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Hedging High Yield and Emerging Market Bond Tail Risk With VIX[®] Futures

EXECUTIVE SUMMARY

High yield corporate bonds and emerging market U.S. dollar-denominated bonds are both credit-focused fixed income sectors. Lack of liquidity at times for both sectors can make hedging bond portfolios a challenge. Traditionally, an index-based credit default swap (e.g., CDX, iTraxx) can be used to hedge credit exposure. However, during periods of market stress, the basis between cash bonds and the synthetic swaps can widen significantly, reducing the effectiveness of the index credit default swap as a hedging tool.

Since both are often considered risky assets, high yield and emerging market bonds tend to resemble equities in the way that they respond to adverse macroeconomic changes and shifts in market sentiment. This prompts us to consider alternative hedging instruments that utilize systematic overlay of liquid equity index derivatives to hedge systematic risk in high yield or emerging market bond portfolios.

In this paper, we investigate the relationship between the credit bond sectors and the CBOE Volatility Index[®] (VIX), a leading indicator of the implied volatility of the U.S. equity market. We also evaluate the effectiveness of using VIX futures as a hedging instrument for high yield and emerging market bond portfolios. Our study shows the following.

- Historically, VIX and VIX futures demonstrate a strong negative correlation to returns of U.S. high yield corporate bonds and emerging market bonds, especially in distressed market environments.
- Compared to VIX spot, VIX futures exhibit stronger negative correlation with credit bonds, which mostly comes from down markets, when the VIX futures curve is more likely to be in backwardation.
- Historically, dynamically allocating VIX futures to high yield and emerging market bond portfolios reduced portfolio drawdown and return volatility and improved risk adjusted returns.

I. INTRODUCTION

High yield corporate and emerging market bonds are two credit-focused bond sectors that are often seen as volatile. Emerging market U.S. dollar-denominated bonds include debt issued by sovereign, quasi-sovereign, and corporate entities from emerging markets. Like high yield bonds, emerging market bonds are exposed to U.S. interest rate changes and credit risk on a sovereign or corporate level. Portfolio managers commonly include both high yield corporate and emerging market bonds in investment mandates given their similar risk profiles and comparable yield levels.

Within fixed income, high yield and emerging market bonds are among the least liquid sectors. That means that during periods of market stress, scaling down a high yield or emerging market bond portfolio tactically can be costly or even difficult to implement without causing significant market impact. There are a couple of common hedging options for high yield and emerging market bonds, each with its own limits and drawbacks.

- Fixed income derivatives: Both high yield and emerging market bonds have duration risk to interest rates and exposure to credit spreads. It is efficient to hedge duration risk with Treasury futures, swaps, or even cash Treasury bonds. To hedge credit risk, it is common to use credit default swap index. However, the basis risk between cash bonds and synthetic swaps is not negligible and can widen significantly at the time of credit stress.
- High yield or emerging market bond ETFs: Theoretically, this strategy sells away the systematic credit market risk and maintains idiosyncratic credit risk. The problem with this hedging option is twofold. First, even with the rapid growth of bond ETFs in recent years, their size is still small relative to the size of all outstanding bonds. As of May 2017, there were 32 high yield bond ETFs and 13 emerging market bond ETFs with AUM of USD 53.5 billion and USD 17.8 billion, respectively, a fraction of the market value of USD 1.5 trillion and 1.8 trillion for the [S&P U.S. High Yield Corporate Bond Index](#) and Bloomberg Barclays EM USD Aggregate Bond Index, respectively. Second, the liquidity and trading cost of bond ETFs should closely reflect that of the underlying bonds. It is not unreasonable to expect wide discounts or premiums and bid-ask spreads from bond ETFs during times of market stress.

Alternatively, we could consider hedging credit portfolios with equity instruments. For high yield and emerging market bonds, credit and liquidity risks are defining for these sectors and challenging to hedge. Together, corporate bonds and stocks represent the full capital structure of companies, and they both respond to changes in the underlying economy and macroeconomic policies. It is not surprising to see that credit bonds can

Tactically scaling down a high yield or emerging market bond portfolio can be costly or even difficult to implement, particularly during times of adverse market movements.

move with equities in a correlated way. Dor and Guan (2017) demonstrated that equity futures can be used to hedge high yield portfolios.

VIX measures the implied volatility of the U.S. equity market, and it has long been closely monitored by fixed income market participants to gauge broad risk sentiment in financial markets. The observation of high VIX levels when credit bonds underperform invites the question of whether VIX futures can be an effective hedging tool to provide downside protection for bond portfolios. As such, the objective of this study is to investigate the correlation between high yield and emerging market bonds and VIX and VIX futures, as well as explore basic hedging strategies using VIX futures.

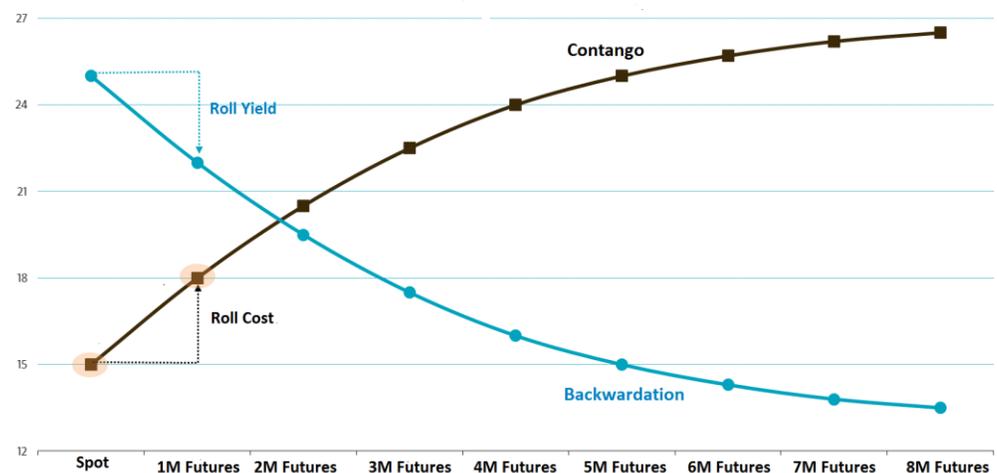
II. VIX AND VIX FUTURES

The CBOE Volatility Index (VIX) measures equity market volatility in the coming 30 days. The index uses [S&P 500®](#) options and a variance swap model to derive an implied volatility across all strikes of options. VIX has a liquid derivatives market, including futures, options, ETFs, and other OTC products. In 2016, the average daily trading volume of VIX futures and options were 238,588 and 588,237 contracts, respectively, and the AUM on VIX-related ETP's exceeded USD 3 billion. A liquid VIX market with size and depth allows VIX products to hedge sizable credit bond portfolios without risking moving underlying bonds.

A liquid VIX market with size and depth allows VIX products to hedge credit bond portfolios of size without risking moving underlying bonds.

A key concept for any futures contracts, not just VIX futures, is the futures term structure, since the futures curve shape dictates whether rolling futures over time incurs cost or benefit. Futures are in contango when the futures term structure is upward sloping, meaning the futures prices are more expensive than the spot. Futures are in backwardation when the futures term structure is downward sloping, meaning the futures prices are less expensive than the spot (see Exhibit 1).

Exhibit 1: Contango and Backwardation



Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

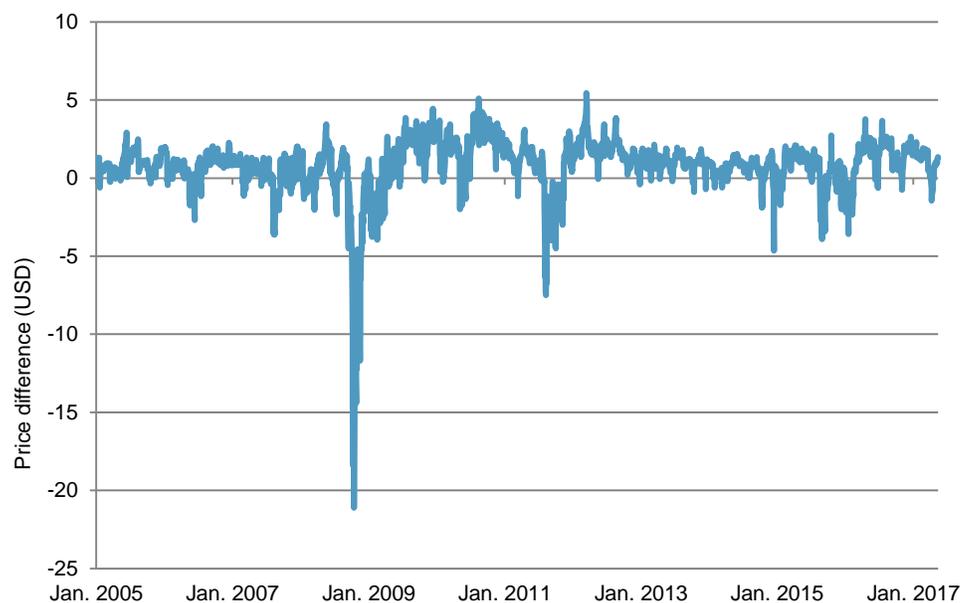
Holding a long position in VIX futures over the long term tends to incur losses because the VIX futures term structure is usually in contango.

Assume a market participant holds a long futures position when the futures curve is in contango. Upon the expiration of the current futures, he may choose either to let the futures expire or roll to the next contract. In the former case, his futures price drops as it converges to the spot; in the latter case, he has to pay the price difference to roll to the next futures contract. Either way he incurs a loss due to contango, which is called “roll cost.” Similarly, when the futures market is in backwardation, a market participant with a long futures position benefits from the futures term structure upon the expiration of the futures contract whether he chooses to let the contract expire or roll to the next one. This is called “roll yield.” Neither roll cost nor roll yield is unique to VIX futures. However, as the VIX futures are usually in contango, as shown in Exhibit 2, there is usually a roll cost associated with holding VIX futures as a hedge (see Exhibit 2).

Although the VIX spot index is somewhat mean-reverting, holding a long position in VIX futures over the long term tends to produce losses because the VIX futures term structure is usually in contango, as market participants usually associate more uncertainty with longer time horizons. However, in a stressed market where immediate risk is perceived by most market participants, the VIX futures curve usually flips into backwardation.

For illustration purposes, Exhibit 2 shows the price difference between the second month VIX futures and the first month contracts, the two most liquid futures contracts in the market, between Jan. 3, 2005, and May 17, 2017. By definition, a positive difference indicates contango and a negative number indicates backwardation; in 2,562 of the 3,114 trading days (82.27%), the VIX futures curve was in contango.

Exhibit 2: Second-Month VIX Futures Price Minus First-Month VIX Futures Price



Source: S&P Dow Jones Indices LLC. Data from Jan. 3, 2006, to May 17, 2017. Chart is provided for illustrative purposes. Past performance is no guarantee of future results.

III. DATA

Since VIX spot is not directly tradable, the [S&P 500 VIX Short-Term Futures Index](#) is used to measure performance of VIX positions. The index seeks to track a position in first- and second-term VIX futures with a weighted average maturity of 30 days. Liu and Dash (2010) showed that even though the index does not track VIX spot perfectly, it maintains the negative correlation of VIX spot with the equity market, thereby making it an attractive instrument for trading and hedging purposes.

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For the hypothetical bond portfolios, the following benchmark indices were used.

- U.S. high yield corporate bonds (US HY): [S&P U.S. High Yield Corporate Bond Index](#)
- Emerging market U.S. dollar-denominated bonds (EMD USD): Bloomberg Barclays EM USD Aggregate Bond Index

IV. CORRELATION ANALYSIS

To analyze the relationship between VIX and bond sector returns, we ran correlation analyses for the various variables. Since the first value date of the S&P 500 VIX Short-Term Futures Index is Dec. 20, 2005, the correlation analysis is presented over two time periods (see Exhibits 3a and 3b). Exhibit 3a shows the correlation matrix of monthly returns of various asset classes with VIX for the past 24 years, and the Exhibit 3b shows correlation matrix with the additional variable of return series of the S&P 500 VIX Short-Term Futures Index since December 2005.

Exhibit 3a: Correlation Between April 1993 and April 2017

INDEX	S&P 500	VIX	S&P U.S. HIGH YIELD CORPORATE BOND INDEX	BLOOMBERG BARCLAYS EM USD AGGREGATE BOND INDEX
S&P 500	1			
VIX	-0.64	1		
S&P U.S. HIGH YIELD CORPORATE BOND INDEX	0.61	-0.43	1	
BLOOMBERG BARCLAYS EM USD AGGREGATE BOND INDEX	0.54	-0.47	0.58	1

Source: S&P Dow Jones Indices LLC, Bloomberg. Data from April 1993 to April 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 3b: Correlation Between January 2006 and April 2017

INDEX	S&P 500	VIX	S&P 500 VIX SHORT-TERM FUTURES INDEX	S&P U.S. HIGH YIELD CORPORATE BOND INDEX	BLOOMBERG BARCLAYS EM USD AGGREGATE BOND INDEX
S&P 500	1				
VIX	-0.68	1			
S&P 500 VIX SHORT-TERM FUTURES INDEX	-0.78	0.79	1		
S&P U.S. HIGH YIELD CORPORATE BOND INDEX	0.72	-0.48	-0.69	1	
BLOOMBERG BARCLAYS EM USD AGGREGATE BOND INDEX	0.60	-0.48	-0.65	0.79	1

Source: S&P Dow Jones Indices LLC, Bloomberg. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

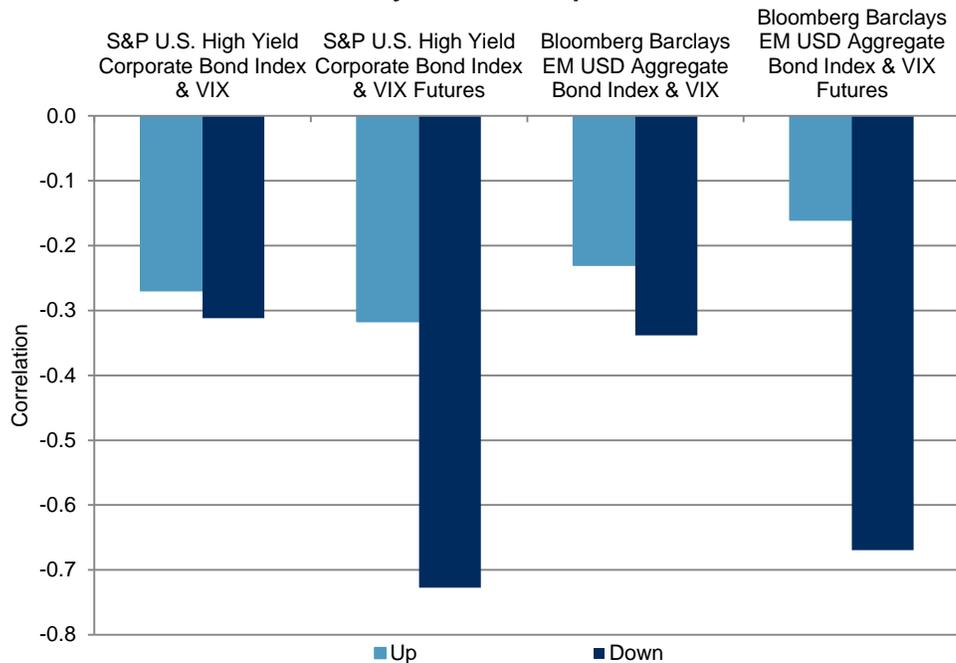
Based on the correlation analysis, we can make the following observations.

1. There is a strong correlation between high yield and emerging market bond returns (0.58 and 0.79). This could be due to the fact that emerging market countries and corporations that issue U.S. dollar-denominated bonds are likely to be closely tied to the strength of the U.S. economy and U.S. companies. The overlapping investor base for high yield and emerging market bonds may also compound the return correlation between these two sectors.
2. There is a strong correlation between high yield and emerging market bonds and the [S&P 500](#). In other words, returns from U.S. large-cap stocks can explain a large part of variance in high yield and emerging market bond returns. Over the past 24 years, 37% of (square of correlation) variance in high yield bond returns and 29% of variance in emerging market bond returns can be explained by the variations in the returns of U.S. equities.
3. There is a strong correlation between VIX and VIX futures. It confirms that VIX futures can be a tradable proxy for VIX spot.
4. There is a negative correlation between VIX and VIX futures and high yield and emerging market bonds. It demonstrates that as high yield and emerging market bonds have more exposure to credit spreads than duration risk, they exhibit more equity-like properties and a strong correlation with equity volatility.
5. It is noteworthy that VIX futures exhibit stronger negative correlation with credit bonds than spot VIX, and therefore argues for a stronger case of VIX futures as a hedging instrument for bonds. In fact, when correlation analysis is conducted for up and down market periods separately, it can be seen that this stronger negative correlation of bonds to VIX futures than to VIX spot comes mostly from down markets (see Exhibit 4).

The overlapping investor base for high yield and emerging market bonds may also compound the return correlation between these two sectors.

Exhibit 4: Correlation of Monthly Returns in Up and Down Markets

As high yield and emerging market bonds have more exposure to credit spreads than duration risk, they exhibit more equity-like properties and a strong correlation with equity volatility.



Source: S&P Dow Jones Indices LLC, Bloomberg. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

In the following section, we further explore the aforementioned asymmetric correlation between the VIX futures and the two credit sectors.

V. VIX FUTURES TERM STRUCTURE IN DOWN MARKETS

Not limited to VIX, futures markets do not tend to move with the spot in the same magnitude. On rare occasions, the two may even move in opposite directions. When trading futures, market participants need to take into account an additional cost, the so-called “cost of carry,” of maintaining or holding a position in the market. The cost of carry comes in different ways, including interest on bonds, storage cost of commodities, and, in the VIX futures market, roll cost of futures contracts.

The stronger negative correlation of credit bonds to VIX futures than to VIX spot could be explained largely by the change in the futures curve when VIX spikes. In other words, when the high yield and emerging bond market is in distress, VIX goes up and the VIX futures curve flips from contango to backwardation, which causes VIX futures to move even further in the opposite direction of the high yield and emerging market bonds.

To verify this conjecture, we quantify the VIX futures curve on any given day (t) as its slope between the first and second month contracts:

$$S_t = \frac{UX2_t - UX1_t}{UX1_t}$$

where UX1 and UX2 refer to the first and second month VIX futures closing price on day t .

By definition, a positive slope indicates contango and roll cost, while a negative slope indicates backwardation and roll yield (positive carry). A steep slope indicates high roll cost in contango or high roll yield in backwardation.

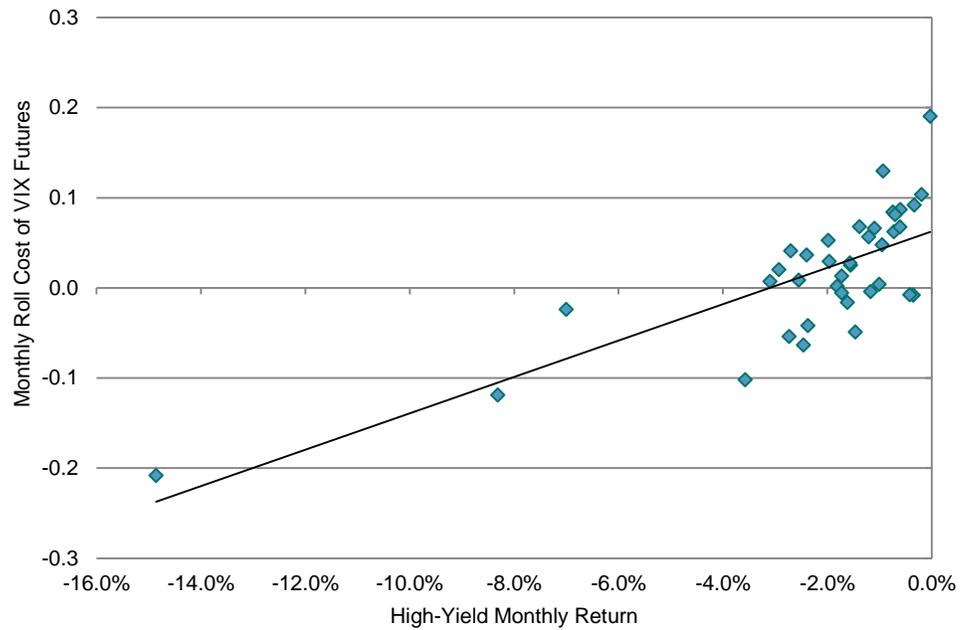
We further define the monthly average VIX futures slope as the average of S_t during the calendar month. In our back-test, this is also the actual monthly roll cost of the [S&P 500 VIX Short-Term Futures Index](#), since it rolls continuously from the first month to the second month contracts. A positive roll cost indicates cost while a negative roll cost indicates yield.

When high-yield emerging market bonds were down, the VIX futures curve was more likely to be in backwardation.

Exhibits 5a and 5b show the monthly roll cost of the S&P 500 VIX Short-Term Futures Index in the months where high yield and emerging market bonds posted losses during our back-testing period. When high yield bonds were down, the correlation between their monthly return and the monthly roll cost of VIX futures was 75%, indicating that the VIX futures curve was more likely to be in backwardation. When emerging market bonds were down, the correlation between their monthly return and the monthly roll cost of VIX futures was 56%, also an indicator of backwardation in the VIX futures curve.

Exhibits 5a and 5b also show that larger loss in high yield and emerging market bonds was usually associated with higher roll yield from VIX futures backwardation. This is further illustrated in Exhibits 6a and 6b: in the months that high yield and emerging market bonds posted a loss of more than 3%, VIX futures tended to rise, sometimes even more than the VIX spot, due to the backwardation in the VIX futures curve (or, in other words, the yield from the roll of a long VIX futures position).

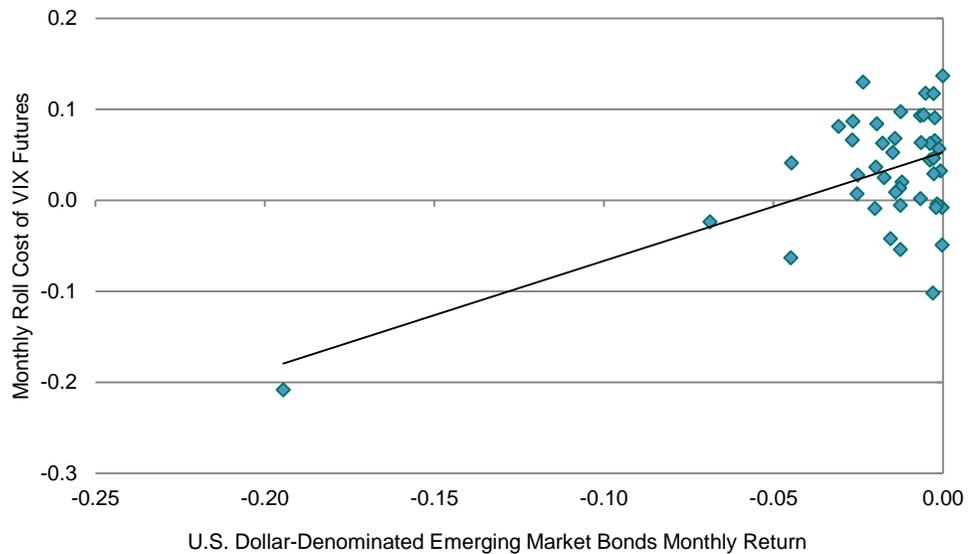
Exhibit 5a: Monthly Roll Cost When High Yield Bonds Are Down



Source: S&P Dow Jones Indices LLC. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

When high yield bonds were down, the correlation between their monthly return and the monthly roll cost of VIX futures was 75%, indicating that the VIX futures curve was more likely to be in backwardation.

Exhibit 5b: Monthly Roll Cost When Emerging Market Bonds Are Down



Source: S&P Dow Jones Indices LLC, Bloomberg. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 6a: Returns and Roll Cost When High-Yield Bonds Are Down More Than 3% (%)

MONTH	S&P U.S. HIGH YIELD CORPORATE BOND INDEX	VIX SPOT	S&P 500 VIX SHORT-TERM FUTURES INDEX	MONTHLY ROLL COST
October 2008	-14.86	52.04	117.29	-20.81
November 2008	-8.32	-7.70	16.75	-11.87
September 2008	-7.00	90.75	36.59	-2.36
August 2011	-3.58	25.23	66.19	-10.16
May 2010	-3.10	45.44	39.97	0.75

Source: S&P Dow Jones Indices LLC. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 6b: Returns and Roll Cost When Emerging Market Bonds Are Down More Than 3% (%)

MONTH	BLOOMBERG BARCLAYS EM USD AGGREGATE BOND INDEX	VIX SPOT	S&P 500 VIX SHORT-TERM FUTURES INDEX	MONTHLY ROLL COST
October 2008	-19.45	52.04	117.29	-20.81
September 2008	-6.87	90.75	36.59	-2.36
September 2011	-4.49	35.86	38.76	-6.31
June 2013	-4.47	3.44	7.26	4.12
November 2016	-3.08	-21.86	-17.87	8.16

Source: S&P Dow Jones Indices LLC, Bloomberg. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

VI. HEDGING CREDIT BOND PORTFOLIOS WITH VIX FUTURES

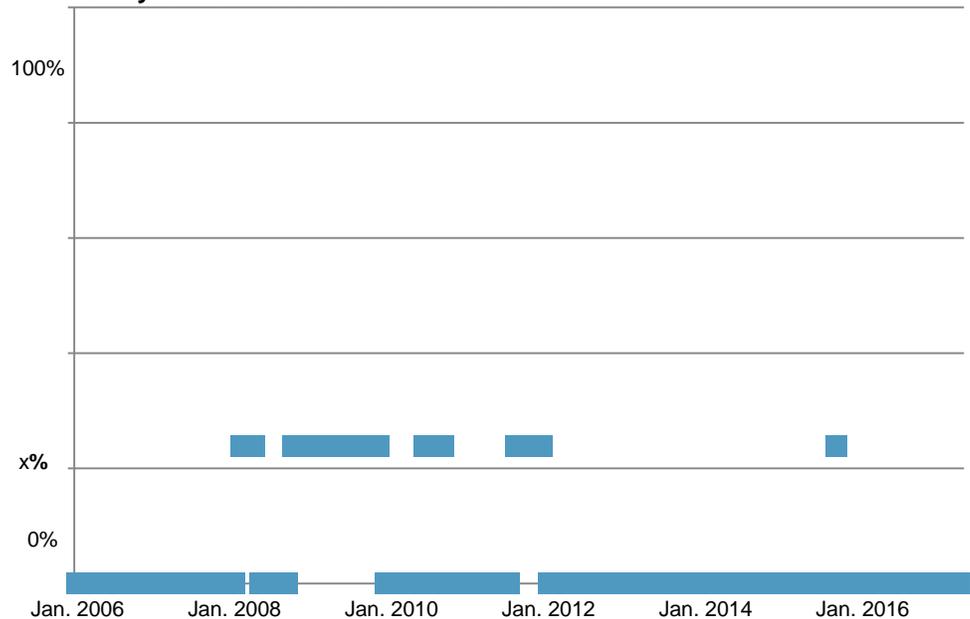
We back-tested two hedging strategies to illustrate the effectiveness and cost of a VIX futures hedge, which may be interesting to U.S. high yield and emerging market bond investors.

Tail risk, which can cause portfolios to suffer large losses, are of special interest to portfolio managers. Given the strong negative correlation between the [S&P 500 VIX Short-Term Futures Index](#) and high yield and emerging market bonds in down markets, VIX futures may hold tail risk hedging opportunities for these bonds. However, as we mentioned earlier, roll cost may create a sizeable performance drag in up markets, which could be considered by a market participant who wishes to institute a cost-efficient tail risk hedge via VIX futures.

To see whether allocating VIX futures provides downside protection to a high yield and emerging market bond portfolio, we back-tested two hedging strategies to illustrate the effectiveness and cost of a VIX futures hedge, which may be interesting to U.S. high yield and emerging market bond investors. Specifically, we back-tested the following two allocation strategies.

1. Static allocation: Allocating a static weight $x\%$ to VIX futures in a bond portfolio.
2. Dynamic allocation: Allocating a fixed percentage ($x\%$) of the portfolio to VIX futures according to the observed VIX spot level. At each month's end, if the VIX spot is equal to or greater than 25, $x\%$ of the portfolio is allocated to VIX futures the next month. If the VIX spot at month's end is less than 25, the allocation to VIX futures is 0. The actual allocation to VIX futures in the testing period is shown in Exhibit 8.

Exhibit 8: Dynamic Allocation to VIX Futures



Source: S&P Dow Jones Indices LLC. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

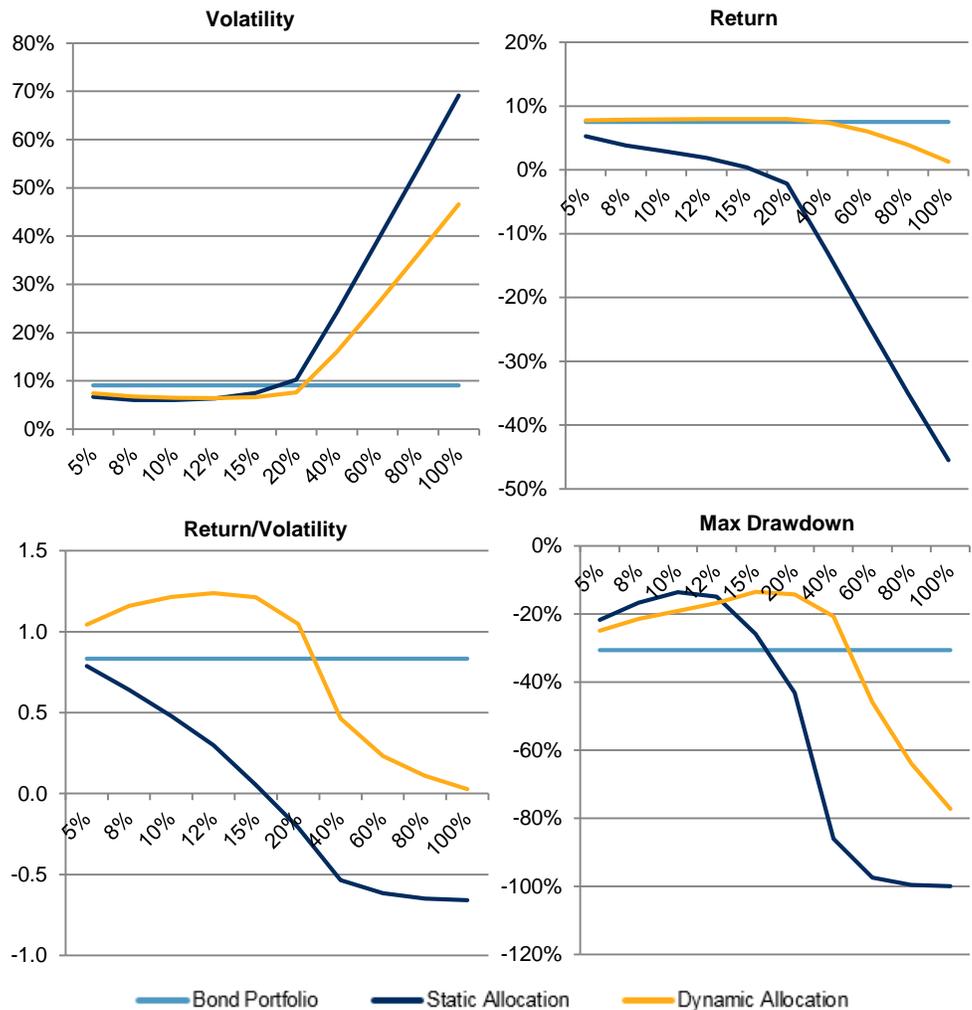
Both static and dynamic allocation of VIX futures can help reduce portfolio volatility, and can therefore provide hedging benefits as long as the VIX futures allocation is kept under 20%.

Hedging a High Yield Bond Portfolio

Exhibit 9 shows risk, return, and drawdown figures for a high yield bond portfolio with allocation to VIX futures ranging from 0 to 100%. Both static and dynamic allocation of VIX futures can help reduce portfolio volatility, and can therefore provide hedging benefits as long as the VIX futures allocation is kept under 20%. Allocating more than 20% to VIX futures proves to overhedge the bond portfolio and introduces VIX as a new risk factor that can raise portfolio volatility as allocation increases.

Similarly, dynamic allocation to VIX futures also improves portfolio returns as long as the allocation is kept under 20%. In comparison, static allocation of VIX futures significantly drags down portfolio return, as rolling VIX futures tends to incur costs. Risk adjusted return, as measured by the ratio of return over volatility, is optimized when VIX futures are dynamically allocated at 12%.

Exhibit 9: Performance Metrics of High Yield Bond Portfolio With Various VIX Futures Allocation



Static allocation of VIX futures can drag down portfolio performance significantly due to expensive cost of rolling VIX futures.

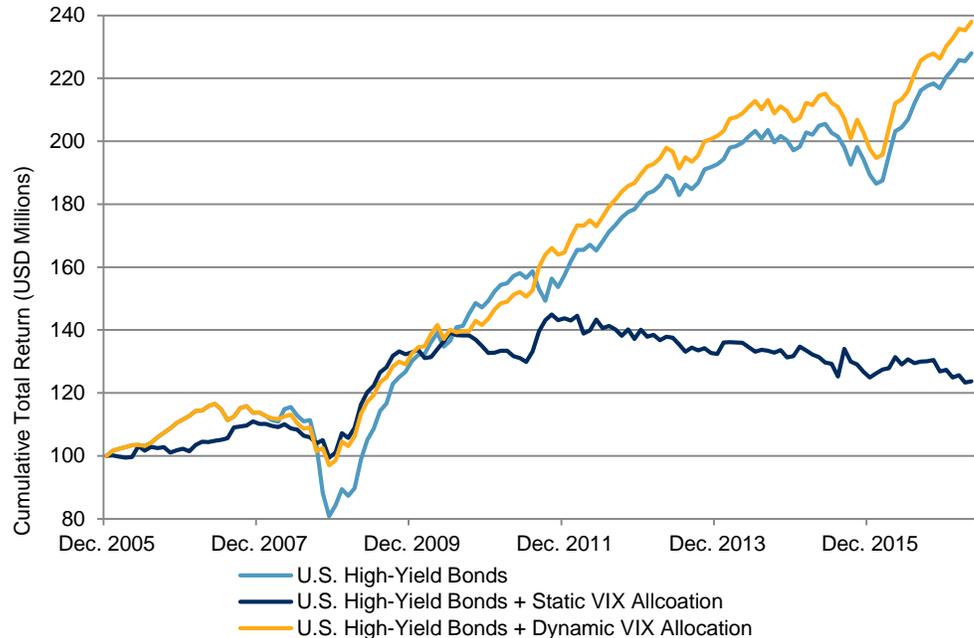
Source: S&P Dow Jones Indices LLC. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibits 10a and 10b show the cumulative returns and performance statistics of a high-yield bond portfolio with and without a VIX futures allocation of 12%. Dynamic allocation of VIX futures can provide downside protection and lessen portfolio drawdown, for example during the market turmoil of 2008, 2009, and 2011, while adding extra return to the bond portfolio. Return per unit of risk improved from 0.83 to 1.24 for the dynamic allocation strategy.

Though static allocation of VIX futures can reduce portfolio volatility and offer downside protection compared to the broad-based, unhedged high yield bond index, it can drag down portfolio performance significantly due to the expensive cost of rolling VIX futures.

In November 2008, at the market trough of the global financial crisis, the maximum drawdown for the dynamically hedged high yield strategy stood at 17%, compared to the 31% experienced by the broad high yield bond market. Similarly, during the second half of 2011, when the European government bond crisis and the U.S. sovereign credit rating downgrade took place, dynamic hedging helped the high-yield bond portfolio by avoiding drawdown (see Exhibit 11).

Exhibit 10a: Cumulative Return of High Yield Bond Portfolio With and Without VIX Futures Allocation of 12%



When the European government bond crisis and the U.S. sovereign credit rating downgrade took place, dynamic hedging helped the high yield bond portfolio by avoiding drawdown.

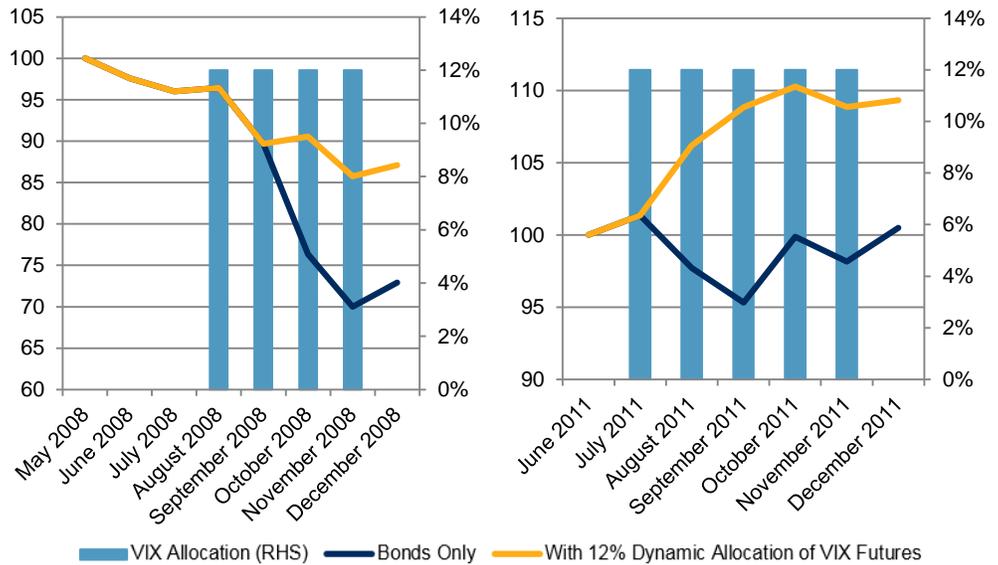
Source: S&P Dow Jones Indices LLC. Data from December 2005 to April 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 10b: Performance Statistics of High Yield Bond Portfolio With and Without VIX Futures Allocation of 12%

CATEGORY	U.S. HIGH YIELD BONDS	STATIC ALLOCATION	DYNAMIC ALLOCATION
Return	7.54%	1.90%	7.95%
Volatility	9.1%	6.4%	6.4%
Return/Volatility	0.83	0.30	1.24
Max Drawdown	-31%	-15%	-17%

Source: S&P Dow Jones Indices LLC. Data from Decemeber 2005 to April 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 11: Total Return of High Yield Bond Portfolio With and Without VIX Futures Allocation of 12% in 2H 2008 and 2H 2011



Source: S&P Dow Jones Indices LLC. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

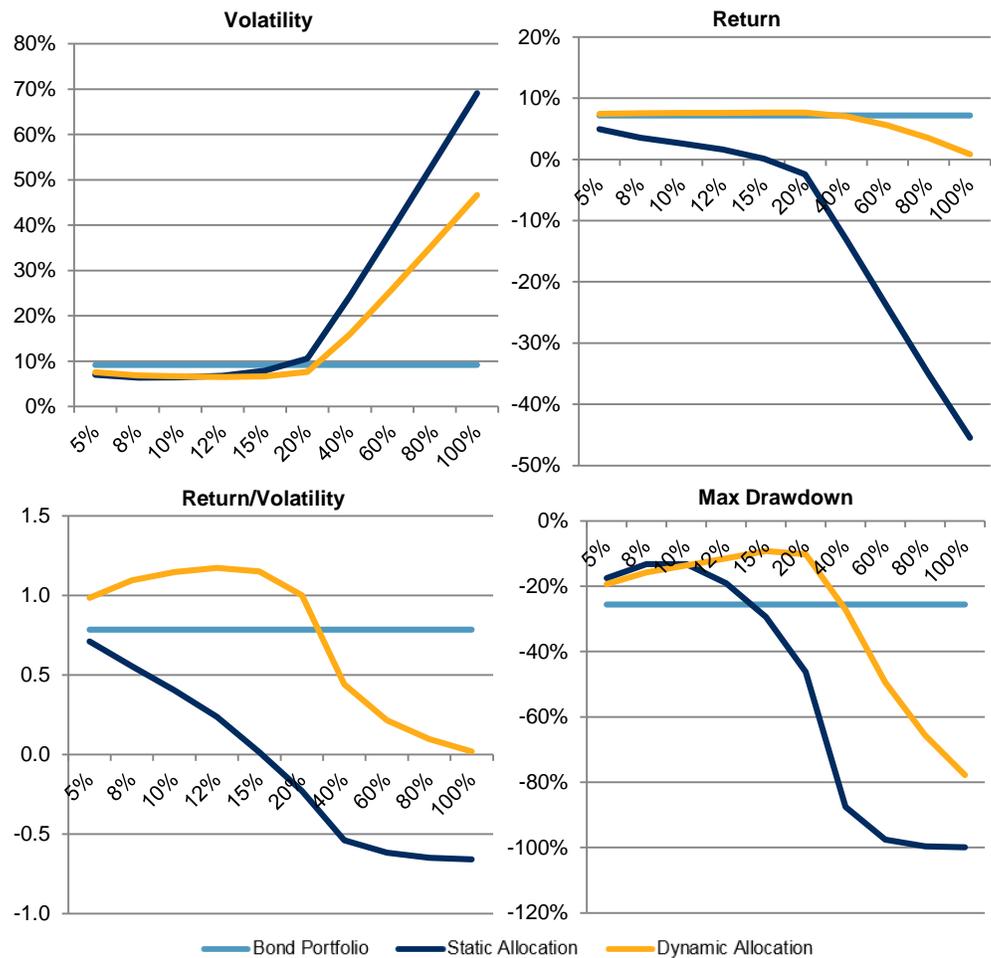
Risk-adjusted return, measured as the ratio of return over volatility, can be optimized when dynamically allocating 12% to VIX futures.

Hedging Emerging Market U.S. Dollar-Denominated Bond Portfolio

Exhibit 12 shows similar back-tested results for allocating VIX futures to an emerging market USD bond portfolio. Allocating less than 20% of portfolio weight to VIX futures hedges portfolio volatility and only dynamic allocation does so without sacrificing return and indeed improves return and risk-adjusted return. Portfolio risk-adjusted return, measured as the ratio of return over volatility, can be optimized when dynamically allocating 12% to VIX futures. Exhibits 13a and 13b provide detailed performance statistics with VIX futures allocation set at 12%.

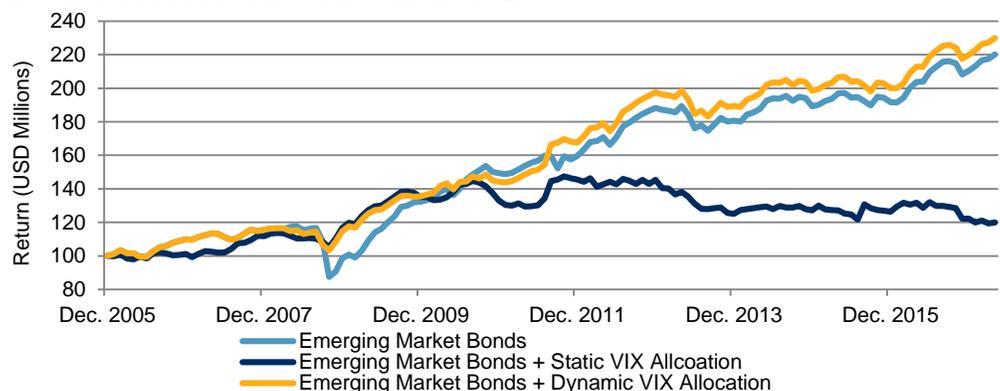
Exhibit 12: Performance Metrics of Emerging Market USD Bond Portfolio With Various VIX Futures Allocations

Allocating less than 20% of portfolio weight to VIX futures hedges portfolio volatility and only dynamic allocation does so without sacrificing return and indeed improves return and risk adjusted return.



Source: S&P Dow Jones Indices LLC, Bloomberg. Data from January 2006 to April 2017. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 13a: Cumulative Return of Emerging Market USD Bond Portfolio With and Without VIX Futures Allocation of 12%



Source: S&P Dow Jones Indices LLC, Bloomberg. Data from December 2005 to April 2017. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

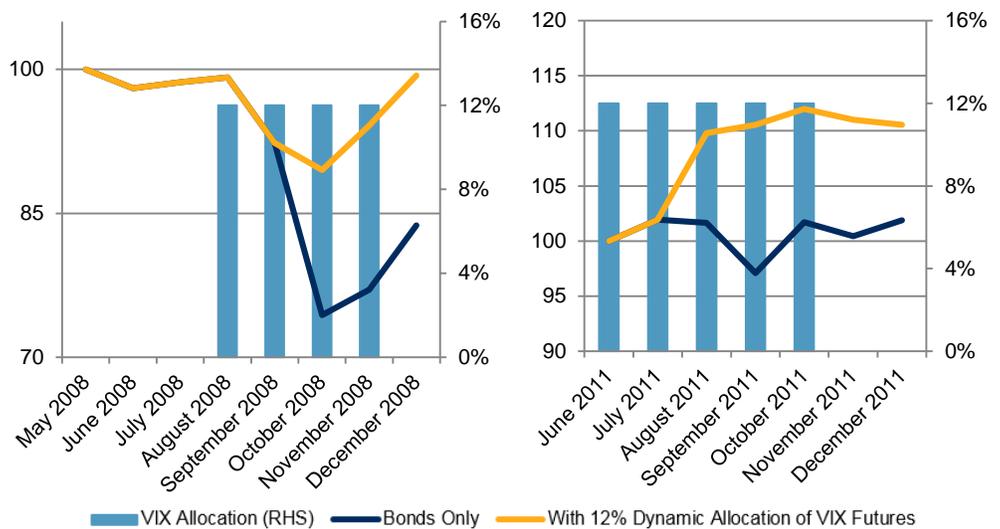
Exhibit 13b: Performance Statistics of Emerging Market Bond Portfolio With and Without VIX Futures Allocation of 12%

CATEGORY	EMERGING MARKET BONDS	STATIC ALLOCATION	DYNAMIC ALLOCATION
Return	7.21%	1.61%	7.62%
Volatility	9.2%	6.8%	6.5%
Return/Volatility	0.78	0.24	1.17
Max Drawdown	-26%	-19%	-11%

Source: S&P Dow Jones Indices LLC, Bloomberg. Data from December 2005 to April 2017. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 14: Total Return of Emerging Market USD Bond Portfolio With and Without VIX Futures Allocation of 12% in 2H 2008 and 2H 2011

Dynamic hedging with a VIX futures allocation of 12% improved the emerging market bond portfolio return by 41 bps while volatility was reduced by 29%.



Source: S&P Dow Jones Indices LLC, Bloomberg. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

As shown in Exhibit 13b, dynamic hedging with a VIX futures allocation of 12% improved the emerging market USD bond portfolio return by 41 bps, while volatility was reduced by 29%. The ratio of return over volatility increased from 0.78 to 1.17. Downside protection can also be seen from the decrease of more than 50% in maximum drawdown. Exhibit 14 shows that dynamic allocation of VIX futures lessened the drawdown in 2H 2008 and helped avoid it in 2H 2011.

VII. CONCLUSIONS

Market participants have long been looking for innovative approaches to hedge credit-focused fixed income sectors, such as high yield corporate and emerging market U.S. dollar-denominated bonds, due to the limitations of traditional fixed income instruments. The liquid VIX futures market may serve as an alternative tail risk hedge that can have no impact on the prices of the fixed income sectors.

The impact of the VIX futures term structure is twofold.

Our back-tests have confirmed the hedging benefit of a dynamic allocation to VIX futures in a high yield and emerging market bond portfolio.

- More often than not, the roll cost from contango made the hedge expensive and prohibitive.
- In stressed markets, the roll yield from backwardation increased the negative correlation between VIX futures and high yield and emerging market bonds, and further improves the effectiveness of the tail risk hedge.

Our back-tests have confirmed the potential benefit of a dynamic allocation to VIX futures in a high yield and emerging market bond portfolio. Furthermore, we found that the risk-adjusted returns of the portfolio, as measured by the ratio of return over volatility, were optimized at the VIX futures allocation of 12% with our allocation algorithm.

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