Quantitative Monographs

Do low-volatility stocks have interest-rate risk?

Equities

Global
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Low-risk investing has been a successful strategy

Over the past few years, low-risk investing, whether it be implemented as low-beta, low-volatility or minimum variance, has been a very successful investment approach. The flows into low risk ETFs and mutual so far this year have been over $15bn.

Has this been driven by interest rates falling since 1981?

It has been suggested that at least part of the success of low-risk funds has come from falling interest rates, and we show using a stylised dividend discount model that in theory low-beta stocks should benefit more from falling interest rates.

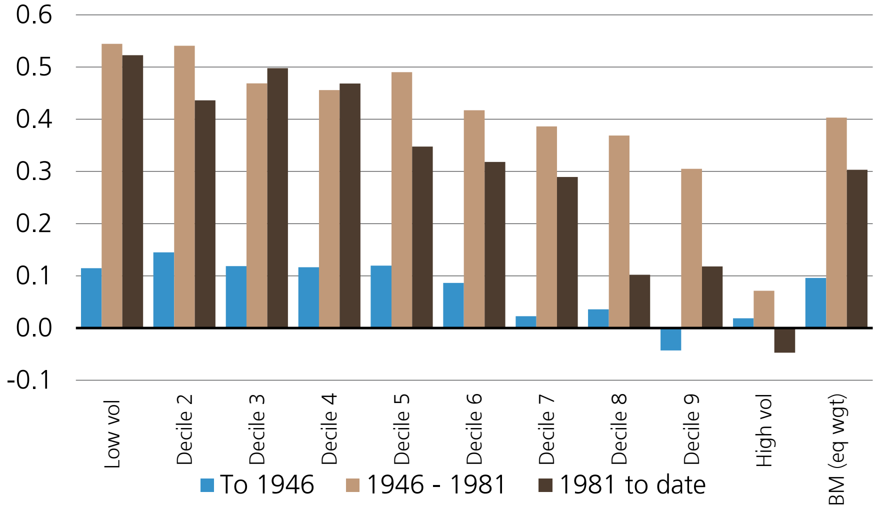
Rates need to move significantly to drive the alpha negative

In a detailed analysis of the returns and alphas of a low-volatility strategy in the US from 1929, we find that, as Figure 1 shows, the low-risk anomaly exists both in the rising rate period from 1946 to 1981 and in the falling rate period from 1981 to 2015. The alphas to the low-volatility portfolio (and the returns to a betting against beta style portfolio) are sensitive to changes in rates and tend to decrease as rates rise. Long rates need to move by more than 50 basis points in a six-month period to push the expected alpha into negative territory.

We investigate how to build portfolios that are rate-insensitive

Industry-neutral portfolios have a lower sensitivity to rates, but the best approach seems to be to build a low-risk portfolio out of a universe of stocks that do not pay a dividend.

Figure 1: Sharpe ratios of decile portfolios based on volatility



Source: The portfolios are created from the CRSP database using the largest 500 names by market cap. The volatility metric used is the 90-day volatility of daily returns and the portfolios are rebalanced quarterly to equal weights. The Sharpe ratios are calculated using the 10-year Treasury interest rate.

Introduction

Low risk investing has been a very successful strategy over the past few years. Institutional Investor, for example, reports that the flows into low risk mutual funds and ETFs have exceeded $15bn for the first seven months of 2016. However questions have been asked as to whether this has been driven, perhaps in part, by falling interest rates. In this note we investigate this question and find that, if history is to be a guide, then people invested in low risk portfolios do not have to worry too much.

To present a brief summary of the paper, we first review the various arguments for why low risk investing works. In particular we highlight the work of Muijjson et al (2015) who argue that in a CAPM world if short rates unexpectedly fall then low beta stocks will outperform.

Low risk names have the best Sharpe ratio in falling and rising rate periods

A long term backtest of a low volatility strategy in the US shows that the low risk effect seems to be robust to changing rates – low risk names have the highest Sharpe ratio in both the rising rate period from 1946 to 1981 as well as the falling rate period which follows this.

The alphas are sensitive to rates …

A more detailed analysis using time varying betas shows that the alpha to low risk is sensitive to rates, but that a large move in rates is needed in order to drive the expected alpha into negative territory.

… as is a betting against beta portfolio

We also find a similar result for a betting-against-beta style portfolio – the return to our betting against beta factor has a negative relationship with contemporaneous changes in interest rates, but again a large move is needed to push returns into negative territory.

Building rate neutral portfolios

Given these results we then ask the obvious question – can one remove the rate sensitivity of low risk names? We address this question in two ways: industry neutrality, which lessens but does not remove the rate sensitivity; and dividend yield neutrality, where we have mixed results but find that low risk zero yield stocks appear to have an alpha which is insensitive to rates.

The final section steps back from alphas, and investigates the overall rate sensitivity of the portfolio – can one create a low risk portfolio where the returns have no sensitivity to changes in rates? We are confident the answer is no.

Credit risk and gearing are potential risks

In *When is the stock market likely to correct?* (29 August 2016) we raise a flag about low risk names being expensive and exposed to credit risk. We think that low volatility names with high levels of gearing might underperform as the credit cycle ends.

Why does low risk investing work?

There are a number of explanations in the academic literature as to why low risk investing (by which we encompass minimum variance, low volatility and low beta styles of investing) is successful – i.e. which explain why low risk names, whether this be low beta, low volatility or minimum variance have a better risk adjusted return than the market. These fall under a few different headings and we give a brief explanation of each topic.

Demand for low beta stocks is low …

1. Incentive-driven explanations:
    a. Delegated money management industry and benchmarking. Most asset managers have a benchmark against which their risk is measured. Hence their main risk measure is not total but relative risk. With this measure a low beta stock is risky, and as we show in Figure 4 below, low risk names have a lower return than stocks with average risks and hence are unattractive. This reduces demand for these names and hence increases the future returns. See Baker, Bradley and Wurgler (2011), Brennan, Cheng and Li (2012)
    b. Leverage aversion and margin constraints. The only way that most benchmarked investors can buy low risk names is to gear them up to a beta of 1, however many investors cannot access gearing (or leverage). See Asness, Frazzini and Pedersen (2012), Frazzini and Pedersen (2014)

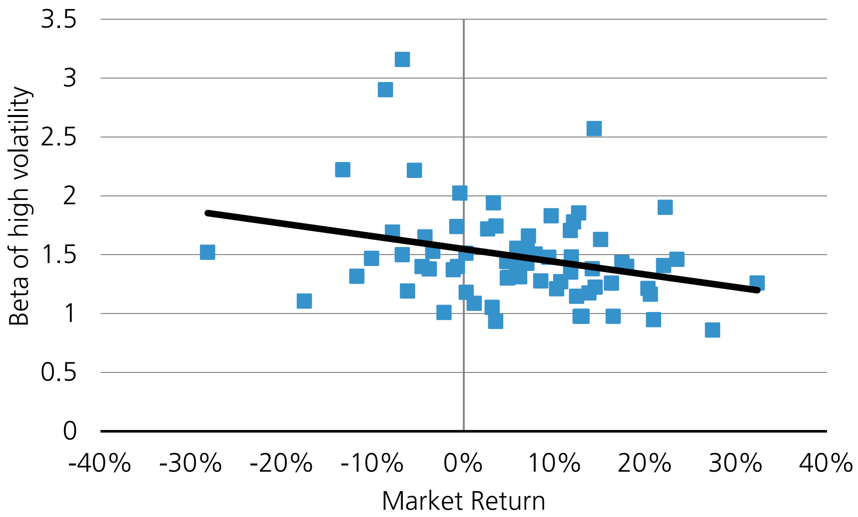
… and / or demand for high beta stocks is high

2. Behavioural explanations:
    a. High-volatility stocks treated like lottery tickets; Barberis and Huang (2008)
    b. Excess demand for high-volatility 'glittering' stocks ; Barber and Odean (2008)
    c. Sell-side tendency for optimistic forecasts for high-volatility stocks; Hsu, Kudoh and Yamada (2013)

And betas vary over time giving it a built in market timing

3. Mechanical explanation:
    a. Time-variation of stock betas - the low risk portfolio beta is not constant. In up markets its beta is close to one whereas in falling markets the beta falls, thus giving the low risk portfolio an "in-built" market timing mechanism. The opposite happens for the high risk portfolio. We illustrate this for the high risk portfolio in Figure 2 below. For details see our publications *Q-Series: Why is low-risk investing* successful (23 September 2011) and 3 reasons why high-risk underperformed (4 December 2013)

Figure 2: High risk beta vs. market return (from 1981 to 2015)



Source: UBS. The betas are estimated on non-overlapping six-month windows and are shown compared to the contemporaneous six month return.

A fourth type of explanation was put forward in *The Low Beta Anomaly and Interest Rates in Risk-Based and Factor Investing* by Muijjson, Fishwick, and Satchell (2015). In this paper they make the valid point that the CAPM theory addresses the ex ante, expected return to an asset – not the ex post return. Their argument (which we show in the Appendix) is that one can rearrange the CAPM formula and show that if interest rates fall unexpectedly then the current price rises and in particular low beta stocks outperform high beta stocks.

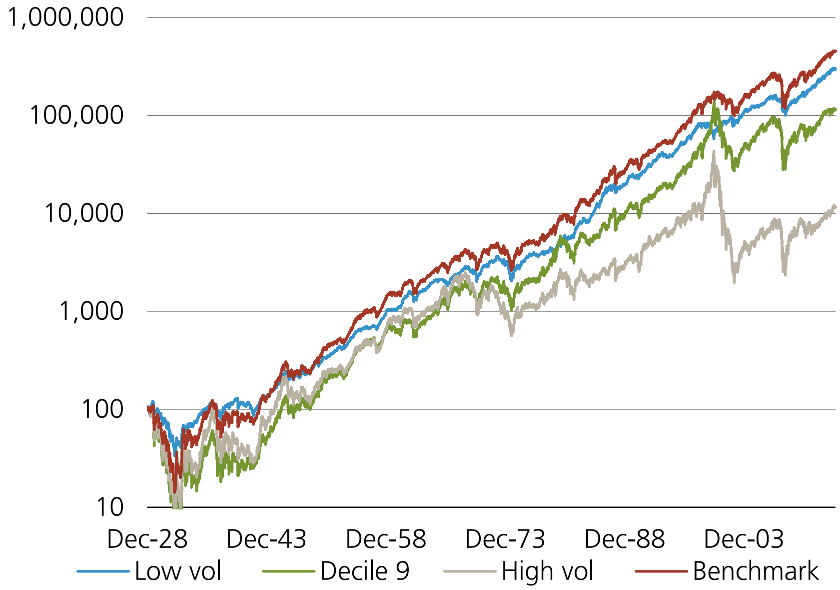
They follow this up with an empirical study using the 43 industry portfolios from the Ken French data library. In this study they find that the alpha for low beta industries is positive when rates fall and negative when rates rise (and the opposite is true for high beta industries). There is, in our view, a weakness in their study in that they use ex-post betas defined over the whole sample in order to define their low and high beta baskets.

In another study, Chow et al (2014) find that there is a duration sensitivity in all their low volatility portfolios. They suggest that this is intuitive: "very low-volatility (and high-yielding) stocks can often be used as fixed-income replacement by investors. These high-yielding low-volatility stocks could be bid up by investors seeking yield and safety when interest rates are low. This then injects duration exposure into low-volatility portfolios."

A long term view of low risk investing

We start by looking at the performance of a very long term backtest of a US based low risk strategy from December 1928 to December 2015. The total returns of a selected number of the decile portfolios are shown in Figure 3 below. A description of the data and portfolio construction approach used is given in the Appendix.

Figure 3: Returns to selected portfolios for the US sorted by volatility



Source: UBS. The portfolios are created from the CRSP database using the largest 500 names by market cap. The volatility metric used is the 90 day volatility of daily returns and the portfolios are rebalanced quarterly to equal weights. The data goes from December 1928 to December 2015.

We show the returns and Sharpe ratios for all the deciles in the figures below. In Figure 4 we see that the highest volatility decile has by far the worst performance, returning an excess return over interest rates of just 11 basis points per year.

Figure 4: Annualised returns of volatility sorted portfolios

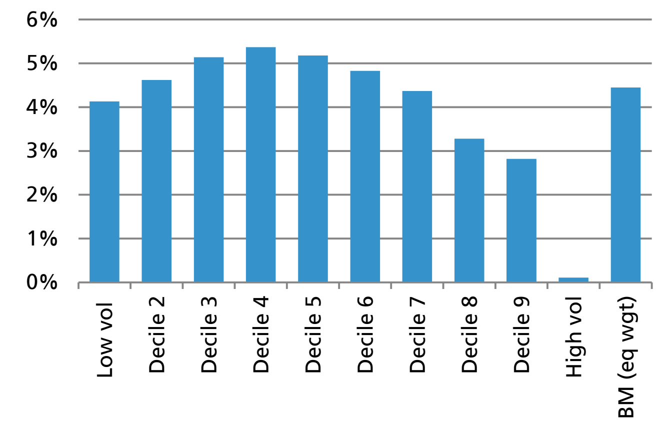
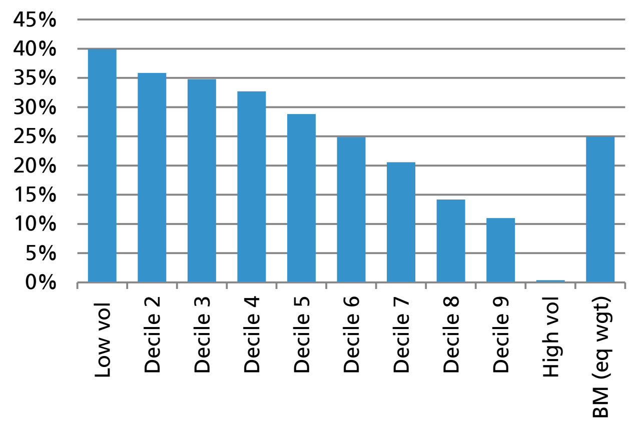


Figure 5: Sharpe ratio of volatility sorted portfolios



Source: Source: UBS. The portfolios are created from the CRSP database using the largest 500 names by market cap. The volatility metric used is the 90 day volatility of daily returns and the portfolios are rebalanced quarterly to equal weights. The Sharpe ratios are calculated using the 10 year Treasury interest rate. The data goes from Dec 1928 to December 2015.

Figure 3 above shows that this highest decile portfolio had a dreadful performance during the unwinding of the tech boom, but as we report in the Appendix (in

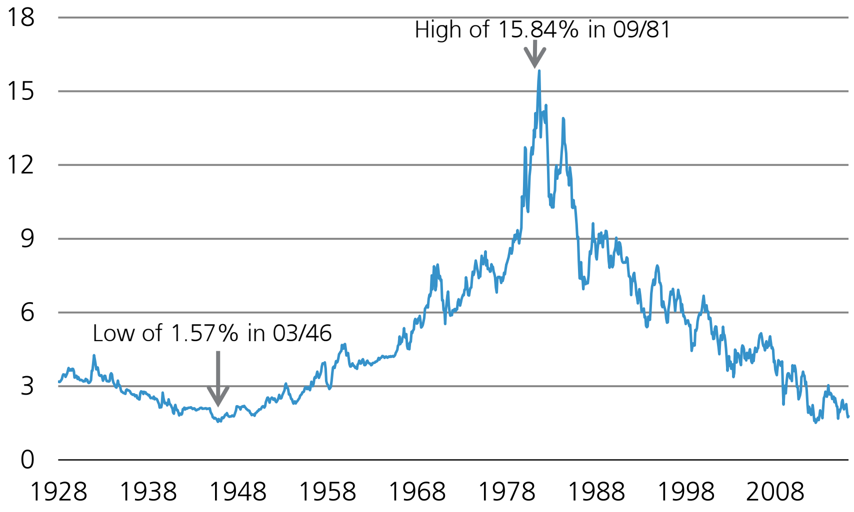
Figure 25), even excluding this period the highest volatility decile has the worst performance. As we saw in *3 reasons why high risk underperformed* (4th December 2013) the best return comes towards the middle of the distribution. Low risk portfolios do not outperform the market in an absolute sense; these stocks tend to underperform, which supports the argument for the Delegated Asset Pricing Model – low beta names have a high tracking error and low relative return, making them unattractive to investors with stock based benchmarks.

When we come to consider risk adjusted returns then, perhaps unsurprisingly, we find the result in Figure 5 where we have a monotonic downward relationship between volatility and the Sharpe ratio. There is also a monotonic upward relationship between the decile portfolio and the subsequent volatility.

How do we decide which way rates are going?

How should we classify periods of either rising or falling rates? As we can see from the 10-year interest rate shown in Figure 6 there are three main periods for US interest rates since 1928. From the start of our data until 1946 rates were falling[1]. They then rose until September 1981; after this high point they declined back to a low of 1.51% in July 2012[2].

Figure 6: US 10 year bond yield



Source: Global Financial Data

However this classification into three broad periods has, to say the least, problems of hindsight. Would we have believed in May 1984 when rates had just gone from 10% to close to 14% that we were in a falling interest rate environment? If there is a behavioural component to the interaction between rates and low risk returns then we have to take this identification problem into account.

In order to overcome this problem we address the problem of measuring the sensitivity of low risk portfolios to changes in interest rates in two different ways. We start by looking at the three regimes we have just identified. We then analyse returns using six month windows.

[1] We note that rates were falling prior to 1928, the previous high being in 1920.
[2] They fell to a new low of 1.36% after the end of our data period in July 2016.

Three big periods

In Figure 7 we show the Sharpe ratios of the decile portfolios in the three periods we delineated above. We see that in all three periods the Sharpe ratios of the lowest volatility decile are above those of the highest volatility decile.

Figure 7: Sharpe ratios of volatility sorted portfolios

	Low vol	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	High vol	BM
To 1946	0.1147	0.1449	0.1186	0.1165	0.1197	0.0864	0.0226	0.0359	-0.043	0.0188	0.0959
1946 - 1981	0.5445	0.5407	0.4688	0.4559	0.4903	0.4172	0.3864	0.3687	0.3052	0.0715	0.4031
1981 to 2015	0.5226	0.4363	0.498	0.4686	0.3477	0.3182	0.2895	0.102	0.1181	-0.0472	0.3031

Source: UBS. The portfolios are created from the CRSP database using the largest 500 names by market cap. The volatility metric used is the 90 day volatility of daily returns and the portfolios are rebalanced quarterly to equal weights. The Sharpe ratios are calculated using the 10 year Treasury interest rate.

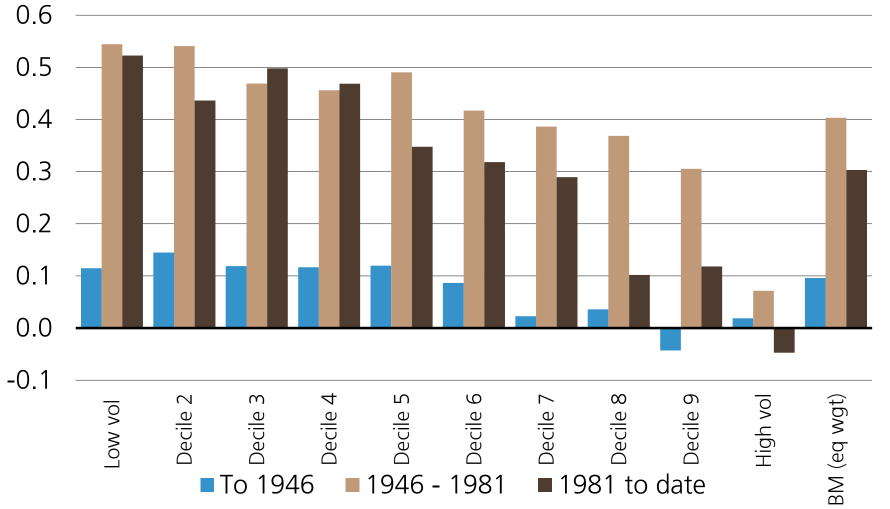
No real low risk effect prior to 1946

In the early part of our sample (up to 1946) there is a very weak low volatility effect (although four out of the five lower deciles have a Sharpe ratio above the benchmark and all five of the higher decile are below the benchmark). This lack of a low risk effect is not too concerning in our view, and if anything provides some indirect support for the delegated asset pricing explanation for the low risk phenomena. Prior to 1946 (if not later) the concept of "a benchmark" and definitely "tracking error" were not that prevalent[3], and so low total risk stocks having a high relative risk was not a concern to investors.

There was a low volatility effect when rates were rising

In the period between 1946 and 1981 when rates were rising there was a very strong low volatility effect with the spread between the Sharpe ratios for the low and high volatility stocks of 0.47.

Figure 8: Sharpe ratios of decile portfolios by volatility



Source: UBS. The portfolios are created from the CRSP database using the largest 500 names by market cap. The volatility metric used is the 90 day volatility of daily returns and the portfolios are rebalanced quarterly to equal weights. The Sharpe ratios are calculated using the 10 year Treasury interest rate

The more recent period does show a slightly larger spread of 0.57. This is mainly due to the very bad performance of high volatility names during the unwinding of the tech boom leading to a negative Sharpe ratio for these names.

[3] The CAPM originated in the early 1960s with the work of Treynor (1961 & 1962), Sharpe (1964), Lintner (1965) and Mossin (1966). This led to the first work on the evaluation of fund managers (Treynor, 1965; Sharpe, 1966; Jensen, 1968). According to Perold (2004), "the first careful study of returns" of US stocks was that of Fisher and Lorie (1964) in which they report average stock returns but not the standard deviation.

In Figure 9 we show the results of a CAPM regression over the three periods. We note that the spread between the alphas has been much greater in the more recent period. We also see that during the pre-1946 period the alpha to the high volatility portfolio is larger than that to the low volatility portfolio although in both cases the standard errors are larger than the alphas. We will drop this period from much of the subsequent analysis.

Figure 9: CAPM regression results for the three periods

	Decile 1		Decile 10	
	Alpha	Beta	Alpha	Beta
To 1946	0.84%	0.422	3.17%	1.011
	(1.40%)	(0.003)	(4.87%)	(0.012)
1946 - 1981	1.53%	0.483	-4.21%	1.458
	(0.66%)	(0.003)	(1.52%)	(0.008)
1981 to 2015	3.02%	0.532	-5.88%	1.520
	(1.10%)	(0.004)	(3.32%)	(0.012)

Source: UBS. The standard errors of the values are shown in parenthesis. The alphas are annualised.

Regressing on the Fama-French size (SMB – small minus big) and value (HML – high minus low) factors along with the market gives us the analysis we see in Figure 10.

Figure 10: Fama-French regression results for the three periods

	Decile 1				Decile 10			
	Alpha	Market	SMB	HML	Alpha	Market	SMB	HML
To 1946	0.04%	0.454	18.74	0.07	-3.14%	1.065	109.41	46.51
	(1.29%)	(0.004)	(0.61)	(0.68)	(3.31%)	(0.010)	(1.58)	(1.75)
1946 - 1981	0.79%	0.504	25.89	7.16	-5.33%	1.505	67.73	2.26
	(0.62%)	(0.003)	(0.74)	(0.71)	(1.41%)	(0.007)	(1.68)	(1.61)
1981 to 2015	2.15%	0.549	-5.69	22.21	-4.57%	1.560	85.27	-53.49
	(1.04%)	(0.004)	(0.73)	(0.77)	(2.89%)	(0.011)	(2.03)	(2.13)

Source: UBS. The SMB and HML factors were taken from Ken French's data website at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html. The standard errors of the values are shown in parenthesis. The alphas are annualised.

The low volatility portfolio has an increasing sensitivity to the HML factor – so over time the sensitivity of the low volatility portfolio to the value factor has increased (although see Goldberg, Leshem and Geddes (2013) who show that recently this tilt towards value has disappeared). The high volatility portfolio shows the opposite trend – prior to 1946 it also has a value tilt, but since then this has reversed.

In the Appendix (in Figure 26 and Figure 27) we show the Sharpe ratios of the portfolios during recessions and growth periods. Low risk tends to have a better Sharpe ratio in both types of period although if anything (and perhaps surprisingly) it has more periods with low risk adjusted returns during recessions than during growth periods.

A more detailed analysis

The above approach does give us some confidence that in a period with an overall increase in rates low risk investing will continue to do well. However, as we have highlighted above, there have been large swings in rates within these long term trends. We were inspired by our earlier work (available here) on low risk investing which highlighted that the beta for a low risk portfolio varies over time. Hence if we run a simple CAPM regression over the whole period (as we did above) then we might be misestimating the alpha given we are not taking the time varying beta into account. A simple solution to the problem is to run multiple, non-overlapping, regressions on shorter windows.

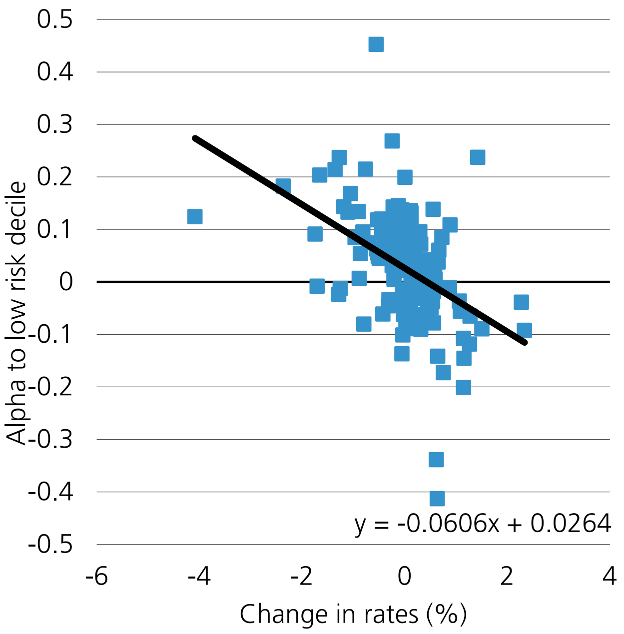
Take time varying betas into account …

We ran the analysis by calculating the alpha of the low risk and high risk deciles in each half year. These are then compared to the contemporaneous changes in long term interest rates[4].

… by running regressions on 6 month windows

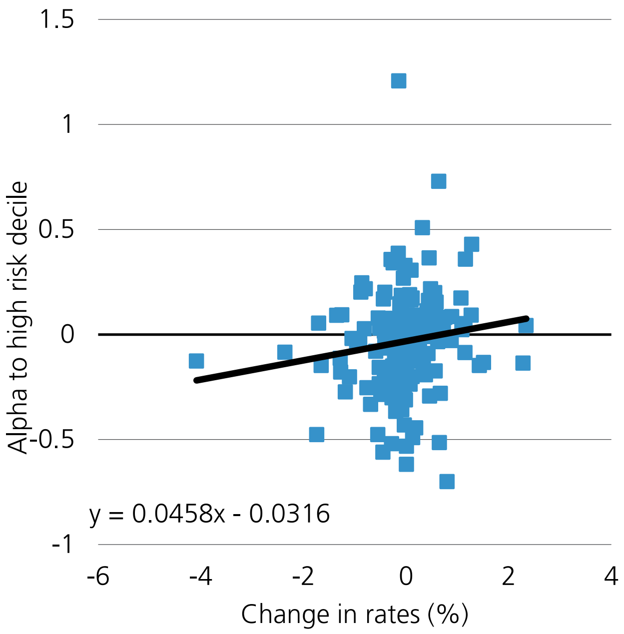
In Figure 11 we show the alpha of the low volatility portfolio against the change (first difference) in 10 year rates. Figure 12 shows the same for the high volatility portfolio.

Figure 11: Alpha to low volatility vs change in rates



Source: UBS. The data goes from 1946-2016. Chart shows the regression of the alphas to the low volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from Jan 1946 to Dec 2015. The standard errors for the parameters are 0.0075 for the intercept and 0.0106 for the slope.

Figure 12: Alpha to high volatility vs change in rates



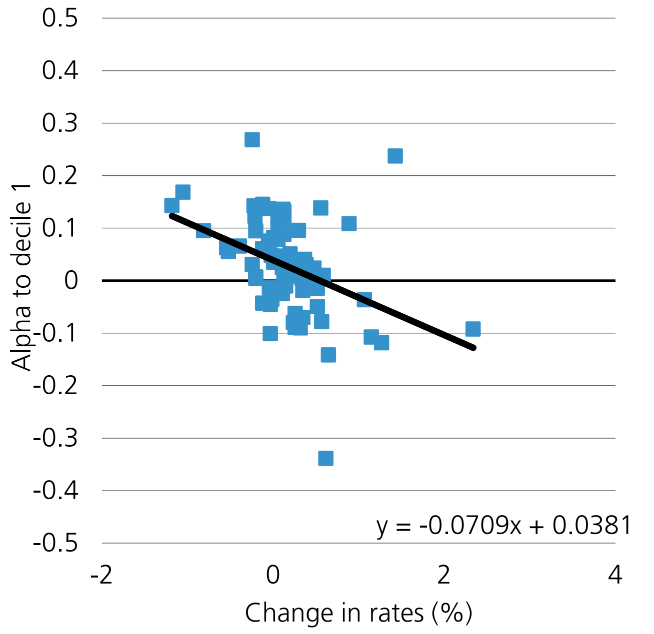
Source: UBS. The data goes from 1946-2016. Chart shows the regression of the alphas to the high volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from Jan 1946 to Dec 2015. The standard errors for the parameters are 0.0175 for the intercept and 0.0247 for the slope.

We see that the result from Muijsson (2015) is preserved with these results. As rates rise the (ex post) alpha from our low risk decile falls and the alpha from high risk rises. In the following two figures we reproduce the results for the low volatility portfolio but now split into the rising and falling rate periods. We see that the slope is similar in both cases but the intercept is significantly larger in the rising

[4] We only have the levels of the 10 year rate daily from Jan 1962; prior to that the data is available monthly. Hence our approach of running a two stage analysis – extracting the alphas and then comparing to changes in rates. Ideally one would run a multivariate regression including the changes in rates but this isn't possible over the whole period.

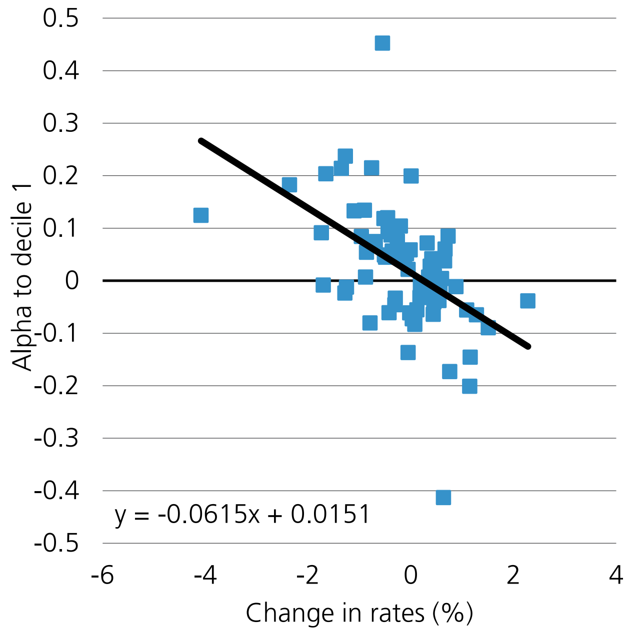
rate period than the falling rate period. The slopes in both charts are significant at the 1% level – the t-stats are -3.45 and -4.75 for the 1946-81 and 1981-2015 periods respectively.

Figure 13: Alpha to low risk vs change in rates 1946-1981



Source: UBS. Chart shows the regression of the alphas to the low volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from January 1946 to June 1981. The standard errors for the parameters are 0.0112 for the intercept and 0.0205 for the slope.

Figure 14: Alpha to low risk vs change in rates 1981-2015



Source: UBS. Chart shows the regression of the alphas to the low volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from July 1981 to December 2015. The standard errors for the parameters are 0.0126 for the intercept and 0.0130 for the slope.

How to reconcile the two results?

This leads us to a conundrum. When we analysed the full period data we found that our low risk decile had the highest risk adjusted return in both the rising- and falling-rate periods. And yet in the results above we find that the alpha for low risk is negatively sensitive to rates. How should we reconcile the two results?

The key comes from looking at the regression equation. If we use the one from Figure 13 as an example:

$$E(\alpha_t) = -0.0709 * \Delta r_t + 0.0381$$

This implies that our expected alpha to low risk hits zero when interest rates rise by 54 basis points in a six month period[5]. But this doesn't happen very often. Our rising rate period is 35 years long – 70 half years and of these rates only rise by more than 54 basis points in 11 of them.

This is the solution to our puzzle – yes our alpha falls if rates rise, but rarely do they rise by enough to push the expected alpha into negative territory.

[5] During the falling rate period the intersection of the trend line with the x-axis is at 25 basis points.

Is there a lead lag effect?

All the above analysis is using contemporaneous alphas and moves in rates. This leads to the obvious question of whether there is a lead-lag effect – do changes in rates in one period lead to a change in the alpha in a subsequent period.

We attempt to answer this in Figure 15. The slopes from the unlagged data are significant for the low volatility portfolio and close to significant for the high volatility one, but the lagged sensitivities at least out to 12 months are insignificant.

This implies that although rates do have an effect on the alphas this cannot be predicted ex ante. We only know how the alpha will have changed by the end of the period.

Figure 15: Slope coefficients from regressing alphas on lagged changes in rates

	Low volatility		High volatility	
	1946-1981	1981 to 2015	1946-1981	1981 to 2015
No lag	-0.071	-0.062	0.062	0.057
	(-3.45)	(-4.75)	(1.60)	(1.95)
6m lag	-0.012	-0.004	-0.16	0.009
	(-0.51)	(-0.29)	(-0.39)	(0.30)
12m lag	-0.043	0.018	-0.002	0.003
	(1.59)	(1.21)	(0.05)	(0.10)

Source: UBS. The table shows the slope coefficients from regressing the 6m alphas to low or high volatility on (potentially lagged) changes in rates. The t-statistics are shown in parenthesis.

Does Betting-against-Beta have similar properties?

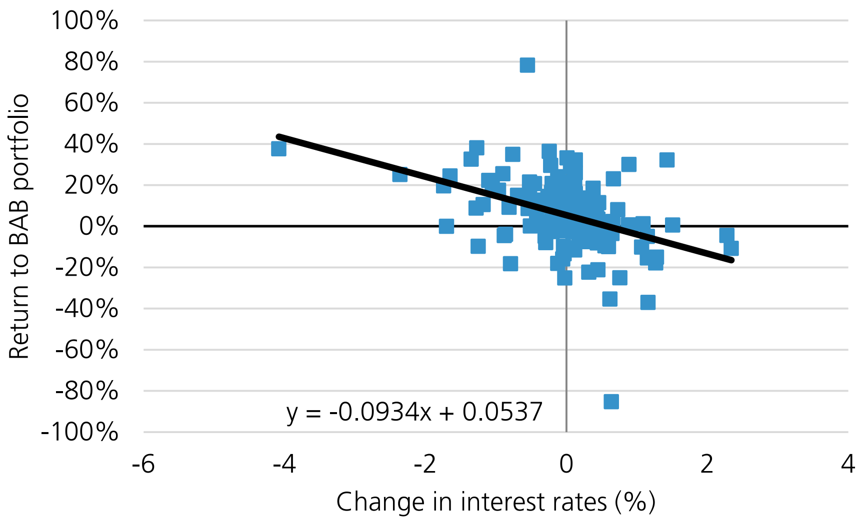
The analysis above is looking at the alphas to the low volatility and high volatility portfolios. In practice one way of implementing the low volatility factor is via a Betting-against-Beta, BAB, (Frazzini & Pedersen (2014)) style portfolio which goes long the low volatility portfolio which is scaled up to have a beta of one, and short the high volatility portfolio which similarly is scaled down to a beta of one. In theory this gives us a market neutral portfolio which is exposed to the low volatility factor.

To implement this we continue with our six-month rebalancing schedule and at the end of December and June take the beta of the low and high volatility portfolios and rescale the returns over the next six months using these betas. This means our six-month BAB return is

$$r_{BAB}^{t+1} = \frac{1}{\beta_t^L}\left(r_L^{t+1} - r_f\right) - \frac{1}{\beta_t^H}\left(r_H^{t+1} - r_f\right)$$

with the obvious notation[6]. Figure 17 shows the returns to our BAB strategy against changes in interest rates.

Figure 16: Returns to betting-against-beta vs changes in interest rates



Source: UBS. The chart shows the six month returns to a betting against beta strategy against changes in 10 year rates. The slope has a t-stat of -5.34 and the intercept one of 3.93. The -85% return occurs in the last six months of 1999.

As above, albeit with returns rather than alphas, we find that there is a negative relationship between the returns to our BAB portfolio and changes in rates. Similarly the trend line intercepts the zero axis at an increase in rates of 57 basis points, which again is rare.

Our conclusions are similar to those above – there is a negative sensitivity but rates need to change by an unusually large amount before the expected return is negative.

[6] To be accurate we should probably name this a "betting against volatility" portfolio as we rank on volatility rather than beta as in the paper, but we stick with the accepted name.

Removing the interest rate sensitivity

This leads to the question of whether we can remove this interest rate sensitivity from the alphas. We will discuss whether we can completely remove any interest rate sensitivity from the portfolio later in the document.

We approach this in two ways. The first is to pursue a strategy of industry neutrality; the second to have either a low or non-existent sensitivity to dividend yields. We explain our reasoning on dividend yield sensitivity below. We are not claiming these are the only ways to achieve the desired outcome but they both seem reasonable.

Industry neutrality

Our first approach to removing the interest rate sensitivity of our low risk portfolio is to impose some form of industry neutrality. The idea was inspired by a blog post, by De Carvalho (2014) where he analyses the performance of the MSCI World Minimum Volatility Index from 01/1995 to 10/2014 and finds that "the alpha [turns] negative when interest rates rise" whereas a sector neutral low risk strategy has a positive alpha in both a falling and rising rate environment.

The implementation of industry neutrality leads to two important questions. The first is a practical one – what industry classification system can we use which goes back to 1946 (or even 1928)? The second is a definitional one – when we say "neutral", to what are we neutral?

Historical industry definitions

To answer the first question we are fortunate in that Ken French has devised a mapping from SIC codes to a 10 industry classification[7], which we used together with the temporal SIC code data from CRSP.

Creating industry neutral portfolios

The second question is harder to answer and there is no one way to approach the problem. As above we start with a universe of the largest 500 names in CRSP. Two benchmark portfolios were calculated – one market cap and one equal weighted. Our low risk portfolios are made up of the lowest 10% of names in each of the 10 industries either equal weighted (so approximately matching the industry weights of the equal weighted benchmark) or market cap weighted but with the industry weights rescaled to match the cap weighted benchmark.

Figure 17: Sharpe ratios for industry neutral low risk portfolios

	Equal Weighted		Cap weighted	
	Low volatility	Benchmark	Low volatility	Benchmark
Full Period	0.394	0.250	0.306	0.202
To 1946	0.127	0.096	0.087	0.010
1946-1981	0.532	0.403	0.448	0.360
1981 to date	0.513	0.303	0.383	0.264

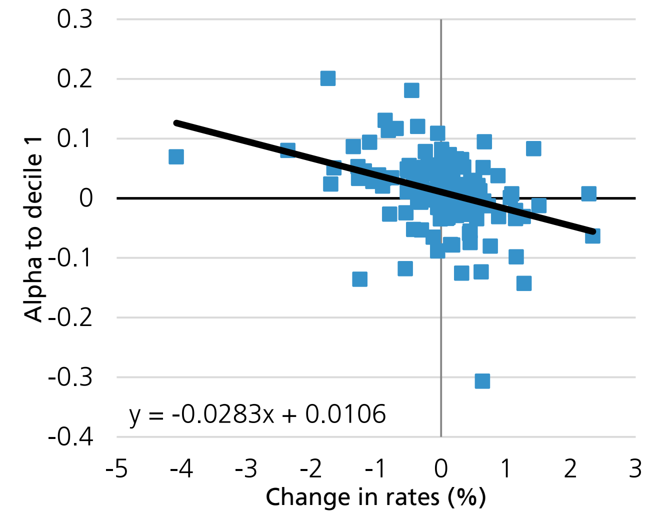
Source: UBS, The portfolios are created from the CRSP database using the largest 500 names by market cap. The volatility metric used is the 90 day volatility of daily returns and the portfolios are rebalanced quarterly to either equal or market cap based weights. The portfolios are industry neutralised using Ken French's 10 industry classification. The Sharpe ratios are calculated using the 10 year Treasury interest rate.

[7] See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_10_ind_port.html for details.

In Figure 17 above the Sharpe ratios for the four portfolios are shown for the full period and our three sub periods. There are three things of note. Firstly the Sharpe ratios of the cap weighted portfolios are uniformly lower than those of the equal weighed portfolios. The size of the low risk effect (measured as the difference in Sharpe ratios) is larger for the equal weighted portfolios. Finally the Sharpe ratios for the equal weighted low risk portfolios and of the equal weighted benchmarks are almost identical to those in Figure 7 for the non-industry neutral portfolios.

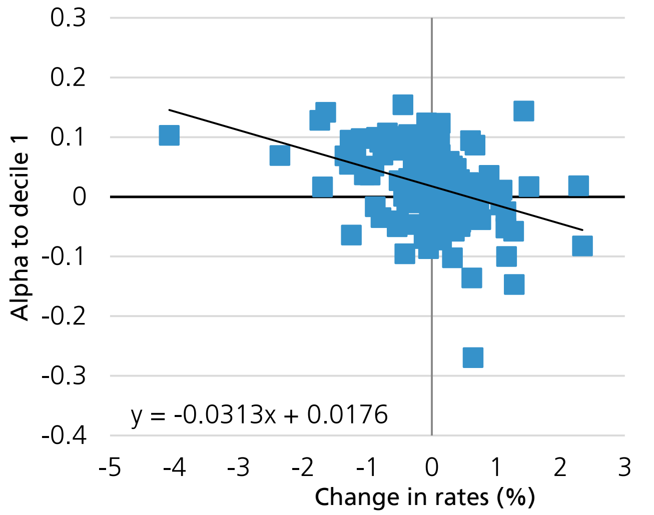
In the two figures below we reproduce Figure 11 for the equal weighted portfolio against the equal weighted benchmark on the left and similarly for the cap weighted portfolio on the right.

Figure 18: Equal weighted alpha vs change in rates



Source: UBS. Chart shows the regression of the alphas to the equal weighted industry neutral low volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from Jan 1946 to December 2015. The standard errors for the parameters are 0.005 for the intercept (a t-stat of 2.36) and 0.006 (a t-stat of -4.40) for the slope.

Figure 19: Cap weighted alpha vs change in rates



Source: UBS. Chart shows the regression of the alphas to the cap weighted industry neutral low volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from Jan 1946 to Dec 2015. The standard errors for the parameters are 0.006 for the intercept (a t-stat of 3.48) and 0.009 (a t-stat of -3.86) for the slope.

In both cases the sensitivity to the alpha is lessened (by around 50%) but at least over this whole period[8] we do not obtain a completely interest rate insensitive alpha.

Dividend yield neutrality

Another approach to consider is to remove (or at least lessen) our exposure to dividend yield. To see why this might make sense consider a simple single stage dividend discount model (with the obvious notation):

$$P_0 = \frac{D_1}{((1-\beta)r_f + \beta r_m - g)}$$

Differentiating this with respect to rates gives

$$\frac{\partial P_0}{\partial r_f} = -\frac{D_1}{\left((1-\beta)r_f + \beta r_m - g\right)^2}(1-\beta)$$

[8] The results for the two subperiods are very similar for both portfolios and hence not reported.

If we divide through by the price and rearrange we obtain

$$\frac{\partial P_0}{P_0} = -\frac{D_1/P_0}{\left((1-\beta)r_f + \beta r_m - g\right)^2}(1-\beta)\partial r_f$$

This gives us two results. Firstly from this we can see that the price return is a function of the dividend yield multiplied by the change in rates[9]. The beta controls this sensitivity. If the beta is below one then if rates fall then the price should rise, whereas if the beta is above one the price should fall. Hence falling rates should be good for low risk names. This is similar to the argument in Muijjson (2015).

So if our expected dividend yield is zero then the price is always insensitive to changes in rates. Given we are looking above at alphas then one could at least ask for the dividend yield of the low risk portfolio to match that of the overall market.

This model is of course too simplistic in two ways. Firstly it is assuming a change in rates is a shift across the yield curve, which is unlikely to be true. Secondly if a company is not paying a dividend then in this model it has a value of zero. In both cases we can improve the model by making a multi-stage DDM and allowing both the dividend and the change in rates to differ for the various future periods, but our simple model gives us some intuition.

Building our yield neutral portfolios

To create a set of dividend yield neutral portfolios we first divided the universe into those stocks which had paid a dividend during the previous 12 months and those that haven't.

For the dividend paying stocks we then did the usual double sort – first on yield and then on volatility. The low volatility portfolios within each dividend yield quintile were aggregated together to give five yield neutral portfolios. The Sharpe ratios for these portfolios are shown in Figure 20 below

Figure 20: Sharpe ratios for double sorted portfolios

		Volatility					
		Low	Q2	Q3	Q4	High	
Dividend Yield	Low	0.3542	0.2536	0.1718	0.1097	0.0695	0.2186
	Q2	0.2655	0.2595	0.1869	0.1649	0.0851	0.2306
	Q3	0.2931	0.2879	0.2528	0.2589	0.1824	0.3157
	Q4	0.4056	0.3036	0.4	0.2421	0.2258	0.3818
	High	0.3724	0.1752	0.2389	0.2672	0.2107	0.3208
		0.4077	0.3173	0.3187	0.2634	0.202	0.314

Source: UBS. The data goes from 1946-2015. The universe is the largest 500 names in the CRSP universe which then paid a dividend over the preceding 12 months from each rebalance date. The stocks are first sorted on trailing dividend yield and then on 12 month daily volatility. The sum portfolios are created either across the rows or vertically. The Sharpe ratios are calculated using 10 year rates.

We can see two expected results. Firstly looking in the last column we see that the highest Sharpe ratio comes not in the highest yield quintile but in the next highest. Secondly the first column shows that the low volatility portfolios have the highest Sharpe ratio in each dividend yield quintile.

[9] This assumes that the dividend and the growth rate are insensitive to changes in rates.

For the zero dividend yield paying names[10] we simply sort on volatility. Figure 21 shows that as expected low volatility names with a zero yield perform the best and the worst names are the zero yield high volatility ones.

Figure 21: Sharpe ratios of zero yield portfolios

	Volatility				
	Low	Q2	Q3	Q4	High
Zero yield	0.3157	0.2312	0.1935	0.1152	-0.0922

Source: UBS. The data goes from 1946-2015. The universe is the largest 1000 names in the CRSP universe which did not pay a dividend over the preceding 12 months from each rebalance date. The stocks are sorted on 12 month daily volatility. The Sharpe ratios are calculated using 10 year rates.

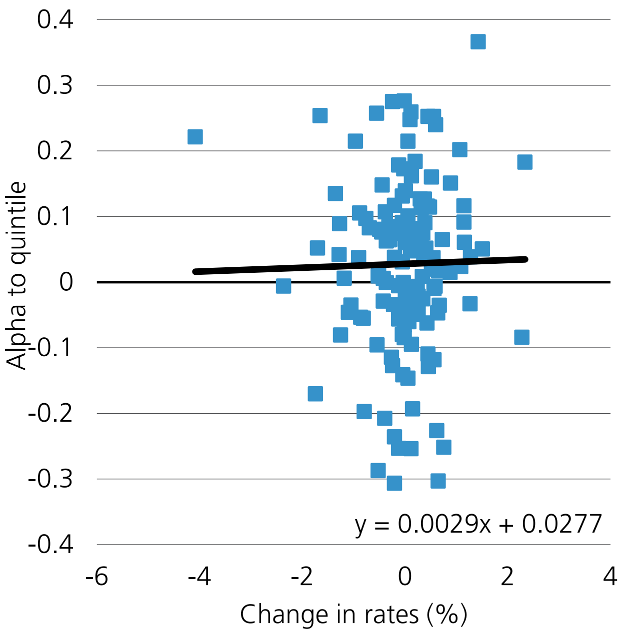
Below we repeat our analysis of regressing the alpha on the change in 10 year rates. And we have succeeded in our quest. The left-hand chart (Figure 22) shows the alpha to the zero-yield low-volatility portfolio; the right-hand chart the alpha to the yield-neutral low-volatility portfolio.

The slope on the left is zero – the alpha to our zero-yield low-volatility portfolio has no sensitivity to changes in rates. For our yield-neutral low-volatility portfolio we have reduced the slope by around 50%. We would note that a double sort does not always create portfolios which are neutral to the first factor – so there could be some remaining yield bias in the low vol portfolio[11].

The sub period analyses (not reported) show that if anything the slope for the zero-yield low-volatility alpha is positive during the rising rate period and negative during the second period. The results for the yield-neutral low-volatility portfolio are similar in both sub-periods.

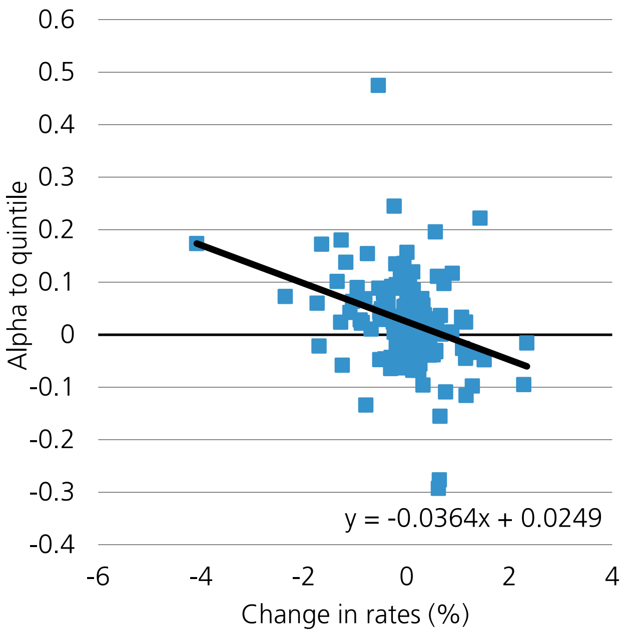
[10] For the zero dividend payers we expanded the universe to the largest 1000 names in order to have a reasonable number of names in each basket.
[11] To see why this could be the case, imagine a double sort on two totally correlated factors which are distributed from 1 to 25. The first sort would put split the data into 1-5, 6-10 etc. and then the second sort would divide these individually. However the portfolio created from adding together the first quintiles of the second sort would have an overall score of 1+6+11+16+21 =55 whereas the top quintile score would be 75. So a bias would remain.

Figure 22: Alpha to zero-yield low-volatility vs change in rates



Source: UBS. Chart shows the regression of the alphas to the zero yield low volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from Jan 1946 to Dec 2015. The standard errors for the parameters are 0.01 for the intercept (a t-stat of 2.34) and 0.015 (a t-stat of -0.039) for the slope.

Figure 23: Alpha to yield-neutral low volatility vs change in rates



Source: UBS. Chart shows the regression of the alphas to the zero yield low volatility decile estimated over non-overlapping six month periods against the contemporaneous change in US 10 year rates from Jan 1946 to Dec 2015. The standard errors for the parameters are 0.023 for the intercept (a t-stat of 3.58) and 0.009 (a t-stat of -4.23) for the slope.

Is complete interest rate neutrality possible?

The analysis above has shown the sensitivity of the ex-post alphas to changes in interest rates. Being able to create, for example, a zero-yield low-volatility portfolio where the alphas are rate insensitive is great, but as Figure 24 shows, this portfolio's total return still has a significant beta to rates most of the time, or in other words its alpha is rate neutral, but its total return is still influenced by interest rates.

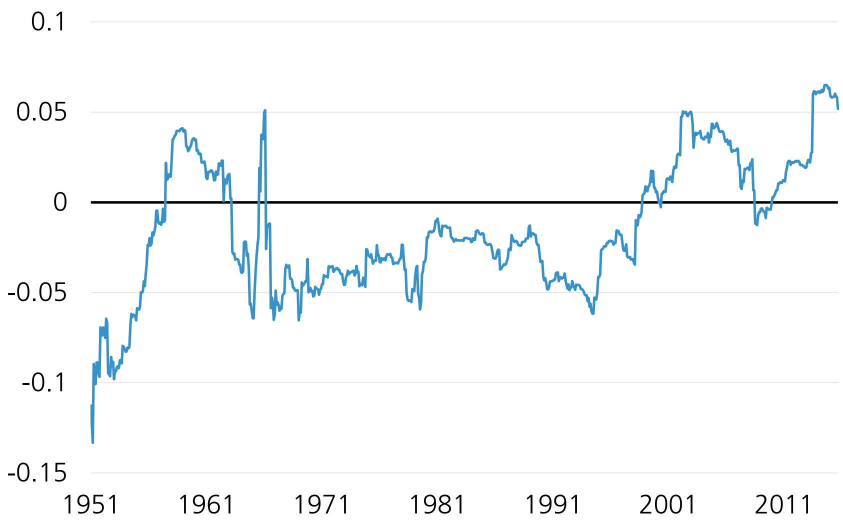
Our zero-yield low-risk portfolio's returns have a sensitivity to interest rate changes

The betas in Figure 24 are from the regression

$$r_{low\ risk,t} = \alpha + \beta_t \Delta r_{f,t} + \epsilon_t$$

i.e. from a regression on changes in risk free rates only.

Figure 24: Rolling beta of the zero-yield low-volatility to changes in rates



Source: UBS. Chart shows the rolling beta of the excess return of the zero-yield low-volatility portfolio regressed on changes in US 10 year rates. A rolling window of 60 months was used.

For most of the period from 1961 to 1999 the beta was negative, which means if rates went up then the portfolio's return was negative. Since 1999 the sign of the beta has changed and is positive. We observe a similar pattern in the S&P 500 as well as for the overall market.

This leads to the question of whether it is possible to build a low risk portfolio which has zero sensitivity to changes in interest rates. The answer appears to be "No". At the end of December 2015 our zero-yield low-volatility portfolio had 64 constituents. Of these only two have a negative beta to changes in rates – the other 62 have a positive sensitivity[12]. So in order to construct a portfolio with a zero aggregate beta we would have to put a huge weight on two names – hardly "low risk".

Even if we broaden our universe we are going to struggle: if we take the lowest volatility half of the zero yield names we still only have 12 out of 160 names with a negative beta to rates.

[12] Of which 36 are significantly positive at the 5% level.

We have repeated this analysis at other times and we tend to find that almost all stocks have the same sensitivity to rates as the market, a perhaps unsurprising result. So true rate insensitivity is probably impossible to achieve.

Appendix

CAPM Argument

This is a brief replication of the discussion from Muijsson (2015). The CAPM says that the expected return r_i for an asset is

$$r_i = \frac{E(P_{i,t+1})}{P_{i,t}} - 1 = r_f + \beta_i(r_m - r_f)$$

This can be rearranged to write the price as

$$P_{i,t} = \frac{E(P_{i,t+1})}{1 + r_f + \beta_i(r_m - r_f)}$$

Partially differentiating this with respect to the risk free rate and the market return gives

$$dP_{i,t} = \frac{-E(P_{i,t+1})}{\left(1 + r_f + \beta_i(r_m - r_f)\right)^2}\left(dr_f + \beta_i(dr_m - dr_f)\right)$$

Given the first part of this equation is bound to be negative then this implies if risk free rates fall the price rises, and in particular low beta stocks outperform high beta stocks.

Data for backtest

The data source is CRSP from December 1928 to December 2015. The universe we use is the largest 500 names in CRSP where the share code is < 13. Occasionally we use the largest 1000 names. The portfolios are rebalanced quarterly to equal weights.

Our base volatility metric is the 6 month volatility of daily returns. As we show below, results for other measures of "risk" give similar results.

Sharpe ratios are calculated using the 10 year Treasury interest rate.

Supplementary results

What happens if you exclude the tech boom?

Figure 25 shows the returns to the different volatility deciles either including or excluding the unwinding of the tech boom. We can see that this makes little difference to many of the deciles but increases the annualised return to the high volatility decile by 16 basis points a year over the whole period.

Figure 25: Analysis of the returns to the volatility deciles including and excluding the unwinding of the tech boom

		Low vol	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	High vol
Full period	Return	4.13%	4.62%	5.14%	5.37%	5.18%	4.83%	4.37%	3.28%	2.82%	0.11%
	Sharpe Ratio	0.40	0.36	0.35	0.33	0.29	0.25	0.21	0.14	0.11	0.00
Ex Tech boom unwind	Return	4.21%	4.68%	5.23%	5.47%	5.32%	4.93%	4.48%	3.42%	3.00%	0.27%
	Sharpe Ratio	0.41	0.36	0.35	0.33	0.30	0.25	0.21	0.15	0.12	0.01

Source: UBS, Ex-Tech Boom data removes all the returns from 1/1/2000 to 31/12/2002. The returns are calculated from 06/1928-12/2015.

Do recessions have an effect?

Figure 26 shows the Sharpe ratios of the volatility decile portfolios during NBER recession periods. It is interesting to note that in the period post 1946 there have been 11 recessions and the low volatility strategy had a worse Sharpe ratio than the high volatility decile in three of them.

Figure 26: Analysis of the Sharpe ratios of the volatility deciles during NBER recessions

	Low vol	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	High vol	BM (eq wgt)	D1 - D10
1929-09-01/1933-03-31	-1.20	-0.89	-0.96	-0.87	-0.92	-0.91	-0.91	-0.89	-1.02	-0.98	-0.99	-0.22
1937-06-01/1938-06-30	-0.58	-0.73	-0.76	-0.81	-0.79	-0.86	-0.72	-0.75	-0.71	-0.82	-0.78	0.24
1945-03-01/1945-10-31	4.48	2.96	3.50	2.77	2.01	2.36	1.88	2.22	1.51	1.79	2.39	2.69
1948-12-01/1949-10-31	2.90	2.15	2.06	1.53	1.43	1.20	0.56	0.74	0.81	0.60	1.24	2.30
1953-08-01/1954-05-31	4.03	5.36	3.15	2.93	3.65	3.82	2.61	3.13	2.13	1.09	3.07	2.94
1957-09-01/1958-04-30	2.90	1.16	1.04	0.67	0.01	0.03	-0.77	-0.56	-0.33	-0.60	0.01	3.49
1960-05-01/1961-02-28	5.40	3.71	4.26	3.75	2.26	2.47	2.37	1.99	1.78	1.23	2.78	4.17
1970-01-01/1970-11-30	-0.60	-0.57	-0.43	-0.58	-0.70	-0.71	-0.82	-1.11	-0.76	-1.30	-0.87	0.70
1973-12-01/1975-03-31	-1.10	-0.85	-0.73	-0.79	-0.47	-0.55	-0.19	-0.34	-0.27	-0.29	-0.52	-0.81
1980-02-01/1980-07-31	1.31	1.37	0.73	0.60	0.49	0.50	0.69	0.18	0.34	0.21	0.59	1.10
1981-08-01/1982-11-30	0.47	0.81	0.24	0.15	-0.12	0.04	0.17	-0.56	-0.74	-0.78	-0.19	1.25
1990-08-01/1991-03-31	0.50	-0.72	0.21	0.39	0.13	0.30	0.11	0.34	0.25	0.90	0.32	-0.40
2001-04-01/2001-11-30	0.13	0.02	0.06	0.01	-0.25	-0.39	-0.70	-0.54	-0.60	-0.34	-0.27	0.46
2008-01-01/2009-06-30	-0.79	-0.81	-0.72	-0.66	-0.73	-0.59	-0.53	-0.71	-0.67	-0.58	-0.68	-0.21

Source: UBS. Returns are shown for the periods in column one. The dates were obtained from the NBER website (http://www.nber.org/cycles.html) and we assumed the recession started at the end of the month.

Figure 27 shows the same analysis for growth periods. Here there is only one period where low risk has a worse risk adjusted performance than high risk, and that is from 1975 to 1980.

Figure 27: Analysis of the Sharpe ratios of the volatility deciles during NBER growth periods

	Low vol	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	High vol	BM (eq wgt)	D1 - D10
/1929-08-31	2.25	2.33	1.46	1.38	0.60	0.48	0.16	-0.29	-0.29	-0.62	0.51	2.86
1933-04-01/1937-05-31	1.46	1.23	1.29	1.20	1.37	1.19	1.15	1.00	1.05	1.23	1.29	0.23
1938-07-01/1945-02-28	0.62	0.60	0.63	0.58	0.68	0.70	0.47	0.49	0.43	0.36	0.57	0.26
1945-11-01/1948-11-30	0.01	0.02	-0.12	-0.13	-0.01	-0.12	-0.19	0.00	-0.02	-0.30	-0.10	0.31
1949-11-01/1953-07-31	1.79	1.63	1.50	1.80	1.51	1.36	1.43	1.17	1.08	0.80	1.39	0.99
1954-06-01/1957-08-31	1.50	1.56	1.31	1.36	1.57	1.45	1.42	1.17	1.08	0.86	1.36	0.64
1958-05-01/1960-04-30	2.09	1.70	1.92	1.36	2.17	1.35	1.48	1.44	0.81	1.87	1.70	0.22
1961-03-01/1969-12-31	0.42	0.42	0.34	0.47	0.35	0.31	0.41	0.41	0.30	0.11	0.37	0.31
1970-12-01/1973-11-30	0.04	0.34	-0.02	-0.24	0.13	0.05	-0.15	0.00	-0.26	-0.73	-0.15	0.77
1975-04-01/1980-01-31	0.23	0.17	0.49	0.51	0.48	0.43	0.61	0.81	0.83	0.45	0.57	-0.22
1980-08-01/1981-07-31	0.38	1.08	0.22	0.34	0.39	0.66	0.45	-0.04	0.06	0.07	0.37	0.32
1982-12-01/1990-07-31	0.73	0.67	0.62	0.67	0.45	0.35	0.46	0.07	0.15	-0.09	0.39	0.82
1991-04-01/2001-03-31	0.50	0.49	0.70	0.64	0.49	0.56	0.40	0.21	0.30	-0.02	0.48	0.52
2001-12-01/2007-12-31	0.55	0.49	0.46	0.50	0.43	0.33	0.35	0.38	0.32	0.01	0.38	0.54
2009-07-01/	1.08	0.86	0.91	0.78	0.75	0.63	0.53	0.40	0.42	0.32	0.65	0.75

Source: UBS. Returns are shown for the periods in column one. The dates were obtained from the NBER website (http://www.nber.org/cycles.html) and we assumed the recession ended at the end of the month.

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Research Publications

Monographs, Keys and Q-Series

Title	Date
What does splitting the financials sector change?	Aug-16
Harvesting Yield from Cross-Asset Carry	Aug-16
When is the stock market likely to correct?	Aug-16
Is it easier to be a quant in small cap?	Aug-16
Follow the smart money	Jul-16
How can supply chains improve earnings visibility?	Jul-16
Where are the attractive dividend paying stocks?	Mar-16
Why does increasing volatility matter?	Feb-16
What crowded positions are bubbling up in equity markets	Feb-16
What happened to Value, and when will it return?	Jan-16
Who benefits from automation?	Nov-15
The Spectre of Equity-Bond allocation	Nov-15
Dynamic Asset Allocation	Nov-15
How will demographics shape investing for the next ten years?	Nov-15
Surfing the macro wave	Sep-15
Why blame Risk-parity and CTAs?	Sep-15
Bonds are better: asset allocation in target dated funds	Sep-15
Low-Risk Investing: perhaps not everywhere	Jul-15
Cost efficient trading with time varying alphas	Jul-15
The Madness of Crowds	Jul-15
Lessons from Behavioural Finance	Jul-15
A Closer look at the Trend Factor	Jun-15
Understanding Size Investing	Jun-15
Safe Dividends in Times of Financial Repression	Jun-14
Costs as a Style Factor	Apr-15
Cross-Asset Seasonality	Mar-15
Extending our quality model to financials	Mar-15
Where are the crowded trades?	Jan-15
Stock Selection using Machine Learning	Jan-15
Investing in Growth	Jan-15
Harvesting Cross-Asset Value	Dec-14
How to avoid 'Torpedoes'	Nov-14

Academic Research Monitor

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Portfolio Construction and Overfitting	Jun-16
UBS Equity Markets Conference	May-16
European Quantitative Conference 2015 Highlights	Apr-16
Does Oil matter for Equity Markets?	Mar-16
Low Risk Investing	Feb-16
Value Investing	Dec-15
Analyst Forecasts and Measuring Distance	Nov-15
UBS Market Microstructure Conference	Oct-15
Equity Risk Premium Forecasting and Market Timing	Sep-15
Behavioural Investing Patterns	Jul-15
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Forecasting the Equity Risk Premium	Aug-14
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Timing momentum & risk parity	Jul-13

PAS User Guides			
Quick Reference Guide	Nov-15	Advanced Analysis	Oct-12
Risk Parity and Composite Assets	Jan-15	PAS Macros	Feb-16
Introduction to the UBS Portfolio Analysis System	Jan-15	Risk Models	Nov-11
Long-Short Analysis	Jan-15	UBS Hybrid Risk Model	Dec-10
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Reports	Apr-14	Portfolio Analysis	Jun-10
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R advice

Title	Date
Optimising in R	Aug-16
Speeding up R / Plotting correlation matrices	Jun-16

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Neutral	FSR is between -6% and 6% of the MRA.	38%	25%
Sell	FSR is > 6% below the MRA.	15%	21%
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Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 30 June 2016.
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