FICC Portfolio Monthly

# Volatility spilling all over the place

Bank of America Merrill Lynch

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## Understanding cross-asset vol spillover dynamics is key

The fast growth of short volatility strategies and its spread among asset classes since 2010 is concerning because volatility across different assets has a common risk factor. Hence, a small disturbance in one asset class might have destabilizing consequences in broad short vol portfolios. In this note we analyze the dynamics of vol spillovers among asset classes. We find that FX and US rates volatility is most affected by moves in other assets (US equities and commodities). On the other hand, US equities and commodities are the most influential assets when it comes to carrying their shocks to other markets. Our work shows that a large variability in volatility spillover measures is observable when major economic events occur. Furthermore, we observe that a regime shift in cross asset volatility spillovers—to a new and higher level—took place during the Global Financial Crisis.

## Directional vol spillover impact measures can add value...

We extend our previous analysis (Spilling the beans on volatility) to provide measures of the magnitude and direction of volatility spillovers. In this way, we look at the total influence a market exerts or receives in the system. A high "TO" measure, as defined in this note, implies that the asset is transmitting volatility *to* other assets, and a high "FROM" measure implies that the asset is vulnerable to volatility spilling over *from* other assets. Therefore we treat both directional measures equally as a negative factor for short vol positions. So we take the average of the "TO" and "FROM" measures for each individual asset and use this as a measure of the system-wide volatility spillover impact of that particular asset class.

## ...to short vol strategies by generating predictive signals

Next, we run a simple predictive regression to test if these impact measures are negatively associated with subsequent short vol returns for their specific asset class. We find that the impact measures may be able to help predict moves in commodities and FX, but not in equities or rates. And perhaps more interestingly, we find that the asset specific vol spillover impact measure shows strong predictive power on detecting drawdown events ahead for all asset classes in our sample (i.e., for equities, commodities, FX and rates). Finally, we turn the impact measure into a signal to illustrate how it might be used in a dynamic short vol strategy. Our results support the idea that vol spillover measures are a useful tool when it comes to mitigating losses from drawdowns.

Quantitative Cross Asset
Global


**QIS Research**
MLI (UK)

**KeyYong Park**
Derivatives Strategist
MLPF&S
keyyong.park@baml.com

**Peter Helles**
Commodity Strategist
MLI (UK)
peter.helles@baml.com

**Francisco Blanch**
Commodity & Deriv Strategist
MLPF&S
+1 646 855 6212
francisco.blanch@baml.com

**Abhinandan Deb** >>
Equity-Linked Analyst
MLI (UK)
abhinandan.deb@baml.com

**Nitin Saksena**
Equity-Linked Analyst
MLPF&S
nitin.saksena@baml.com

**Anshul Gupta** >>
Equity-Linked Analyst
MLI (UK)
agupta113@baml.com

**Myria Kyriacou**
FICC Quant Strategist
MLI (UK)
myria.kyriacou@baml.com




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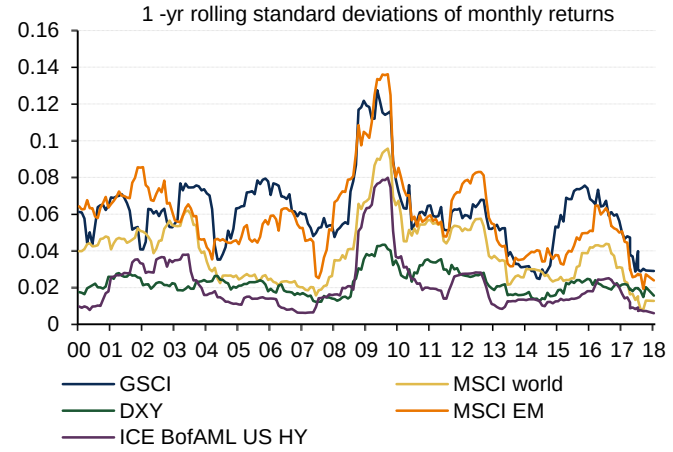
# Volatility spilling all over the place

### Understanding cross-asset vol dynamics is important

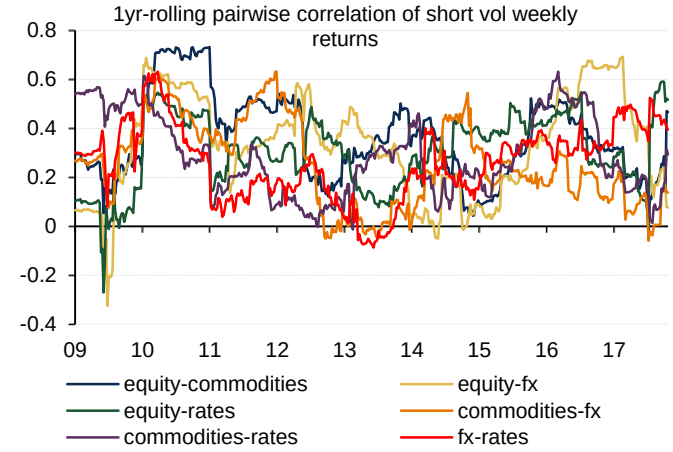
The volatility of asset returns is a crucial input for risk management, asset allocation, and volatility targeting strategies. It is therefore of primary interest to learn more about the volatility dynamics in financial markets. In recent years, due to a low yield and low volatility environment, short volatility strategies have grown tremendously in popularity across different assets. However, volatility across various asset classes can be at times highly correlated, as we observed in 2008 (Chart 1) and hence the extraordinary growth of short volatility strategies might create risks. The cross-asset correlation of short vol strategies is generally high (Chart 2). And as a consequence of the commonality among the strategies, any volatility shock to an asset can potentially spread to the whole market, as we saw recently when equity market volatility spiked.

**Chart 1: Volatility across various asset classes can be at times highly correlated, as we observed in 2008**




Source: Bloomberg
Note: X-axis displays years (20xx)

**Chart 2: The cross-asset correlation of short vol strategies is generally high**




Source: Bloomberg , BofA Merrill Lynch Global Research
Note: We used the following short vol strategies: MLCVDK6D index, MLEISVSP index, MLEIS2TY index, and MLEISVXE index for commodities, equities, rates, and FX. X-axis displays years (20xx)

### We extend our vol spillover measure to more asset classes

In our last CPM (Spilling the beans on volatility) we analyzed the interconnections between markets from a different angle using a spillover measure. The measure is based on the shares of the forecast error variance ascribed to spillovers between particular markets.[1] We then turned our spillover metric into a signal, and used this to construct a dynamic strategy which upscales or downscales cross-asset vol positions. In this piece, we take a step forward considering more asset classes including US equity, US treasuries (representing rates), USDEUR (representing FX) and global commodity markets. And furthermore we also quantify pairwise directional impacts from one market to another.[2] The directional pairwise volatility spillover enables us to capture the individual contributions of assets to the aggregate volatility spillovers.

[1] Diebold, Francis X., and Kamil Yilmaz. "Measuring financial asset return and volatility spillovers, with application to global equity markets." *The Economic Journal* 119.534 (2009): 158-171.
Diebold, Francis X., and Kamil Yılmaz. "On the network topology of variance decompositions: Measuring the connectedness of financial firms." *Journal of Econometrics* 182.1 (2014): 119-134.

[2] We calculate the spillover metric from the forecast error variance-covariance matrix from a 4-variable VAR, where each varaible is the intra-week realized volatility. We use weekly high, low, opening and closing prices to estimate the intra-week realized volatility following Garman and Klass (1980) and Alizadeh et al. (2002): Volatility = 0.511(h-l)2 – 0.019[(c-o)(h+l-2o)-2(h-o)(l-o)]-0.383(c-o)2 where h, l, o and c stand for the log of daily high price, low price, opening price and close price respectively.

### A spillover table enables us to picture "to and from" volatility spillovers

We first characterize volatility spillovers over the entire sample period using weekly data from 1998 to present. We follow the methodoly of Diebold, Francis X., and Kamil Yilmaz to calculate the volatility spillover table (Chart 3) using Forecast Error Variance Decomposition (FEVD). The ij-entry in the spillover table is the estimated contribution to the forecast error variance of market i coming from shocks to market j. The off-diagonal column sums (labelled Contributions TO others) or row sums (labelled Contributions FROM others), when aggregated across markets, give the numerator of the spillover measure. And, the column sums or row sums (including diagonals), when aggregated across markets, give the denominator of the spillover measure. The result of the spillover metric for the entire sample is 18%. FX (USDEUR) and US treasuries are the assets mostly affected by the innovations to other assets. On the other hand, US equity and Global commodities are the most influential assets carrying their shocks to other assets.

**Table 1: Spillover table**

| Vol Spillover | SPX | BCOM | USDEUR | 2YR UST | Contribution FROM others |
|---|---|---|---|---|---|
| SPX | 88.8 | 7.8 | 3.4 | 0.0 | 11.2 |
| BCOM | 8.0 | 88.8 | 3.2 | 0.0 | 11.2 |
| USDEUR | 7.3 | 14.0 | 77.4 | 1.3 | 22.6 |
| 2YR UST | 20.9 | 2.8 | 2.0 | 74.4 | 25.6 |
| Contribution TO others | 36.2 | 24.5 | 8.5 | 1.4 | spillover = 17.7% |

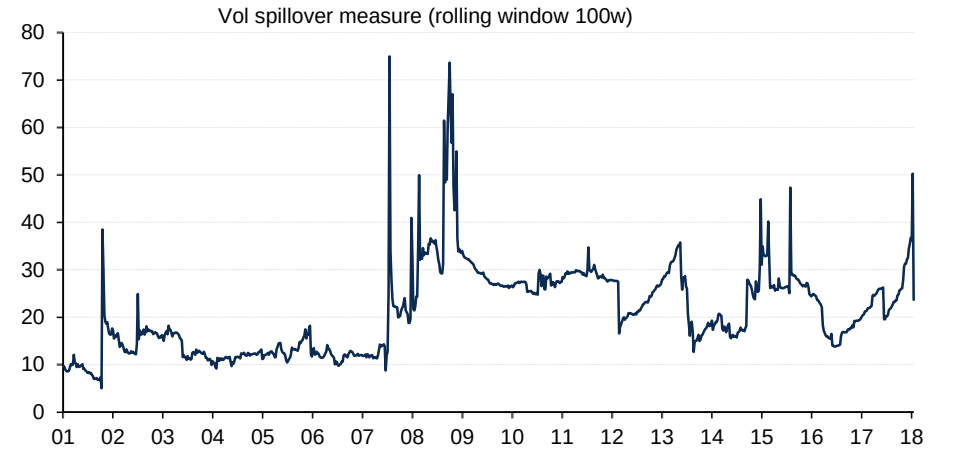
Source: BofA Merrill Lynch Global Research estimates

Note: Data spans from Oct. 1998 to Feb. 2018. The variance decomposition is based upon a weekly VAR order of 2, identified using a Cholesky factorisation with the ordering as shown in the column heading. The ij-th entry is the estimated contribution to the variance of the 10-week-ahead return forecast error of sector i coming from innovations to returns of sector j. Contribution FROM others = sum of off-diagonal terms by rows. Contribution To others = sum of off-diagonal terms by columns

### Historically, our spillover measure traces vol spikes and contagion episodes

A time-varying volatility spillover measure requires rolling estimation over the sample period. So we use 100-week rolling sample periods to compute a time series for the volatility spillover measures. Chart 3 shows that high volatility spillover is historically observable when major economic events occur: the Dot-com bubble burst in 2001, the Global Financial Crisis in 2008-2009, the European debt crisis in 2012, the "flash crash" in 2015 due to various economic reasons such as the Fed's first rate hike in nine years, crude oil plummeting, and a weakening Chinese economic outlook. It also captures the recent spike in VIX. Furthermore, we can observe that a regime shift in volatility spillovers, to a new and higher level, took place during the Global Financial Crisis.

**Chart 3: Time-varying volatility spillover measure**



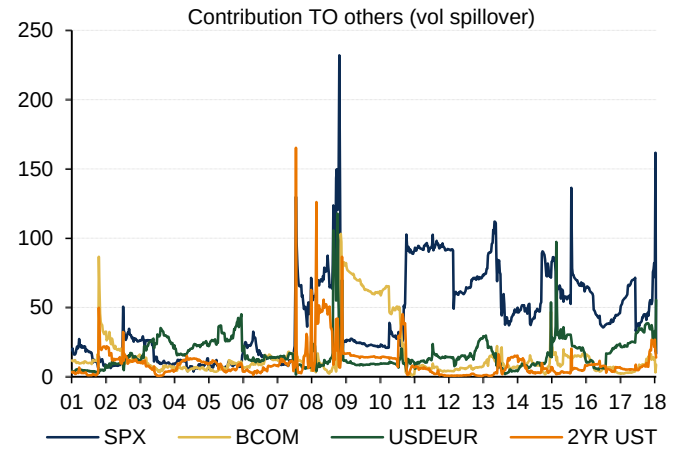

Source: BofA Merrill Lynch Global Research estimates

Note: We plot moving volatility spillover measure, defined as the sum of all variance decomposition 'contributions to others' (or equivalently 'contributions from others') from spillover tables, respectively, estimated using 100-week rolling windows. The 100-week rolling analysis discards first 100-week observations. X-axis displays years (20xx)

**We suggest a directional measure of pairwise market connectedness…**

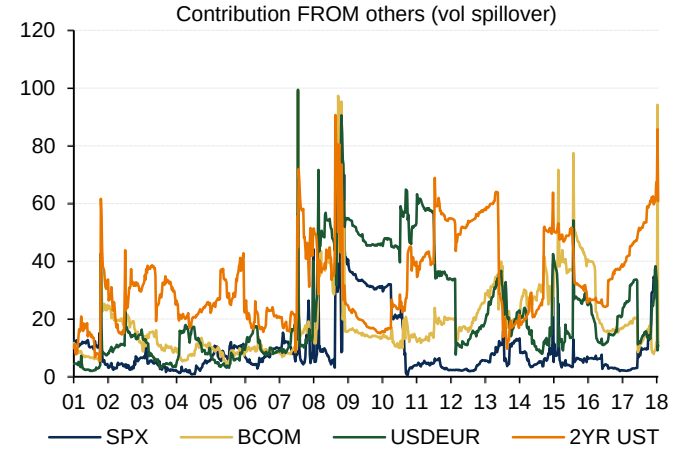
From the rolling sample estimates we also have a time-varying directional measure of pairwise connectedness from one market to another. For each rolling sample we sum up the off-diagonal terms of the spillover matrix by columns and rows, and from that we can derive aggregate "FROM" and "TO" connectedness measures (Chart 4 and Chart 5). This allows us to investigate the total influence a given market exerts or receives in the system. We can reaffirm that US equity is the biggest net sender of volatility shocks and UST is the biggest net receiver of volatility shocks, relative to their own respective vols.

**Chart 4: US equity is the biggest net sender of volatility shocks**




Source: BofA Merrill Lynch Global Research estimates
Note: X-axis displays years (20xx)

**Chart 5: UST is the biggest net receiver of volatility shocks**

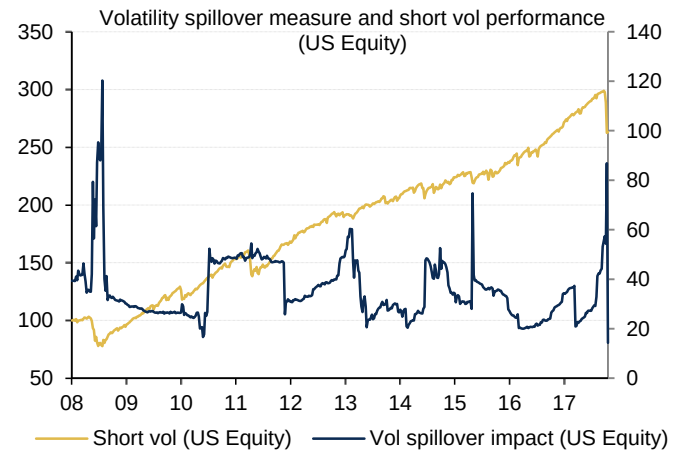



Source: BofA Merrill Lynch Global Research estimates
Note: X-axis displays years (20xx)

**…which we use to calculate the asset specific vol spillover impact**

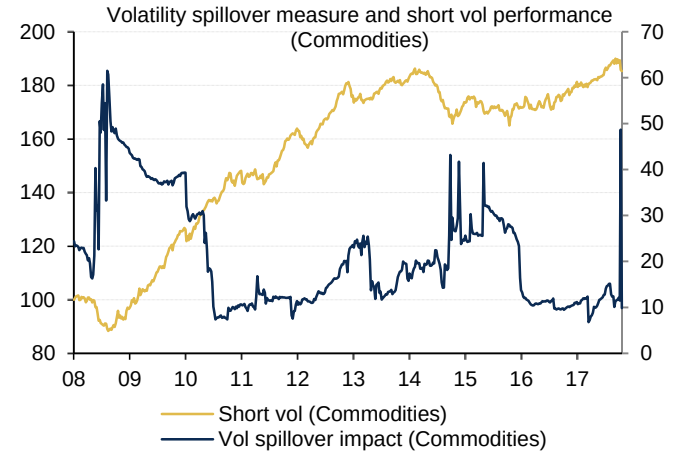
We then take the average of "TO" and "FROM" measures of each individual asset and use this as measure of the system-wide volatility spillover impact of that particular asset class. We call this the asset specific volatility spillover impact measure, or impact measure for short (Chart 6 through Chart 9). A high "TO" measure implies that the asset is transmitting volatility to other assets and a high "FROM" measure implies that the asset is vulnerable to the volatility spillovers. So high levels of both measures relative to their own history have negative implications for short vol positions and hence should be considered equally.

**Chart 6: High "TO" measure implies that the asset is transmitting volatility to other assets…**



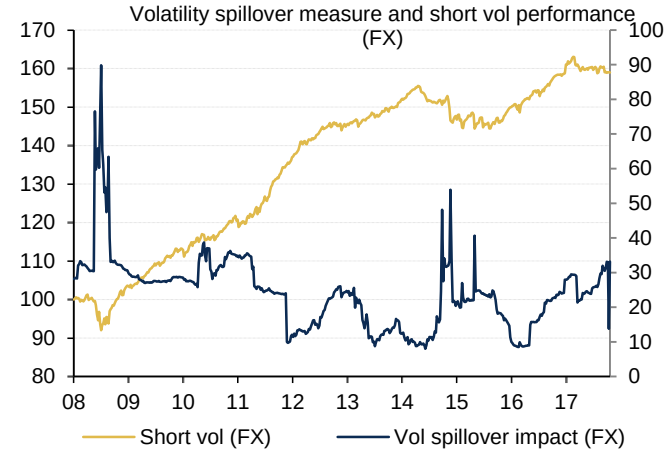

Source: Bloomberg , BofA Merrill Lynch Global Research estimates
Note: X-axis displays years (20xx)

**Chart 7: …and high "FROM" measure implies that the asset is vulnerable to the volatility spillovers**



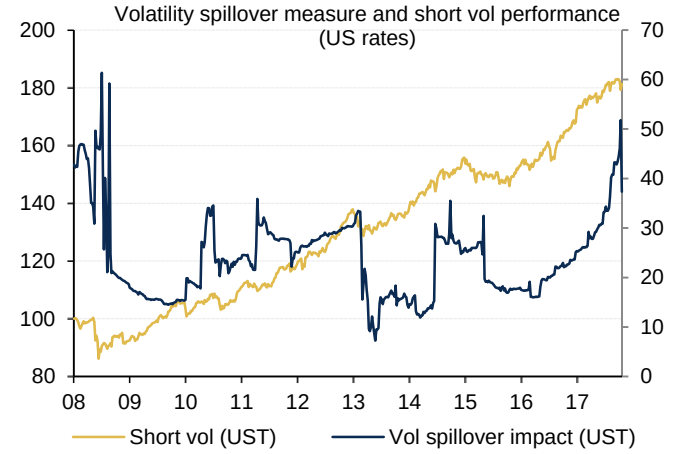

Source: Bloomberg , BofA Merrill Lynch Global Research estimates
Note: X-axis displays years (20xx)

**Chart 8: High levels of both measures have negative implications for short vol positions…**




Source: Bloomberg , BofA Merrill Lynch Global Research estimates

**Chart 9: …and hence should be considered equally by taking the average of "TO" and "FROM" measures**




Source: Bloomberg , BofA Merrill Lynch Global Research estimates

**The impact measure predicts short vol returns for most asset classes…**

The next logcial question is to see whether the impact measure can predict the performance of short vol strategies and thus use it as a signal to scale exposure to these strategies. First, we test if the impact measure has statistically significant predictive power over weekly returns for short vol strategies, and second we test the predictive power on large drawdowns. So first we regress weekly returns for short vol strategies on the lagged impact measure, lagged credit spread, and lagged yield spread. According to BIS (2012)[3], variables that are proxies for credit risk and funding liquidity consistently show up as common predictors of volatility across several asset classes. So we included credit spread and yield spread in our predictive regression as control variables. We find that the impact measures are negatively associated with subsequent short vol returns except UST and have statistically significant predictive power for commodities and FX in our sample (Table 2).

**Table 2: We test if the vol spillover impact measure for each asset class has statistically significant predictive power over weekly returns for short vol strategies.**

| US Equity | Beta | t-stat | p-value |
|---|---|---|---|
| Vol spillover impact measure | -0.003 | -1.29 | 0.20 |
| Yield spread | 0.001 | 0.67 | 0.50 |
| Credit spread | 0.002 | 1.27 | 0.20 |
| | | | |
| **Commodities** | **Beta** | **t-stat** | **p-value** |
| Vol spillover impact measure | -0.002** | -2.05 | 0.04 |
| Yield spread | 0.001* | 1.70 | 0.09 |
| Credit spread | 0.001 | 1.31 | 0.19 |
| | | | |
| **FX** | **Beta** | **t-stat** | **p-value** |
| Vol spillover impact measure | -0.002* | -1.80 | 0.07 |
| Yield spread | 0.000* | 0.50 | 0.62 |
| Credit spread | 0.001* | 1.76 | 0.08 |
| | | | |
| **US treasury** | **Beta** | **t-stat** | **p-value** |
| Vol spillover impact measure | 0.001 | 0.89 | 0.38 |
| Yield spread | 0.000 | 0.66 | 0.51 |
| Credit spread | 0.000 | -0.22 | 0.83 |

Source: BofA Merrill Lynch Global Research estimates

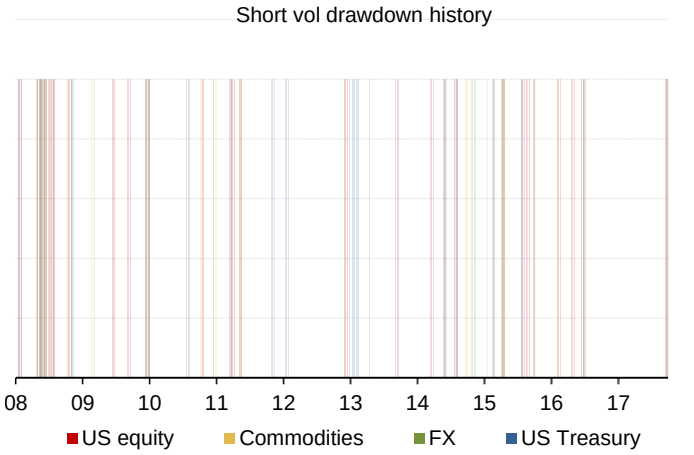
Note: Data spans from May. 2008 to Feb. 2018 based on short vol strategies data availability *significant at 10% level. **significant at 5% level. ***significant at 1% level. To correct for serial correlation in the residuals, Newey-West HAC standard errors are used to calculate t-stats and p-values. Back-testing is hypothetical in nature and reflects application of the strategy prior to its introduction. It is not actual performance and it is not intended to be indicative of future performance.

[3] Christiansen, Charlotte, Maik Schmeling, and Andreas Schrimpf. "A comprehensive look at financial volatility prediction by economic variables." *Journal of Applied Econometrics* 27.6 (2012): 956-977.

**...and also has predictive power over large drawdowns of short vol strategies**

To test whether the impact measure predicts material drawdowns we first define what constitutes the material short vol strategy drawdown episodes in the history. If a decline in value from a previous local maximum to a subsequent trough within a rolling 4-week window is larger than 2%, then we define it as an episode of "drawdown". Chart 10 shows the short vol drawdown history. We then run a binary logit model by regressing the dichotomous dependent variable (drawdown = 1 otherwise 0) on the independent variables used for our predictive regression. For all asset classes, vol spillover impact measure shows strong predictive power on detecting drawdown events ahead (Table 3). These statistical results provide theoretical background why volatility spillover impact signals would have improved the current short vol strategies across different assets.

**Chart 10: Short vol drawdown history for each asset class**




Source: Bloomberg , BofA Merrill Lynch Global Research estimates
Note: We picked 2% for simplicity as any threhold is arbitrary. One could also pick a threhold based on the individual asset class' stdevs which are 1.4%, 0.8%, 0.6%, and 1% for US Equity, Commodiites, FX, and US Treasury, respectively. X-axis displays years (20xx)

**Table 3: Binary logit model testing if vol spillover impact measure has predictive power on detecting drawdown events ahead**

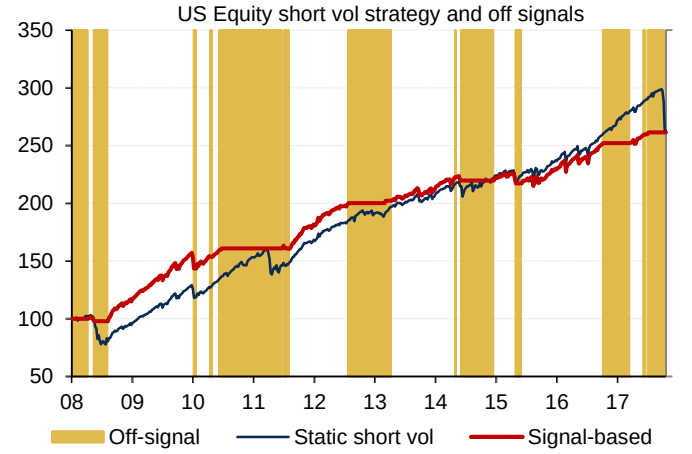
| US Equity | Beta | z-stat | p-value |
|---|---|---|---|
| Vol spillover impact measure | 1.71*** | 4.69 | 0.00 |
| Yield spread | 0.78*** | 3.85 | 0.00 |
| Credit spread | 0.00 | 0.02 | 0.98 |
| **Commodities** | **Beta** | **z-stat** | **p-value** |
| Vol spillover impact measure | 1.23*** | 3.15 | 0.00 |
| Yield spread | 0.32 | 1.33 | 0.18 |
| Credit spread | 0.32 | 1.11 | 0.27 |
| **FX** | **Beta** | **z-stat** | **p-value** |
| Vol spillover impact measure | 2.86*** | 5.37 | 0.00 |
| Yield spread | 0.28 | 0.61 | 0.54 |
| Credit spread | 0.61 | 0.94 | 0.35 |
| **US treasury** | **Beta** | **z-stat** | **p-value** |
| Vol spillover impact measure | 1.27** | 2.54 | 0.01 |
| Yield spread | 0.76*** | 3.30 | 0.00 |
| Credit spread | 0.11 | 0.43 | 0.66 |

Source: BofA Merrill Lynch Global Research estimates
Note: Data spans from May. 2008 to Feb. 2018. *significant at 10% level. **significant at 5% level. ***significant at 1% level. We used Newton-Raphson with Marquardt steps to estimate the covariance matrix. Back-testing is hypothetical in nature and reflects application of the strategy prior to its introduction. It is not actual performance and it is not intended to be indicative of future performance.

**The impact measure could help enhance performance of short vol strategies**

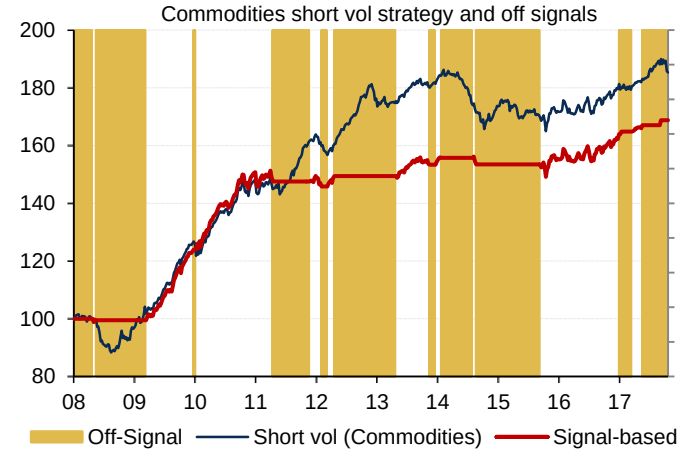
The predictive power of the impact measure for short vol strategy returns and drawdowns creates scope for using the impact measure to construct a signal in a dynamic vol strategy with enhanced risk-adjusted returns over the static version. If the vol spillover impact measure is larger (smaller) than its 1yr historical average, then it produces off (on) signals. This is intuitive given that a high volatility spillover impact measure should hurt the short vol positions. As seen in the charts below (Chart 11 through Chart 14), the off-signals have been generated ahead of large drawdowns and helped to mitigate losses from them. Therefore on/off signals have the potential to improve risk-adjusted returns by maintaining similar returns and reducing volatilities significantly.

**Chart 11: Signals from vol spillover impact measure can improve static short vol strategies (US equity)**



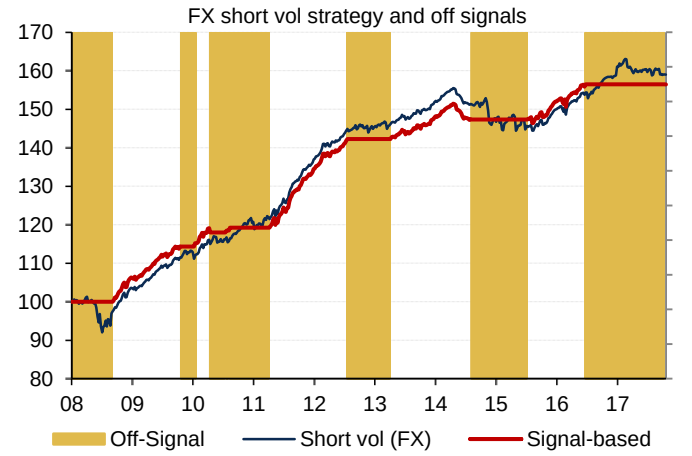

Source: Bloomberg , BofA Merrill Lynch Global Research estimates
Note: Back-testing is hypothetical in nature and reflects application of the strategy prior to its introduction. It is not actual performance and it is not intended to be indicative of future performance. X-axis displays years (20xx)

**Chart 12: Signals from vol spillover impact measure can improve static short vol strategies (Commodities)**



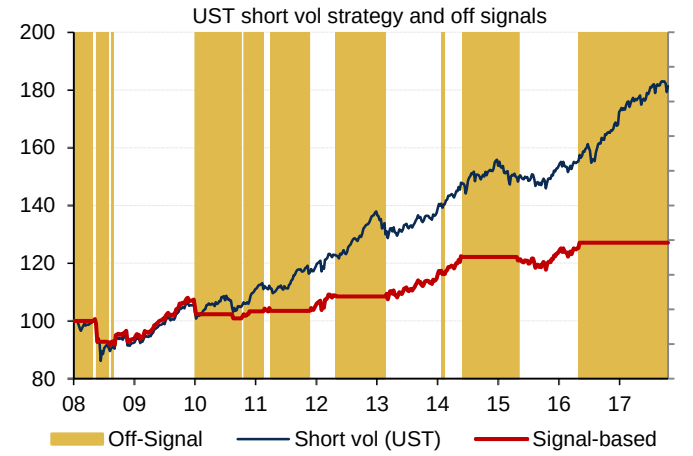

Source: Bloomberg , BofA Merrill Lynch Global Research estimates
Note: Back-testing is hypothetical in nature and reflects application of the strategy prior to its introduction. It is not actual performance and it is not intended to be indicative of future performance. X-axis displays years (20xx)

**Chart 13: Signals from vol spillover impact measure can improve static short vol strategies (FX)**




Source: Bloomberg , BofA Merrill Lynch Global Research estimates
Note: Back-testing is hypothetical in nature and reflects application of the strategy prior to its introduction. It is not actual performance and it is not intended to be indicative of future performance. X-axis displays years (20xx)

**Chart 14: Signals from vol spillover impact measure are not very successful in improving static short vol strategies (US rates)**




Source: Bloomberg , BofA Merrill Lynch Global Research estimates
Note: Back-testing is hypothetical in nature and reflects application of the strategy prior to its introduction. It is not actual performance and it is not intended to be indicative of future performance. X-axis displays years (20xx)

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