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Trading volatility

How we benefit from changing market conditions

- New strategies in the volatility space can benefit during turbulent as well as calm periods
- The strategies in this research have historically performed especially well during periods of market stress
- Performance makes a case for adding volatility strategies to a balanced portfolio of equities, bonds and other alternative risk premiums

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How we benefit from changing market conditions

Investors can insure their financial portfolios by buying derivative products such as options. An option price is usually quoted in terms of implied volatility, which can be understood as the amount of future market volatility that would justify the option price. Historically, implied volatility was often higher than the subsequently realized volatility. This volatility related premium compensates the seller for the associated tail risk. However, constantly changing market environments mean that the premiums paid for options also change with time. Therefore, situations can occur where selling options is not attractive and a long option position could even provide cheap insurance against outsized market moves.

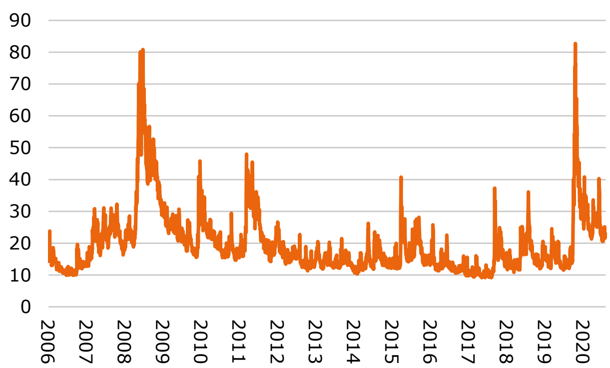
In this paper we consider the traditional factors momentum, value and carry, and explore whether factor-based strategies can benefit from changing volatility premiums in the VIX, a major volatility index that aggregates option prices on the S&P500 index.

What are VIX futures?

A widely used measure of volatility in the stock markets is the CBOE Volatility Index, or VIX (see Figure 1). The index is often tracked by financial media as a “fear index” or market sentiment indicator. Futures on the VIX are highly liquid instruments and, like options, carry a volatility-related risk premium. In this paper, we will describe the VIX, the market for VIX futures, and the factor strategies. We will then define the volatility strategies and evaluate their stand-alone and joint performances.

The VIX Index measures the implied volatility, or market price of volatility, on the S&P 500 Index over the coming month, based

Figure 1: CBOE Volatility Index (VIX), 2006-2020

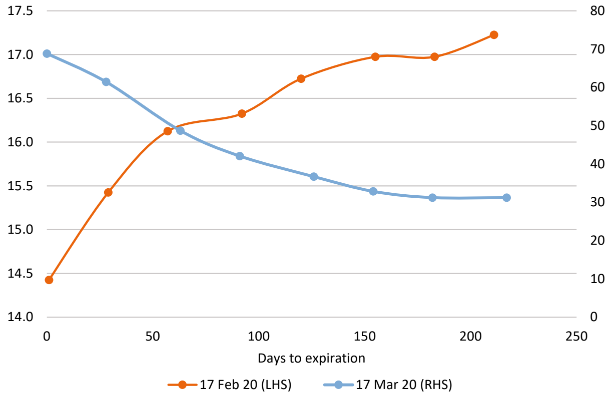


Source: Bloomberg

on a basket of S&P 500 option prices[1]. Volatility is defined as a standard deviation of returns, a statistical measurement of return dispersion. A VIX level of 20 corresponds to daily mean absolute returns of 1% in the S&P 500 Index, a VIX of 40 to 2%, and so on[2]. The one-month implied variance at any point in time tends to be higher than the subsequently realized variance over the next month, which is a manifestation of the variance risk premium.

The VIX measures the implied volatility of options with a one-month average maturity, and therefore does not reflect the expected cost of holding a long volatility position. As the one-month horizon rolls forward, the index tracks different instruments over time. Volatility differences across different instruments cannot be interpreted as return and cannot be replicated using market instruments.

Figure 2: VIX future prices corresponding to term structures on 17 Feb 2020 and 17 Mar 2020



Source: VIXCentral.com, NN Investment Partners

The cost of holding a long volatility position, or the cost of carry, is reflected in the prices of VIX futures across maturities. At expiration of a VIX future, the contract delivers the cash value of the index, that is, the one-month implied volatility. A VIX future expiring in one month is therefore related to S&P 500 options maturing in two months.

The collection of future prices across maturities is called the "term structure". Figure 2 presents two examples of VIX term structures. The blue dots represent the prices of VIX futures contracts which expire in a given number of days from 17 February 2020, as indicated on the horizontal axis, and likewise for the orange dots where the snapshot is from 17 March 2020.

These two dates were chosen because they illustrate two common shapes that occur in futures markets: contango, or upward sloping (orange line), and backwardation, or downward sloping (blue line). The contango shape is common in calm markets, whereas the backwardated shape indicates a substantial shock in the markets. The two shapes in Figure 2 plot the periods just before and just after the markets priced in the global impact of the Covid virus.

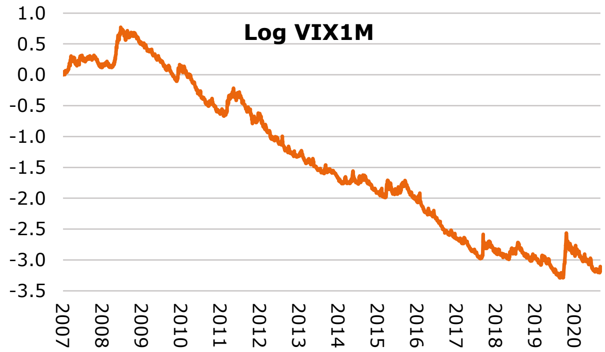
The shape of the term structure reflects two things: market expectations of future implied volatility and the cost of carry. The effect of the two is not easy to disentangle. Figure 2 shows that on 17 February 2020, during "normal" calm markets, the futures market was in contango. This means that, if the term structure were to stay the same, a short position on any point on the curve would "roll down" to the left, earning a positive carry for the seller of VIX futures. Of course, this comes at the risk of a sudden event, which could result in soaring VIX futures prices. The backwardated curve in Figure 2 is not dominated by the variance risk premium, but by market expectations that the implied volatility will revert to lower levels.

Figure 1 showed that the VIX Index is typically around 15-20, with some sudden spikes of variable magnitude. After each spike, the VIX reverts back to lower levels. These spikes correspond to periods of market stress with increased implied volatilities. The two most notable spikes during this time period were the great financial crisis around 2009 and the Covid-19 crisis in 2020.

VIX futures do not exhibit the same mean-reverting behaviour as the VIX index. To illustrate this, we consider the performance of a long VIX futures position on the two earliest-expiring contracts. The weight of those two contracts is chosen such that the weighted average of the maturities is one month.

The benefit of targeting a fixed average maturity is that the risk varies less throughout the month than buying the first or second contract and rolling it at expiration. The reason is that the front of the curve tends to be more volatile than further back. This particular combination of the first two VIX futures is denoted VIX1M, referring to the average maturity of one month. The logarithmic return of long VIX1M is depicted in Figure 3. Its downward slope is consistent with negative cost of carry of holding long volatility positions.

Figure 3: Logarithmic performance of one-month weighted maturity VIX futures



Source: Bloomberg, NN Investment Partners

1 To be precise, the VIX index is the square root of the one-month variance swap rate, which can be interpreted as the expected variance. Due to Jensen's inequality for concave functions, the expected square root of variance (i.e., the expected volatility) is bounded from above by the square root of the variance swap rate. In other words, the VIX can be seen as a proxy for expected volatility with a positive bias. For a comprehensive overview of how the VIX is constructed, see (CBOE, 2019) and (Demeterfi et al., 1999).

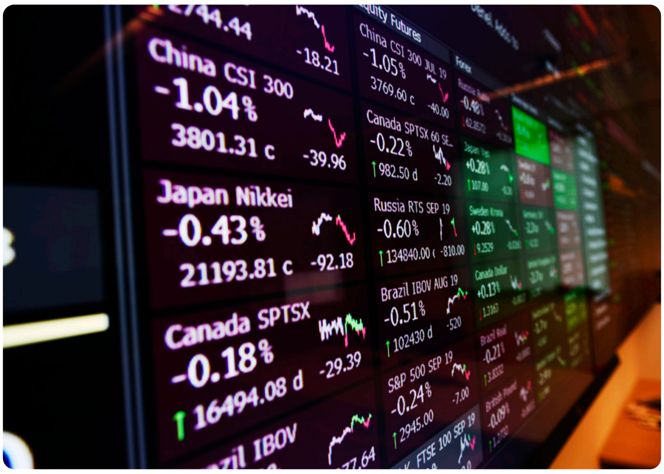
2 Under the assumption that S&P 500 returns are independent and have a normal distribution. This is calculated by using the fact that the mean of a half-normal distribution is given by $\sigma\frac{\sqrt{2}}{\sqrt{\pi}}$ and, due to independence, volatilities are normalized from annual to daily by dividing by $\sqrt{252}$.

Factor premiums and their explanations

In this section we review the rationale behind the types of factor strategies – value, momentum and carry – and how they relate to volatility. Value strategies aim to buy undervalued and sell overvalued assets and benefit from convergence to "fair value". Momentum strategies benefit from trends; positioning is based on recent performance. Carry strategies benefit when the term structure stays the same and nothing changes but the passage of time.

We can identify several types of drivers of risk premiums: risk-based, behavioural and market structural. The value factor can be explained by the fact that investors have capital constraints and are not always able to buy "cheap" assets or sell them when they are "expensive". Some investors are not permitted to take short positions, and others cannot apply leverage due to risk-based or market structural reasons.

A behavioural explanation is that investors pay too much attention to recent events, and overly fear distressed situations. These explanations are relevant for VIX futures as well. Investors may be unable to short VIX futures when it is "expensive" after a major event, due to loss of capital in the event or due to a recency bias that makes them fear further misery. Similarly, investors may be unwilling to buy VIX futures if long positions have been costly for an extended period of time, even though they are currently "cheap" (Sinclair, 2020).



Within momentum, past winners arguably face a greater risk going forward because their investment opportunities have been adjusted. This is especially true for VIX futures. If there has been an increase in implied volatilities, the potential upside of long volatility positions has decreased. In addition, empirical evidence shows that macroeconomic risks and time-varying risk premiums can explain a sizable portion of the momentum premium (Moskowitz, 2010). A behavioural explanation for momentum is that investors underreact to new information and subsequently overreact.

Carry has drivers that are similar to value and momentum, in that it reflects the embedded time-varying risk premium. A market structural explanation for high carry is that it indicates excessive hedging demand, whereas low carry could point towards excessive volatility selling. Taking the opposite side of the crowded trade and taking the role of a liquidity provider is expected to be profitable.

Strategy implementation

How do we capture the carry, value and momentum premiums with adaptive long/short time-series strategies? To achieve market neutral positioning in the long run, we rank the values of the factor measures in increasing order. We take long positions when the value of the measure is in the top 40%, short positions when in the bottom 40%, and neutral positions in between. We apply the signals resulting from the strategies to a weighted combination of the first two VIX futures, such that the average maturity is one month (VIX1M), and we scale the VIX futures position to an annualized volatility of 10%. For ease of exposition, we scale the strategy performance out-of-sample to 10% volatility. The time period of the back-test ranges from 1 June 2006 until 31 December 2020.

Momentum

Due to the VIX's tendency to rise quickly and revert more slowly, as shown in Figures 1 and 3, we can infer that short-term windows are needed to ensure sufficient reactivity. Using large windows makes the signal not adaptive enough in situations of market stress. On the other hand, a very short lookback window will lead to trades that are largely driven by noise, which gives a lot of false signals and leads to unnecessary turnover. To strike a balance between performance and adaptivity, we apply EWMA momentum with a half-life of one month.

Carry

The shape of the VIX term structure reflects market expectations of future volatility, as well as risk premiums at different horizons. Empirical evidence suggests that much of the variation of the VIX term structure can be explained by differences in the risk premium investors are willing to pay for different maturities (Johnson, 2017). The carry strategy takes long or short positions in VIX futures depending on the estimated carry, proxied by the rolldown that is measured.

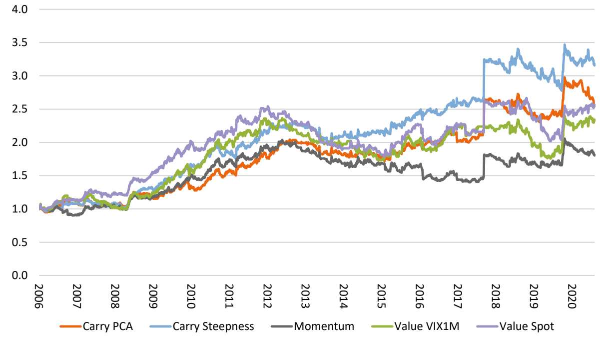
We use two different measures of carry. *Carry PCA* is based on a principal component analysis (PCA). PCA decomposes the term structure into orthogonal components in the decreasing order of the amount of variance in the term structure that each component explains. The first principal component can be interpreted as the "level" of the term structure; the second principal component represents the "slope" or "steepness" of the term structure. Higher-order principal components represent convexity and higher order effects. In this strategy, we use the second principal component of the term structure (where the first five contracts are included) as a measure of slope, which is in line with the approach in (Johnson, 2017). *Carry steepness* uses the one-month carry in the VIX futures (VIX1M) market versus VIX spot. If there is no contract expiring in one month, the one-month price is inferred through linear interpolation.

Both approaches aim to capture the same carry premium. Carry PCA has the advantage that it corrects the amount of slope for higher order effects, and it tends to be more stable as a larger range of maturities is considered. On the other hand, the carry steepness approach directly proxies the relevant rolldown on the maturity that we trade. Combining the two models improves strategy diversification and is therefore expected to improve risk adjusted returns.

Value

We use two implementations to compare the VIX with the realized volatility; the difference can be used as a measure of value. The first implementation, *value spot*, compares the VIX with the subsequent realized volatility. This is a way to measure the historical volatility risk premium. If the risk premium is relatively high, VIX levels are likely to revert eventually to the long-term mean. The second implementation, *value VIX1M*, compares the interpolated VIX1M futures level to realized volatility. Both methods are valid ways of measuring risk premiums. We diversify our strategies by including both implementations.

Figure 4: Comparison of performance of factor strategies, 1 Jun 2006 - 31 Dec 2020



Source: NN Investment Partners

Strategy results

In this section we consider the standalone performance of the individual strategies. We then examine the joint performance when combining the sub-strategies and factors based on equal weighting.

Performance of individual strategies

Table 1 and Figure 5 summarize the performance statistics of all strategies. The return/risk ratio (Ret/Risk) is the compound annualized growth rate (CAGR) divided by the volatility of the strategy. The MAR ratio is the compound annualized growth rate divided by the maximum drawdown (MaxDD) over the full sample.

An advantage of the MAR ratio with respect to Ret/Risk ratios is that it does not solely rely on the first two moments of a distribution, while the returns of VIX futures are non-normal and thus not characterized by the mean and standard deviation. In addition, the MAR ratio prefers strategies with a more consistent performance.

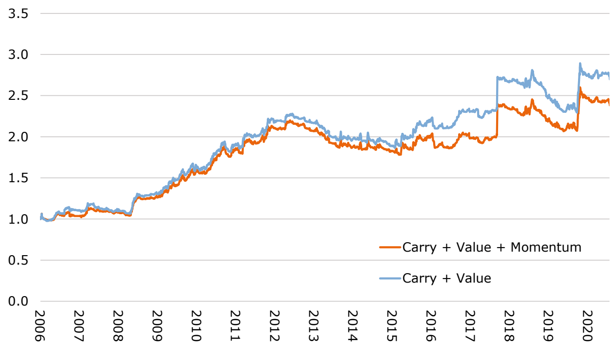
In this case, the Ret/Risk and MAR ratios give a similar impression of the relative performance of the strategy. The carry strategies perform best, with value not far behind. The momentum strategy's performance is positive but clearly not as good as the others.

Table 1: Performance metrics of all factor strategies, 1 Jun 2006 - 31 Dec 2020

Name	Ret/Risk	MaxDD	MAR Ratio
Carry PCA	0.66	0.16	0.41
Carry Steepness	0.82	0.19	0.44
Momentum	0.41	0.31	0.13
Value VIX1M	0.63	0.27	0.24
Value Spot	0.61	0.29	0.21

Source: NN Investment Partners

Figure 5: Performance comparison of carry, value and momentum versus carry and value



Source: NN Investment Partners

Joint performance

To assess the diversification benefits of different factor strategies on top of each other, it is important to measure the similarity between strategies. A common way to measure similarity of two strategies is by considering the Pearson correlation, illustrated in Table 2. Linear correlation is susceptible to outliers, whose effect is more pronounced when dealing with heavy-tailed distributions as is the case for VIX futures. Therefore, when calculating the correlations, we trim the 5% largest absolute returns in Table 2.

Table 2. Correlation between daily strategy returns (5% largest absolute returns trimmed)

	Carry PCA	Carry Steepness	Momentum	Value VIX1M	Value Spot
Carry PCA	1.00	0.78	0.72	0.29	0.31
Carry Steepness		1.00	0.55	0.23	0.26
Momentum			1.00	0.30	0.38
Value VIX1M				1.00	0.72
Value Spot					1.00

Source: NN Investment Partners

The correlation of returns between strategies within the same factor is high, which is logical, as they are constructed to benefit from the same factor premium. The correlation between momentum and carry is remarkably high, indicating that combining those strategies yields little in the way of diversification benefit. Intuitively, the similarity of the momentum and carry strategies can be understood as follows: when a sudden macroeconomic shock occurs, the front of the VIX curve increases more rapidly than longer-dated contracts, which means carry and momentum strategies will both take long positions. Conversely, momentum will take a short position during periods of high roll-down, which we can predict by measuring carry in the term structure. Table 3 shows that momentum's limited diversification benefits result in worse performance metrics.

Table 3: Performance comparison of equally weighted combinations of factor strategies

Name	ReturnRisk	Volatility	MaxDD	MAR Ratio
Carry + Value	0.90	0.08	0.18	0.38
Carry + Value + Momentum	0.76	0.08	0.19	0.32

Source: NN Investment Partners

Summary and conclusion

Our analysis of momentum, value and carry strategies as applied to VIX futures has shown that all factor strategies provide attractive risk-adjusted returns and are market neutral over the long run. On a portfolio level, we noticed that momentum and carry are similar in positioning and provide little diversification benefit with respect to each other.

Ever-changing option premiums have been shown to be exploitable using factor strategies that are known to work across asset classes. The strategies in this research have in the past performed especially well during periods of market stress, which helps to make a case for adding volatility strategies to a balanced portfolio of equities, bonds and other alternative risk premiums.

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