfolio Sensitivity to 10-year Treasury Rates (regression coefficient)



Note: The sample period is July 1963-November 2019. The figure displays the regression coefficient of high vol (D10) portfolio returns on monthly changes in the 10y Treasury rate, controlling for different risk models. The rolling window is 10 years. High vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs.
Source: FRED, Ken French data library, Barclays Research

FIGURE 12

L/S Low Vol (D1-D10) Portfolio Sensitivity to 10-year Treasury Rates (t-stat)



Note: The sample period is July 1963-November 2019. The figure displays the t statistics of the regression coefficient of high vol (D10) portfolio returns on changes in the 10-y Treasury rates, controlling for different risk models. The rolling window is 10 years. High vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. The dashed lines represent the 2.5% and 97.5% confidence interval.
Source: FRED, Ken French data library, Barclays Research

changes in the specifications. The key finding that low vol portfolio returns are not much sensitive to changes in interest rates continue to hold. In the interest of space, all these robustness checks are available from the authors upon request.

Understanding the Sources of Low Vol Risk-Adjusted Returns

Having shown that low vol portfolios display little sensitivity to interest rates, we now turn to a more systematic analysis of the risk exposures of those portfolios and decompose their performance by using known drivers of cross-sectional variation in returns. To understand how a low vol portfolio relates to other standard risk factors, we proceed in two steps. First, we look at correlations. Then, we use regressions to control for the co-movements between low vol returns and other risk factors. Figure 13 reports the correlation coefficients between long-short low risk portfolios (in the last four columns and rows) with Fama-French five-risk factors (in the five columns and rows). The elements in the upper triangular matrix represent the standard correlation coefficient (also known as Pearson correlation), and it is designed to measure the strength of a linear relationship between the two variables. The elements in the lower triangular matrix represent the rank (Spearman) correlation, and it is designed to detect monotonicity in the relationship between the two variables. Specifically, this measures the correlation between the ranks of two variables, as opposed to that between variables themselves. One advantage of the Spearman correlation is that the correlation coefficient is less sensitive to non-normality in the distribution of the variables. Diagonal entries, which represent the correlation between a variable and itself (and, by definition, equal one) are left blank. To enhance the clarity of the table, we overlay it with a heat map, where dark colors indicate a large (in absolute value) correlation coefficient.

We focus on the results based on the Pearson correlation, as both measures lead to the same conclusions. Moreover, this latter finding that the coefficients above the diagonal are quite similar to those below the diagonal indicates correlations is robust to the presence of potentially large portfolio returns. Several important conclusions can be drawn from Figure 13. Long-short low vol strategies are negatively correlated with market excess returns. This is expected, as low vol stocks have lower beta than high vol stocks; thus, the long-short portfolio has negative exposure to the market factor. In contrast, the correlation between BAB and market excess returns is, by construction, close to zero. Furthermore, low vol strategies (except BAB) are negatively related to SMB, suggesting a tilt toward large companies. BAB has different return dynamics than the other long-short low vol portfolios. The pairwise correlation between BAB and the other low vol strategies is at most 0.44, whereas the other correlations range between 0.82 (between low vol Beta and RVar) and 0.95 (low vol Var and RVar).

FIGURE 13

Correlation Matrix of Returns

	FF5					L/S Low Vol			
	Mkt_Rf	SMB	HML	CMA	RMW	Beta	Var	RVar	BAB
Mkt_Rf		0.28	-0.25	-0.39	-0.23	-0.67	-0.61	-0.55	-0.11
SMB	0.25		-0.06	-0.10	-0.35	-0.60	-0.63	-0.70	-0.02
HML	-0.24	-0.04		0.69	0.06	0.33	0.35	0.32	0.34
CMA	-0.34	-0.11	0.67		-0.03	0.42	0.44	0.38	0.33
RMW	-0.20	-0.26	-0.19	-0.20		0.39	0.52	0.57	0.31
L/S Low Vol (Beta)	-0.67	-0.57	0.30	0.36	0.28		0.85	0.82	0.38
L/S Low Vol (Var)	-0.61	-0.62	0.30	0.36	0.37	0.84		0.95	0.44
L/S Low Vol (RVar)	-0.54	-0.69	0.26	0.31	0.41	0.80	0.94		0.37
L/S BAB	-0.10	0.04	0.27	0.24	0.07	0.30	0.28	0.21	

Note: The sample period is July 1963-November 2019. The standard (Pearson) correlation is reported in the upper triangular matrix, the rank (Spearman) correlation in the lower triangular matrix. The L/S low vol portfolios go long low vol stocks and short high-vol stocks. Low vol portfolios are formed on univariate sorting based on CAPM beta ("Beta"), total variance ("Var"), idiosyncratic (or residual) variance ("RVar"), and betting-against-beta ("BAB"). Portfolios are rebalanced yearly (Beta) or monthly (Var, RVar and BAB), and returns are value weighted and ignore transaction costs. Source: Ken French data library, AQR data library, Barclays Research

Next, we use a time-series (multivariate) regression to investigate whether low vol excess returns are explained by exposures to those asset pricing factors introduced above. Using OLS with Newey-West standard errors, we estimate:

$$LV_{i,t} - Rf_t = \alpha + \boldsymbol{\beta}' \mathbf{F}_t + \varepsilon_t$$

where, as before, $LV_{i,t}$ stands for the monthly return on the i^{th} portfolio decile formed on univariate sorting based on idiosyncratic variance, and Rf_t is the risk-free rate, proxied by the one-month Treasury rate. The coefficient α is the portfolio's alpha, $\mathbf{F}_t$ is a vector of stock market risk factors, and ε_t represents a residual risk that is unrelated to the factors. Significant abnormal alphas indicate that an investor already trading the Fama-French five factors could realize significant gains by starting to trade the low vol strategy (ie, the i^{th} decile low vol portfolio). In contrast, insignificant abnormal alphas indicate that the investor has little to gain by getting exposure to that strategy. Compared with the specification discussed previously, there are two main differences. First, the dependent variable is the portfolio excess return, rather than the total return.[8] Second, the change in the 10y Treasury rate is not included as an explanatory variable.

Figure 14 reports the Jensen's alpha for the raw excess returns (which correspond to their unconditional mean), the CAPM model (second row), the Fama-French three-factor model (third row; FF3), and Fama-French five-factor model (last row, FF5). We indicate with stars when the coefficients are significant at the 10% level or better. In contrast to the univariate correlation analysis reported in Figure 13, a multivariate regression simultaneously controls for multiple risk factors that might affect low vol excess returns.

We find that low vol portfolios have positive excess returns, all significantly different from zero. For instance, the low vol D1 and D2 portfolios generated average excess returns of, respectively, 0.57% and 0.61% per month. In contrast, high vol portfolios have slightly negative average excess returns. Those of low vol remain positive and highly significant, even after controlling for the CAPM and the FF3 risk model. However, once we add the profitability and the investment factors to FF3, the performance of low vol portfolios is not anomalous anymore. The only exception is represented by the high vol portfolio, which displays an abnormal return of -0.50% per month after controlling for FF5 factors. Consequently, the long-short low vol portfolio, which goes long low vol stocks and shorts high-vol stocks (based on RVar), still delivers a positive and significant alpha of 0.54%. The intercept of the long-short low vol portfolios (last two columns) shrinks by half after controlling for Fama-French factors. For instance, BAB raw returns are, on average, 0.86% per month when controlling only for the market factor, but decrease to 0.71% and 0.43% after including FF3 and FF5, respectively.

FIGURE 14

Risk-Adjusted Alpha (%/m) based on Various Risk Models

	Returns in Excess of the Risk-Free Rate (Sorting Var = RVar)										Returns	
	D1 Low Vol	D2	D3	D4	D5	D6	D7	D8	D9	D10 High Vol	L/S Low Vol (RVar)	L/S BAB
Raw Returns	0.57***	0.61***	0.54***	0.65***	0.66***	0.81***	0.63***	0.80***	0.56*	-0.04	0.62**	0.82***
CAPM	0.19***	0.14***	0.03	0.11	0.07	0.18**	-0.05	0.07	-0.25*	-0.90***	1.09***	0.86***
FF3	0.15**	0.13***	-0.01	0.03	0.02	0.15**	-0.07	0.03	-0.26***	-0.92***	1.07***	0.71***
FF5	0.04	0.02	-0.13**	-0.09	-0.07	0.12	-0.06	0.12	-0.04	-0.50***	0.54***	0.43***

Note: The sample period is July 1963-November 2019. The dependent variable is the excess return on the decile volatility portfolios, which are formed on univariate sorting based on residual variance. The last two columns are the return on the long-short portfolios that go long low vol stocks and short high-vol stocks, based, respectively, on residual variance and BAB. Portfolios are rebalanced monthly, and returns are value weighted (except BAB) and ignore transaction costs. The table reports the intercept (annualized risk-adjusted alpha) of the regression of the portfolio excess returns on various risk factors. "CAPM" comprises the market factor. "FF3" and "FF5" stand for the Fama and French three- and five-factor model, respectively. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively, and are based on robust (autocorrelation-consistent Newey-West) standard errors. Source: Ken French data library, AQR data library, Barclays Research

[8] By regressing low vol excess returns onto the returns of the Fama-French factors, we investigate whether low vol portfolios exhibit any abnormal return that is not captured by their exposures to other equity risk factors.

To understand the sources of low vol returns, Figure 15 reports the factor loadings on Fama-French five factors for the ten portfolio deciles and the long-short portfolios (last columns). By construction, the last row in Figure 14 equals the first row in Figure 15. The FF5 factors explain most of the variation of the low vol decile portfolio excess returns for 1963-2019, with the adjusted R^2 ranging between 87% and 92%. This finding is consistent with those of Fama and French (2016) and Novy-Marx (2016), who conclude that the five-factor model provides a good description of low vol decile returns.

Low vol stocks have a CAPM beta less than 1 and tilt to large, conservative and profitable companies.[9] In contrast, high vol stocks have a CAPM beta larger than 1 and tilt to small, aggressive and unprofitable companies. We also find that the loading coefficients are mostly monotone in the portfolio deciles, increasing for market beta and SMB loadings and decreasing for CMA and RMW, respectively. For instance, the lowest low vol decile portfolio has a market beta of 0.83, a negative loading on SMB (-0.22) and positive coefficients on CMA and RMW, with all coefficients significantly different from zero. On the other hand, the high-vol decile portfolio (D10) has a market beta greater than one (1.21), a positive loading on SMB (thus, indicating a small size tilt) and negative loading on CMA and RMW.

Most of the return dynamics of the long-short low vol portfolio is explained by exposures to the FF5, with an adjusted R^2 of 77% (see the results in the penultimate column). In contrast, Fama-French factors subsume only some of the BAB factor dynamics (in the last column), accounting for just 24% of its time series variation. As pointed out by Novy-Marx and Velikov (2019) and Han (2020), this latter finding is related to the non-standard procedures used in the BAB construction that effectively boil down to equal-weighted stock returns.[10] Hence, BAB performance dynamics are driven by overweighting micro- and nano-cap stocks.

FIGURE 15

Factor Loadings on Fama-French Five Factors

	Returns in Excess of the Risk-Free Rate (Sorting Var = RVar)										Returns	
	D1 Low Vol	D2	D3	D4	D5	D6	D7	D8	D9	D10 High Vol	L/S Low Vol (RVar)	L/S BAB
Alpha	0.04	0.02	-0.13**	-0.09	-0.07	0.12	-0.06	0.12	-0.04	-0.50***	0.54***	0.43***
Mkt_Rf	0.83***	0.96***	1.03***	1.09***	1.12***	1.16***	1.20***	1.24***	1.27***	1.21***	-0.38***	0.07
SMB	-0.22***	-0.16***	-0.10***	0.01	0.08**	0.18***	0.29***	0.45***	0.61***	0.92***	-1.14***	0.13**
HML	0.11***	0.01	0.11***	0.20***	0.12***	0.05	0.01	0.02	0.00	-0.06	0.17	0.17
CMA	0.15**	0.17***	0.11**	0.06	0.05	-0.03	-0.11	-0.21**	-0.44***	-0.55***	0.71***	0.47***
RMW	0.23***	0.21***	0.29***	0.30***	0.23***	0.10	0.04	-0.14**	-0.39***	-0.90***	1.13***	0.56***
Adj. R^2	0.87	0.91	0.92	0.92	0.91	0.91	0.91	0.90	0.90	0.89	0.77	0.24
Observations	677	677	677	677	677	677	677	677	677	677	677	677

Note: The sample period is July 1963-November 2019. The dependent variable is the excess return on the decile volatility portfolios, which are formed on univariate sorting based on residual variance. The last two columns are the return on the long-short portfolios that go long low vol stocks and short high-vol stocks, based respectively on residual variance and BAB. Portfolios are rebalanced monthly, and returns are value weighted (except BAB) and ignore transaction costs. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively, and are based on robust (autocorrelation-consistent Newey-West) standard errors. Source: Ken French data library, AQR data library, Barclays Research

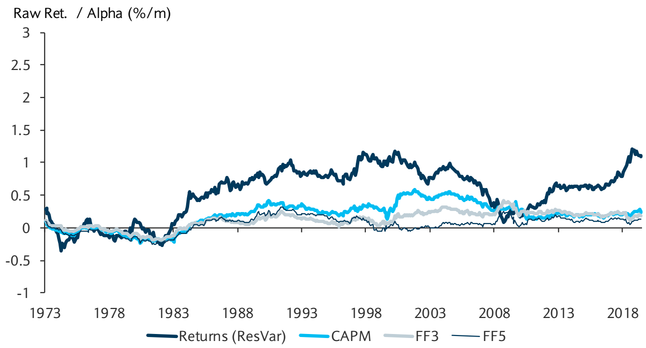
To shed some light on the stability of the alpha coefficient, we look at the 10-year rolling average of excess returns, as well as the 10-year rolling alpha for the CAPM, the FF3 and FF5 models for the long-only (D1) and L/S (D1-D10) low vol portfolio, reported respectively in Figure 16 and Figure 17. The sample starts in 1973 because of the 10-year initialization

[9] The FF5 risk factors are long-short, while the low vol D1 portfolio is long-only. As a robustness check, we regress the D1 portfolio excess returns on the long leg of the FF5 factors, and the results (available upon requests) remain very similar to those in Figure 15, including the insignificant alpha.

[10] First, the rank-based weighting scheme creates portfolios that are almost indistinguishable from equal-weighted portfolios. Second, the BAB factor is market neutral by leveraging the low beta portfolio and de-leveraging the high beta portfolio. The hedging with leverage is generated by scaling the underlying long and short portfolios by their predicted betas, rather than by directly hedging using the market portfolio. In practice, BAB is hedged by buying the equal-weighted, rather than the value-weighted, market portfolio. Consequently, BAB has limited capacity and after accounting for transaction costs, its net alpha is no longer significant relative to the FF5 factor model.

FIGURE 16

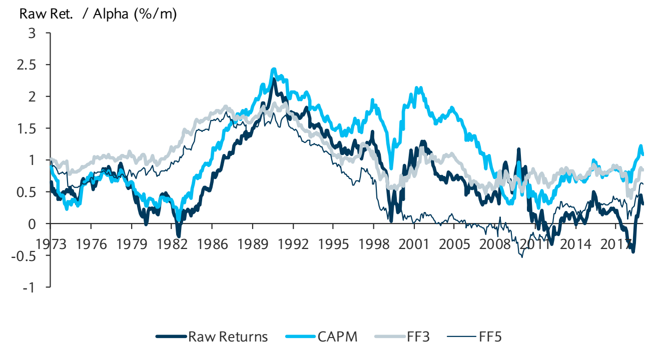
Alpha (%/m) of Low Vol (D1) Portfolio Excess Returns



Note: The sample period is July 1963-November 2019. The figure displays the rolling average of returns on the low volatility portfolio in excess of the risk-free rate, as well as the Jensen's alpha of a regression of the low vol decile (D1) portfolio excess returns on three risk models: CAPM, Fama-French three (FF3) and five (FF5) factor model. The rolling window is 10 years. Low vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. Source: Ken French data library, Barclays Research

FIGURE 17

Alpha (%/m) of L/S Low Vol (D1-D10) Portfolio Excess Returns



Note: The sample period is July 1963-November 2019. The figure displays the rolling average of returns on the low volatility portfolio in excess of the risk-free rate, as well as the Jensen's alpha of a regression of the low vol decile (D1) portfolio excess returns on three risk models: CAPM, Fama-French three (FF3) and five (FF5) factor model. The rolling window is 10 years. Low vol decile portfolios are formed on univariate sorting based on residual variance. Portfolios are rebalanced monthly, and returns are value weighted and ignore transaction costs. Source: Ken French data library, Barclays Research

period. The raw returns of the low vol portfolios have varied markedly over time. For instance, the long-only portfolio returns ranged between -0.3% and 1.2% per month. In contrast, the risk-adjusted alpha tends to be lower and less volatile than excess returns. For instance, the FF3 alpha ranges between -0.2% and 0.4%. The alpha of the long-short low vol portfolio based on FF5 has been close to zero since the late 1990s. This finding is in line with Blitz, Baltussen, and van Vliet (2019), who also document that the alpha of the long-short low-risk factor is insignificant in 1991-2018.

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