Hedging Systematic Risk in High Yield Portfolios with a Synthetic Overlay: *A Comparative Analysis of Equity Instruments vs. Credit Default Swaps*

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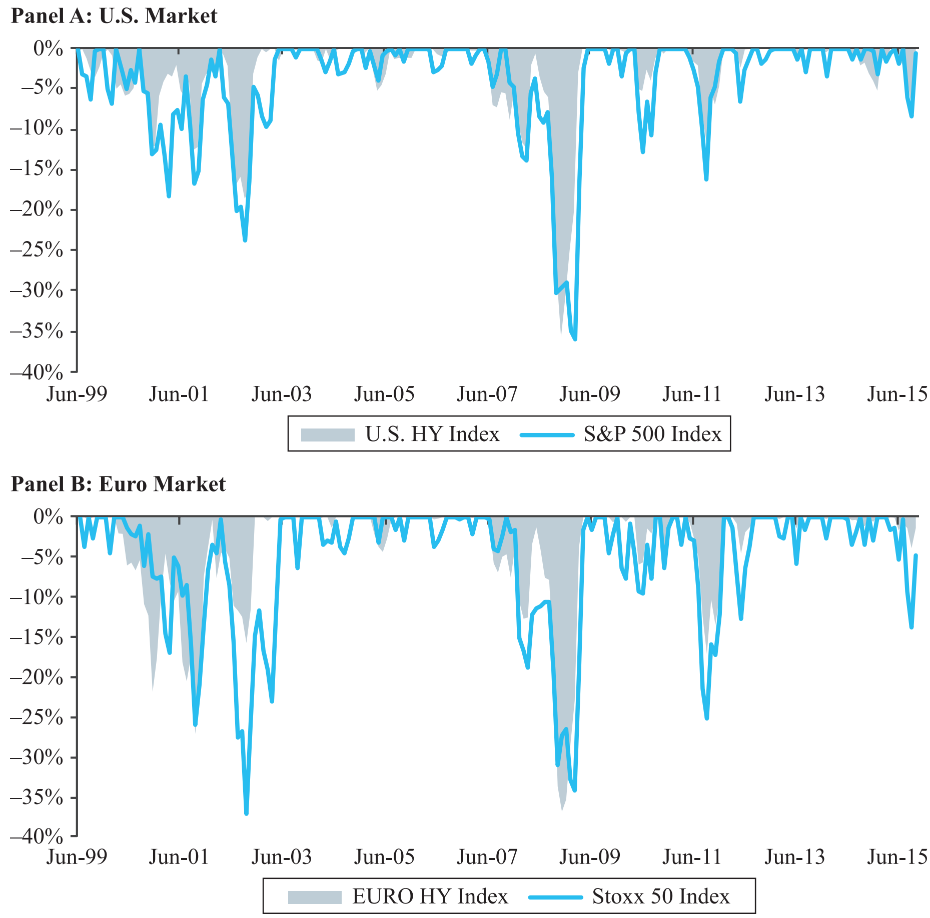
How should a high yield credit portfolio manager hedge the impact of adverse *systematic* market changes on her portfolio? The relative illiquidity of the high yield market renders scaling down portfolio positions on a tactical basis costly to implement.[1] Another option is "shorting" an ETF, but existing high yield ETFs may lack sufficient size to be a realistic hedging instrument for institutional size portfolios, and also result in high shorting costs.[2]

A different approach involves a synthetic overlay using index credit default swaps (e.g., CDX, iTraxx). Establishing a position in a standard swap contract is relatively cheap and can be done quickly once the necessary legal documents are in place. However, recent research by Desclee, Maitra, and Polbennikov [2016] highlighted the possibility of a large basis risk between the cash and synthetic high yield markets that may result in index credit default swaps being ineffective as hedging instruments in certain market regimes.

Another choice for a synthetic overlay involves equity index derivatives. This idea can be motivated by the fact that the reaction of high yield bonds to adverse macro-economic changes, and interest rates in particular, often resembles that of equities more than (investment grade) bonds.[3] For example, Exhibit 1 shows that since 1999, drawdowns in the U.S. and Euro High Yield markets (over any six-month period) followed very closely the dynamics of their respective equity market in terms of both timing and magnitude. This may indicate that equity instruments can offer an effective way to hedge systematic downturns in the high yield market despite the difference in asset class dynamics and in the underlying constituents.

Our objective in this study is to compare the efficacy of equity index derivatives (futures and options) to index credit default swaps in hedging the systematic risk of a generic well-diversified portfolio of high yield securities. Since the results depend not only on the properties of the hedging instruments, but also on additional decisions made by a portfolio manager (for example the hedge ratio), we begin with a simple scenario, which corresponds to an unskilled portfolio manager who employs a passive hedge. In this setup, the manager initially selects only the hedging instrument and the extent to which the portfolio would be hedged (i.e., "hedge ratio"), which remains unchanged throughout the analysis period. To evaluate the effectiveness of the hedge

EXHIBIT 1
Drawdown Dynamics in U.S. and Euro High Yield and Equity Markets



Note: The exhibits compare the drawdown dynamics of the Bloomberg Barclays U.S. High Yield and S&P 500 Indexes and Bloomberg Barclays Euro High Yield and Stoxx 50 Indexes. Drawdown is calculated over a rolling six-month window.

Source: Bloomberg, Barclays Research.

we examine the reduction in risk based on several measures including volatility, downside risk, drawdown, and worst monthly loss.

The results indicate that between 2004 and 2015 equity futures have been generally more effective than credit default swaps in hedging systematic risk in both U.S. and Euro markets, despite the fact that both exhibited similar correlations with high yield cash markets' performance. The advantage of equity futures over credit default swaps was particularly significant when using measures of risk that captured the left tail of the return distribution. We examine the reasons for these dynamics and show that they are related to the behavior of the cash–synthetic basis during periods of market stress.

Despite the reduction in risk when equity futures were used (irrespective of the hedge ratio), the associated cost (i.e., lower performance) resulted in lower risk adjusted returns. We demonstrate that using a combination of equity futures and selling out-of-the-money equity put options has been very effective historically. The income generated from "writing" the options far outweighed the fact that the benefit from the futures' hedge was limited in severe market downturns.

Next, we look at a scenario where the overlays are deployed opportunistically by incorporating the notion of skill (defined as the probability of making correct *directional* market calls) into our analysis. We find that the advantage of equity derivatives over credit default swaps

Exhibit 2

Descriptive Statistics for the Indexes and Hedging Instruments

	Index	Credit Default Swaps	Equity Futures
Panel A: U.S. Market	**U.S. High-Yield**	**CDX.HY**	**S&P 500**
Avg. Ret (%/mo)	0.65%	0.49%	0.58%
Volatility (%/mo)	2.90%	2.58%	4.22%
Max. Drawdown	–33.31%	–24.90%	–53.26%
VaR 95%	–3.16%	–4.05%	–7.22%
Worst Month	–15.91%	–6.53%	–17.26%
Beta to Index	1.00	0.67	1.06
Correlation with Index	1.00	0.75	0.73
Panel B: Euro Market	**Euro High-Yield**	**iTraxx.XO**	**Stoxx 50**
Avg. Ret (%/mo)	0.69%	0.61%	0.37%
Volatility (%/mo)	3.50%	2.51%	5.30%
Max. Drawdown	–37.58%	–19.59%	–57.05%
VaR 95%	–4.51%	–3.65%	–9.14%
Worst Month	–17.94%	–7.45%	–15.35%
Beta to Index	1.00	0.53	1.01
Correlation with Index	1.00	0.74	0.67

Note: Statistics are based on monthly data between September 2004 (September 2005 for Euro) and October 2015 using total returns for the High Yield Indexes and unfunded returns for swaps and equity futures.

Source: Bloomberg, Barclays Research.

in both markets is maintained irrespective of the skill level. Furthermore, with low to moderate skill levels, the hedge ratios that maximize risk-adjusted returns range around 50%. Empirically, this ratio optimally traded the hedging benefit with the cost resulting from incorrect market calls, and cases where the direction or the magnitude of the hedging instrument returns resulted in overall losses. In contrast, if both futures and options were used as described earlier, the optimal approach would have been to fully hedge the portfolios for all skill levels.

A simulation-based approach offers a simple and quick way to capture mangers' skill in making discretionary calls in regards to deploying the overlays. However, since the process (or set of indicators) used by a manager in forming his views is not specified, the results may seem abstract and unrealistic. We therefore repeat the analysis using an explicit market-based signal, with historical success rates that correspond to a moderate skill of about 10%–15%. Deploying the combined futures and options overlay using this simple signal increased the performance of the high yield portfolios by 1.5% and 2.5% per year on average over using credit default swaps in the U.S. and Euro markets, respectively.

PERFORMANCE WITH A PASSIVE OVERLAY

Hedging Instruments

To represent the return profile of a generic high yield portfolio, we chose to use the Bloomberg Barclays U.S. and Euro High Yield Indexes. However, since we are looking to hedge *systematic* risk, our results should apply to any well diversified portfolio of high yield securities that exhibits high correlation with the indexes. As credit hedging instruments, we employ the CDX.HY in the U.S. market and iTraxx.XO in the Euro market with their performances based on the unfunded returns of the on-the-run contract (i.e., the current contract is rolled to a new series every six months). The equity hedges (futures and options) were based on the S&P 500 and Stoxx 50 Indexes in the United States and Europe, respectively. The futures' returns were calculated in a similar fashion to the swaps, except the contracts were rolled on a quarterly basis (the calculations of the options returns are described in the next section).

Exhibit 2 reports various return statistics characterizing the performance of the indexes, CDX/iTraxx contracts, and equity futures during the sample period between September 2004 (September 2005 for the Euro market) and October 2015. The table indicates that in the United States both hedging instruments earned similar returns and their correlations with the monthly performance of the index were almost identical (0.75 and 0.73). They did differ materially, however, when it came to risk. The volatility of S&P 500 futures was higher than that of CDX.HY by more than 50%, and the worst monthly return was nearly three times as large in absolute value (−17.26% vs. −6.53%, respectively). It is interesting to note, therefore, that while the volatility of the U.S. High Yield Index was only a little higher than that of the CDX contract (2.90%/month and 2.58%/month, respectively), and its 95% monthly VaR was actually lower (−3.16%/month vs. −4.05%/month for the CDX), its tail risk-statistics were more extreme. The Index's worst monthly return was similar to that of the S&P 500 futures, and its maximum drawdown (−33.31%) was substantially higher than that of the CDX.HY (−24.90%).

The results for the Euro market are similar in spirit with two noticeable differences. First, in terms of performance the Stoxx 50 futures lagged the iTraxx.XO by a wide margin (24 bps/month) over the period. Second, the difference between the correlations of the Stoxx 50 and iTraxx.XO with the Euro High Yield Index was larger than in the U.S. case (0.07 versus 0.02, respectively).

As our main objective is to compare credit default swaps and equity futures in terms of their hedging characteristics, we look first at their abilities to reduce portfolio risk. We consider a simple setup where a portfolio manager has only two decisions to make: which hedging instrument to use and the degree to which her portfolio should be hedged. For simplicity, the hedge ratio (the notional value of the hedging instrument as a percentage of the portfolio's market value) remains constant throughout the entire period. Exhibit 3 illustrates the change in the indexes' risk as the hedge ratio increases from zero to 100% using either the swaps or futures in each market. The results are shown for four different measures of risk that capture progressively more of the tail properties of the return distribution of the hedged indexes.

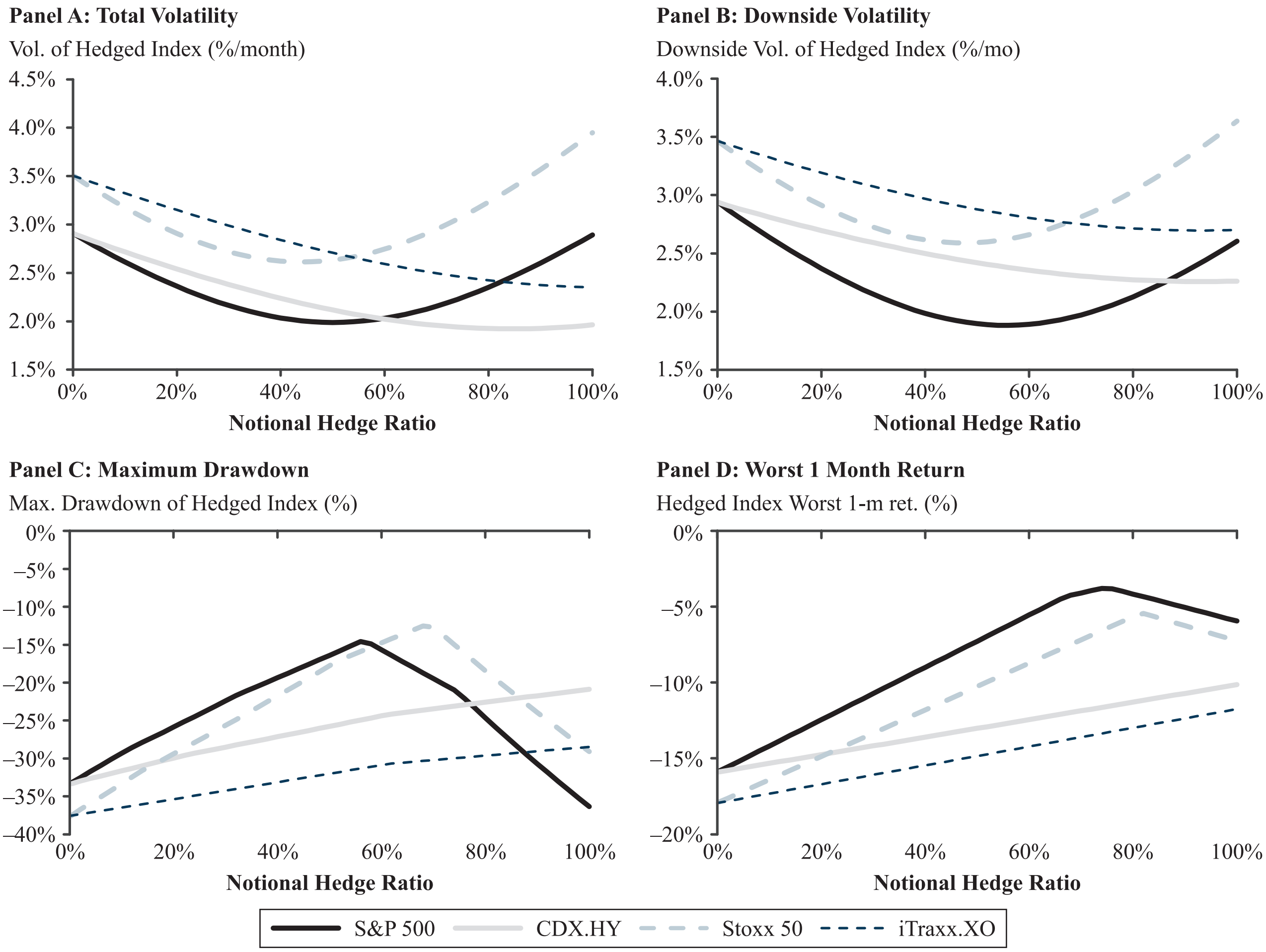
With respect to volatility (Panel A), employing CDX.HY reduces volatility consistently from 2.90%/month (unhedged index) to a minimum of 1.93%/month as the hedge ratio increases to 76%. Beyond that level, volatility remains essentially unchanged (fully hedging would result in volatility of 1.96%/month). Using S&P 500 futures instead results in several interesting dynamics. The volatility of the hedged index declines faster initially (compared with using CDX.HY), reflecting the futures' higher beta to the index. For hedge ratios above 52%, the volatility stemming from the uncorrelated part of the equity market return more than offset the hedging benefit and, as a result, the overall volatility of the hedged index increases. Yet, irrespective of the hedge ratio, the volatility of the hedged index is lower than that of the unhedged index. Hence, even without employing the "optimal" hedge ratio, a portfolio manager using S&P 500 futures would have been able to reduce her portfolio volatility. Moreover, the futures' overlay reduced the risk of the High Yield Index more effectively than did the CDX.HY for any hedge ratio below 58% (as reflected by the line intersection on the chart), and even minimized volatility to a level only slightly higher than that reached when using the CDX (1.99%/month versus 1.93%/month, respectively).

If we examine "downside volatility" instead, CDX.HY leads to a maximum reduction of 68 bps/month (with full hedging), while using equity futures lowers downside volatility by as much as 105 bps/month (with a hedge ratio of 56%). The advantage of equity futures over CDX.HY is even more evident in Panels C and D, which examine the changes in maximum drawdown, and worst one-month return. With a hedge ratio of 56% for example, the index hedged with S&P 500 futures experienced a maximum drawdown of 14.6% compared to about 25% if hedged using CDX.HY. Similarly, the S&P 500 hedge reduced the worst one-month return by as much as 76%, twice the reduction using CDX.HY (36%). For both measures we continue to see a pattern of persistent reduction in risk when using CDX.HY as opposed to an inverted U-shape (i.e., a minimum) if equity futures were employed instead. Furthermore, using S&P 500 futures seems to have dominated the CDX.HY hedge irrespective of the hedge ratio.

The results for the Euro High Yield Index mimic the U.S. results very closely in terms of both the shape of the hedged index risk-curves (irrespective of the risk measure) using either instrument, and the relative advantage of the futures hedge over the use of iTraxx.XO. But perhaps more impressive is the fact that despite the difference in the (absolute) level of risk between the two indexes (across all risk measures), the optimal hedge

Exhibit 3

Hedged Indexes Performance as a Function of Hedge Ratio



Note: The hedge ratio (the notional value of the hedging instrument as a percentage of the portfolio's market value) remained constant during the analysis period between September 2004 (September 2005 for Euro) and October 2015. Downside volatility was calculated using only months in which the High Yield Indexes earned negative returns. Maximum drawdown represents the largest percentage decline in cumulative returns from peak to the following trough.

Source: Barclays Research, Bloomberg.

ratios, which minimized the respective risk statistics, are quite similar. The minimum volatility and drawdown for the U.S. Index, for example, were achieved at hedge ratios of 52% and 56%, respectively, while the corresponding figures for the Euro Index were 44% and 68%.

Drivers of Difference in Hedging Effectiveness

The results in the previous section indicate that the S&P 500 and Stoxx 50 futures would have been more effective in general than the corresponding credit default swaps in reducing the systematic risk of the U.S. and Euro High Yield Indexes. This is somewhat surprising given the almost identical correlation of S&P 500 futures and CDX.HY with the U.S. Index, and even more so in the Euro market where the correlation of the Stoxx 50 futures was lower than that of the iTraxx.XO. Indeed, the similar correlation in the United States is itself surprising in light of the fact that the S&P 500 futures represent a different asset class and that there is essentially no overlap between its constituents and those underlying the High Yield Index as opposed to the case of CDX.HY.

The fact that the gap in hedging ability between the futures and credit default swaps increases as our risk measures concentrate more on the left tail of the portfolio return distribution suggests that the relation between the performance of the futures and the high yield indexes may be asymmetric. To see if this is indeed the case, Exhibit 4 reports the performance of the indexes and hedging instruments separately for "good" and "bad" states of the market based on two indicators. The first is simply based on the monthly performance of the high yield market (negative or positive) as represented by the Bloomberg Barclays Indexes (Panel A). As this indicator is available only ex-post, the second indicator (Panel B) is based on the magnitude of the spread change during the previous month, and can therefore be observed ex-ante. To define a spread change as "large" we do not use an absolute cut-off value but rely on the findings in Ben Dor et al. [2007] regarding the relation between spread volatility and spread level. Specifically, a "negative" market state would correspond to a spread widening larger than one standard deviation during the previous month.[4]

The reason this indicator may have predictive ability is related to the relative illiquidity of the high yield market. Illiquidity results in auto-correlation of monthly returns, as new information cannot be incorporated into prices instantaneously. We discuss this in greater detail in the next section.

Exhibit 4

Performance of Indexes and Hedging Instruments by Market State

	High Yield Index	Credit Default Swaps	Equity Futures	High Yield Index	Credit Default Swaps	Equity Futures
Panel A: Index Return (contemporaneous)		**Negative**			**Positive**	
	U.S.	**CDX.HY**	**S&P 500**	**U.S.**	**CDX.HY**	**S&P 500**
Avg. Ret (%/mo)	–2.31%	–1.95%	–3.19%	1.86%	1.49%	2.12%
Volatility (%/mo)	2.94%	2.01%	4.05%	1.83%	2.07%	3.19%
Correlation with HY Index	1.00	0.64	0.77	1.00	0.58	0.41
Beta to HY Index	1.00	0.44	1.06	1.00	0.66	0.72
	Euro	**iTraxx.XO**	**Stoxx 50**	**Euro**	**iTraxx.XO**	**Stoxx 50**
Avg. Ret (%/mo)	–2.74%	–1.68%	–4.52%	2.06%	1.53%	2.33%
Volatility (%/mo)	3.46%	2.33%	4.85%	2.42%	1.92%	4.06%
Correlation with HY Index	1.00	0.63	0.66	1.00	0.58	0.35
Beta to HY Index	1.00	0.42	0.93	1.00	0.46	0.59
Panel B: Spread Change (ex-ante)		**Spread Widening > 1 Std.**			**Other**	
	U.S.	**CDX.HY**	**S&P 500**	**U.S.**	**CDX.HY**	**S&P 500**
Avg. Ret (%/mo)	–0.22%	0.25%	–0.19%	0.83%	0.54%	0.73%
Volatility (%/mo)	4.81%	3.70%	6.17%	2.32%	2.30%	3.71%
Correlation with HY Index	1.00	0.81	0.84	1.00	0.72	0.66
Beta to HY Index	1.00	0.63	1.08	1.00	0.71	1.05
	Euro	**iTraxx.XO**	**Stoxx 50**	**Euro**	**iTraxx.XO**	**Stoxx 50**
Avg. Ret (%/mo)	–0.78%	0.04%	–0.81%	1.03%	0.74%	0.64%
Volatility (%/mo)	4.81%	3.50%	6.66%	3.06%	2.22%	4.92%
Correlation with HY Index	1.00	0.79	0.84	1.00	0.71	0.58
Beta to HY Index	1.00	0.58	1.17	1.00	0.52	0.93

Note: In Panel A, the sample (in each market) was partitioned based on the index monthly realizations (positive or negative). In Panel B, the sample was partitioned to two states corresponding to the previous month spreads widening by more than one standard deviation or not.

Source: Barclays Research, Bloomberg.

Looking at Panel A reveals that in both high yield markets, the correlation of equity futures with the indexes varied considerably, as one may have expected. In months with negative return realizations, the correlations were 0.77 and 0.66 (U.S. and Euro, respectively), whereas in months with positive performance they were significantly lower (0.41 and 0.35). Furthermore, as a result of this asymmetry, the correlations of the indexes with the futures in "bad" months were actually higher than with credit default swaps. Hence, although over the entire sample equity futures and credit default swaps exhibited similar correlations with the high yield indexes, at times where a portfolio manager would have been most interested in hedging an adverse move in the high yield index, equity futures' hedging ability proved superior.

Similar results are also apparent in Panel B when market states were determined ex-ante based on the behavior of spreads in the previous month. S&P 500 futures again exhibited an asymmetry in their correlation with the High Yield Index and had a higher correlation than the CDX.HY in months that were preceded by large spread widening by historical standards (0.84 versus 0.66, respectively). Moreover, notice that CDX.HY performance in months following significant spread widening was actually positive (0.25%/month), while the index earned negative returns on average. The same dynamics can be observed in the Euro market with respect to both the Stoxx 50 futures and iTraxx.XO.

To see the difference in the hedging dynamics of equity futures and credit default swaps more clearly, Exhibit 5 examines their correlation and beta to the high yield indexes in the worst months in our sample. The sample months are sorted by ascending order in terms of monthly index performance, and the correlations and betas are calculated over an increasing number of the worst months (denoted by N) starting with five.

The plots show that in the 10 worst performance months—when hedging was most needed—U.S. futures had a correlation of 0.8 or higher, while the correlation between CDX.HY and the high yield index was less than 0.3. Furthermore, the betas, which are affected by both correlations and volatilities of the hedging instruments, were fairly stable in these months, indicating that the volatilities of the instruments did not vary by much. (This last point is important since it implies a manager can have more confidence when sizing his hedge.) In the Euro market, the Stoxx 50 beta exhibits a larger degree of variability than in the U.S. market but the patterns are overall similar, boasting higher correlation with the Euro high yield index than the iTraxx.XO.

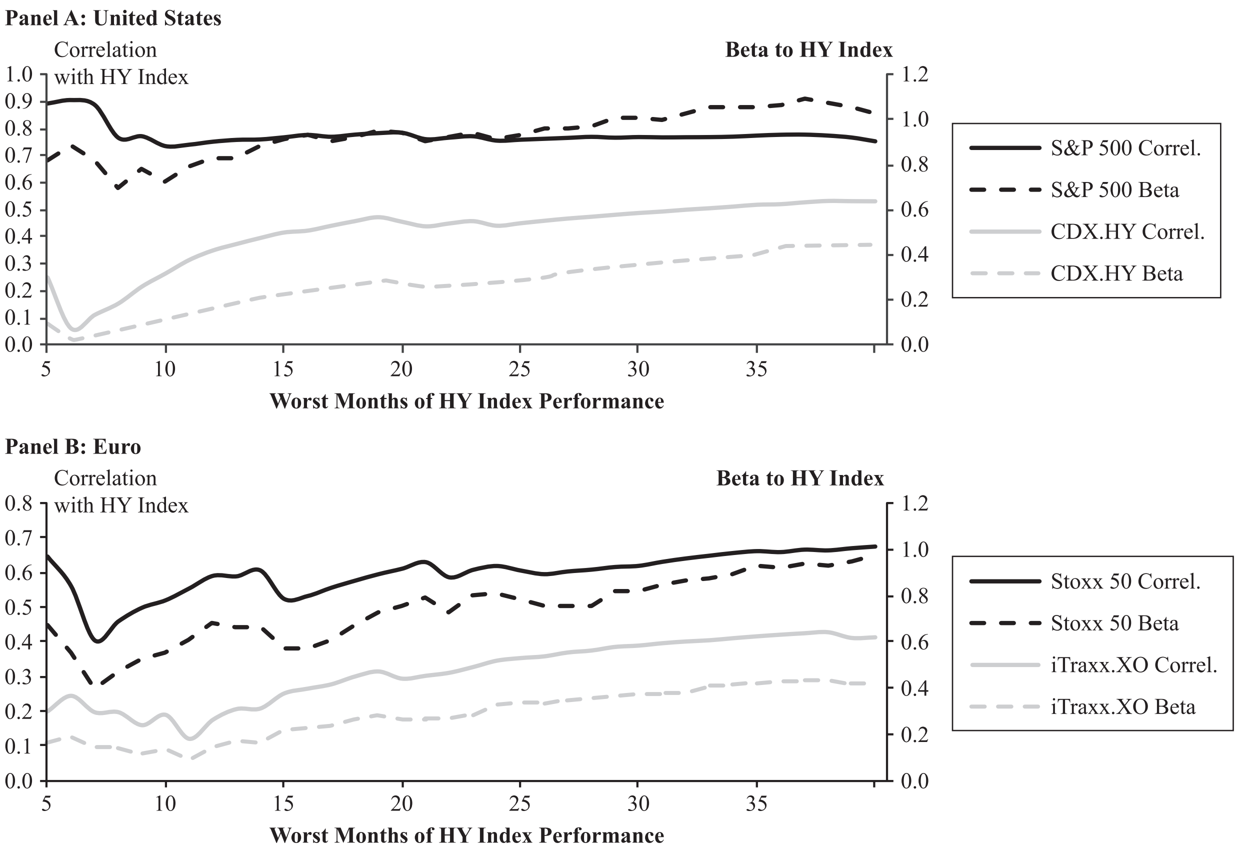
The dynamics shown in Exhibits 4 and 5 not only help explain the results in Exhibit 3 (i.e., the superior hedging ability of futures over credit default swaps) but also suggest that simple signals such as unusual spread widening may be used to improve the efficacy of an overlay hedging strategy using equity futures. They do not explain, however, the reason for the relatively poor tracking of the high yield indexes by the respective credit default swaps contracts (compared with equity futures).

In a recent study, Desclee, Maitra, and Polbennikov [2016] analyze the performance difference between the Bloomberg Barclays U.S. and Euro High Yield Indexes and CDX.HY and iTraxx.XO over the period January 2006 to August 2015. They find that differences in seniority, maturity, quality, sector, and issuer composition accounted for only a small part (29 bps/yr) of the overall annual tracking error (219 bps/yr), while the rest reflected the basis between cash and synthetic markets. In contrast, in the investment grade market the basis played only a very small role on average with almost the entire difference being driven by compositional factors (70 bps/yr).[5]

The dynamics of the basis are closely tied to liquidity conditions in the market.[6] Konstantinovksy, Ng, and Phelps [2016] introduced a measure of liquidity in credit markets termed LCS–Liquidity Cost Scores, which represent the cost of an institutional size round-trip transaction in a bond as a percentage of its market price based on traders' quotes. Plotting the monthly return differences between the High Yield Indexes and the credit default swaps in each market against the monthly change in the indexes' LCS suggests a very clear relation (Exhibit 6).

Months when LCS values increased (i.e., liquidity declined) were generally associated with a larger tracking error between the cash index and the respective credit default swap contract, and vice versa. Hence, although an index credit default swap contract could have been an ideal overlay instrument to hedge against systematic risk in the high yield market, it proved to be ineffective exactly at times when protection was most needed. These periods of market stress were also generally associated with a decline in liquidity that severed the linkage between cash and synthetic markets due to the reduced ability of arbitrage activity. In equity markets, however,

EXHIBIT 5
Correlation/Beta of Hedging Instruments during Index Worst Months



Note: The sample months were sorted by ascending order in terms of monthly index performance. The exhibit shows the correlations and betas calculated over the N worst months starting with N = 5.

Source: Barclays Research, Bloomberg.

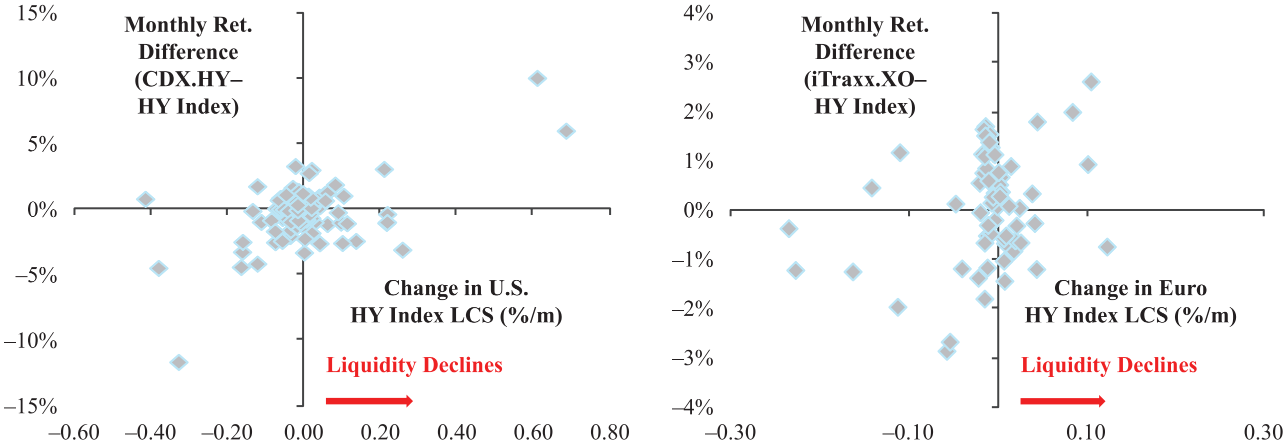
cash and future markets remained tightly linked, which resulted in S&P 500 futures being a more effective hedge than index credit default swaps for both U.S. and Euro High Yield Indexes.

Hedging Costs and the Use of Equity Options

The analysis so far focused solely on reducing risk but did not consider costs (i.e., the reduction in performance). Incorporating costs is essential not only because hedges in general reduce overall performance, but also because they may affect the relative attractiveness of the different instruments.[7]

Panel A of Exhibit 7 compares the risk-adjusted performance (i.e., Sharpe Ratios) of the unhedged indexes in the two markets to the results using the futures and credit default swaps. In the Euro market, Stoxx 50 futures dominated the iTraxx.XO irrespective of the hedge ratio and resulted in a slight improvement to the Sharpe Ratio of the unhedged index (0.55–0.56 vs. 0.54) for hedge ratios between 4% and 34%. In contrast, S&P 500 futures delivered better Sharpe Ratios than CDX.HY only for hedge ratios below 30%, primarily because as shown in Exhibit 2, Stoxx 50 futures substantially underperformed iTraxx.XO during the sample period (37 bps and 61 bps/month, respectively), whereas the opposite was true in the case of the U.S. market. Hence, although

Exhibit 6
Liquidity and Return Differences between CDX/iTraxx and HY Indexes



Note: LCS data for U.S. and Euro High Yield securities is available since January 2007 and May 2010, respectively. The changes in index-level LCS are based on aggregating the LCS values of all underlying constituents.

Source: Barclays Research, Bloomberg.

S&P 500 futures co-moved more closely with the High Yield Index as we have previously shown, the degradation in performance more than offset the benefit once the hedge ratio exceeded 30%.

However, irrespective of the hedge ratio, using either CDX.HY, iTraxx.XO or S&P 500 futures resulted in Sharpe Ratios that were lower than those generated by the unhedged index. Even the unusual performance of the Stoxx 50 futures during the sample (relative to the iTraxx.XO) resulted in essentially the same Sharpe Ratio as that of the unhedged index. These results reflect the fact that a passive hedge or a tactical hedge placed by a low-skill manager might be ineffective either because the underlying portfolio increased in value (i.e., no need to hedge), the correlation between the portfolio and the hedging strategy was negative (i.e., the hedge amplified the magnitude of the loss) or since the scaling of the hedge was inappropriate. Consequently, risk may decline disproportionally relative to performance.

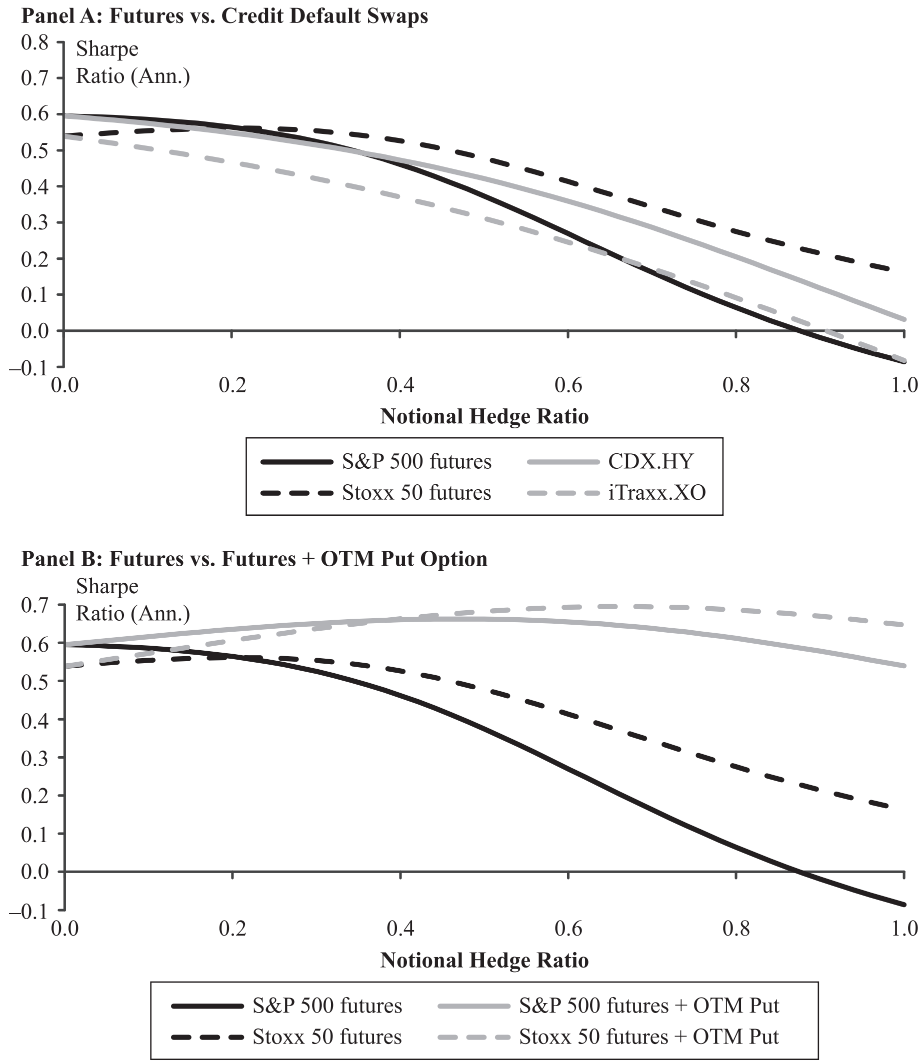
One possible solution for reducing the hedging costs when using equity futures is to combine them with "writing" an out-of-the-money (OTM) short-maturity put option on the underlying equity index. This may improve performance since the option premium is collected consistently, while the benefit of the futures' hedge is reduced only in periods when the decline in the futures price is so large (as is also likely the case for the value of the underlying high yield portfolio) that it would trade below the strike price of the option. The use of short-maturity OTM put options is motivated by the ample research on the skew in implied volatility curve reflecting investors' demand for insurance, and the fast decay in the options' value as they approach expiration.

To examine this idea, we use S&P 500 and Stoxx 50 put options with strike prices equal to 95% of the then-current spot level of the indexes. The options have three months to maturity and are rolled on a monthly basis.[8] It is important to note that we do not claim that the strike price we use is in any way optimal. It is possible that using a put option with a different strike price would have resulted in a better trade-off between the income level and the reduction in hedging ability given the actual return distributions of the equity indexes in the sample. Regardless, the 95% strike we use should still illustrate the change in the futures' overlay dynamics.

Exhibit 8 plots the premiums of the put options as a percentage of the underlying index spot value and reveals several interesting patterns. First, as one may expect, the premiums in both markets exhibit similar dynamics reflecting the generally similar behavior of the underlying markets. Second, the premiums are considerable and amount to an average of 2.67% and

Exhibit 7

Sharpe Ratio of Hedged Indexes by Instrument and Hedge Ratio

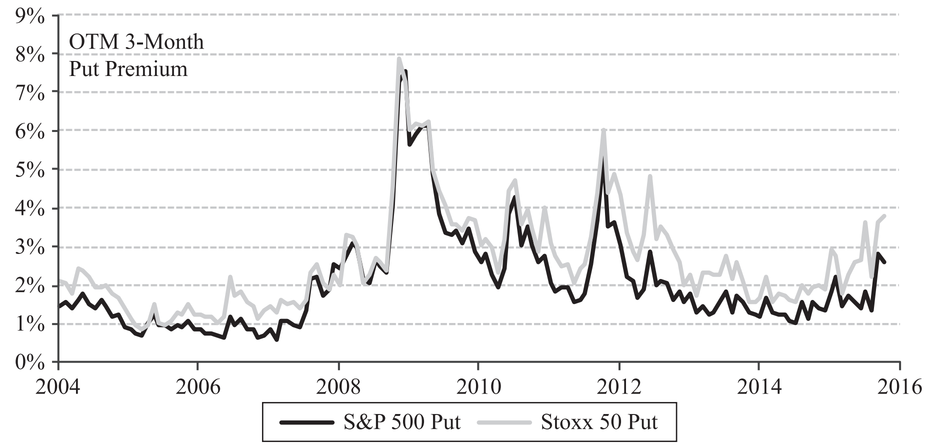


Note: Sharpe Ratios are calculated using returns over 1-month Libor.
Source: Bloomberg, Barclays Research.

2.11% in the Euro and U.S. market, respectively. The somewhat higher premium in the Euro market can be attributed to the difference in the diversification of the underlying index constituents (i.e., the Stoxx 50 would be expected to have a higher volatility, all else equal). Third, although premium levels varied over time, the adjustment was gradual with long periods of elevated premiums (indicating high levels of implied volatility).

Panel B of Exhibit 7 displays the Sharpe Ratios of the U.S. and Euro Indexes hedged with the future/OTM option combination alongside those attained if only futures are used. Two key results applicable to both markets can be observed. First, the future/OTM option combination dominated the futures-only hedge irrespective of the hedge ratio. Second, the performance generated by the option "writing" led to higher Sharpe Ratios than the unhedged index. In the United States the Sharpe Ratio increased from 0.6 to as high as 0.66 for hedge ratios ranging between 0.34 and 0.6. Notice that even for somewhat lower or higher hedge ratios the

EXHIBIT 8
S&P 500 and Stoxx 50 Put Options Premiums



Note: The S&P 500 and Euro Stoxx 50 options are hypothetical contracts priced at the beginning of each month using the contemporaneous implied volatility curve. Their strike prices are set to 95% of the then-current respective index spot level at the beginning of each month.

Source: Barclays Research.

risk-adjusted performance was higher than that of the unhedged index. Only for hedge ratios beyond 0.85, the resulting Sharpe Ratio was lower than 0.6. In the Euro market, the future + OTM option hedge led to Sharpe Ratios that were consistently higher than that of the unhedged index.

To better understand the effect of the option inclusion, Exhibit 9 breaks down the change in Sharpe Ratio to changes in return and volatility of the hedged indexes as a function of the hedge ratio. The charts indicate that the option inclusion led to a substantial reduction in the hedging cost of 5.49% and 4.79% per year in the U.S. and Euro markets, respectively (when the index was fully hedged).[9] In the Euro market, the overall performance was actually higher than that of the unhedged index as a result of using the OTM option. In contrast, the increase in volatility was quite modest and for hedge ratios above 0.78 (U.S.) and 0.64 (Euro), the inclusion of the option resulted in lower volatility compared with the futures-only case. The difference between the return and volatility dynamics reflects the linearity of the former versus non-linear nature of the latter. As a result, the benefit of the futures' hedge increases initially, but starts to rapidly decline once the "cost" incurred from either hedging when the high yield index rose in value or from times when the hedge was not effective supersedes the average benefit. Finally, notice that the minimum volatility with and without the OTM option is quite similar, although it is achieved at different hedge ratios.

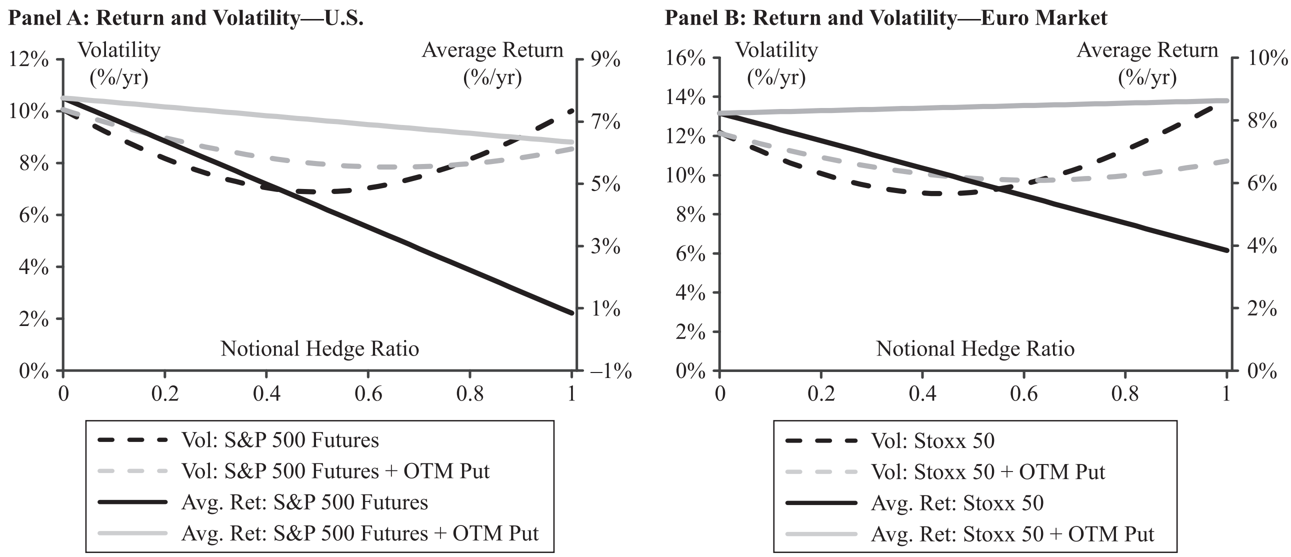
To see the impact of the futures-only and futures/OTM option hedges on the time-series dynamics of the high yield indexes, Exhibit 10 plots the cumulative performance and drawdown (over trailing six-month intervals) assuming a 50% hedge ratio. The chart includes the unhedged index alongside the results for the index hedged using the two equity overlays.

The charts illustrate nicely the difference in cumulative performance between the futures overlay and the futures + OTM option overlay. Using the latter in the U.S. and Euro markets led to a consistent outperformance over the unhedged index throughout most of the sample period (until early 2013 in the U.S. market). In contrast, the performance of the index hedged with the futures-only overlay started to deviate from that of the unhedged index in 2009, resulting in a substantial underperformance by the end of the sample. The charts also indicate that the same overlay tended to perform similarly across markets, with correlations of 0.84 and 0.81 for the active returns (vs. the unhedged index) using the futures-only and futures + OTM option hedges respectively.

The advantage of the futures + OTM option overlay can also be seen when looking at the drawdown dynamics of the indexes (Panels C and D). Not surprisingly,

EXHIBIT 9

Return and Volatility of Hedged Indexes with OTM Put "Writing"



Note: The chart displays the return and volatility of the high yield indexes when hedged with futures or futures + OTM Put option overlays.
Source: Bloomberg, Barclays Research.

the charts show that with this overlay the drawdown figures are lower than those of the unhedged index over almost all six-month periods. The results are similar when compared to using the futures overlay with the exception of the peak of the financial crisis during the third quarter of 2008, when the futures overlay resulted in the lowest drawdown in either market as the OTM put options were exercised.

DYNAMIC HEDGING

The analysis in the previous section compared the efficacy of different overlays and the extent to which it varied as a function of the hedge ratio. The overlays were deployed passively throughout the analysis period using an unchanged hedge ratio. In practice, it is more likely that an overlay would be deployed on a tactical basis, given the portfolio manager view of the conditions in the high yield market. The manager would need to assess not only the likelihood of the high yield market declining but also consider the behavior of the hedging instrument (i.e., what would be the correlation of the overlay with her portfolio) and sizing of the hedge. Hence, one more factor we need to take into account when comparing the hedging success of the different overlays is the manager's "skill." The level of skill can play an important role as different overlays may prove superior for low and high levels of skill, for example.

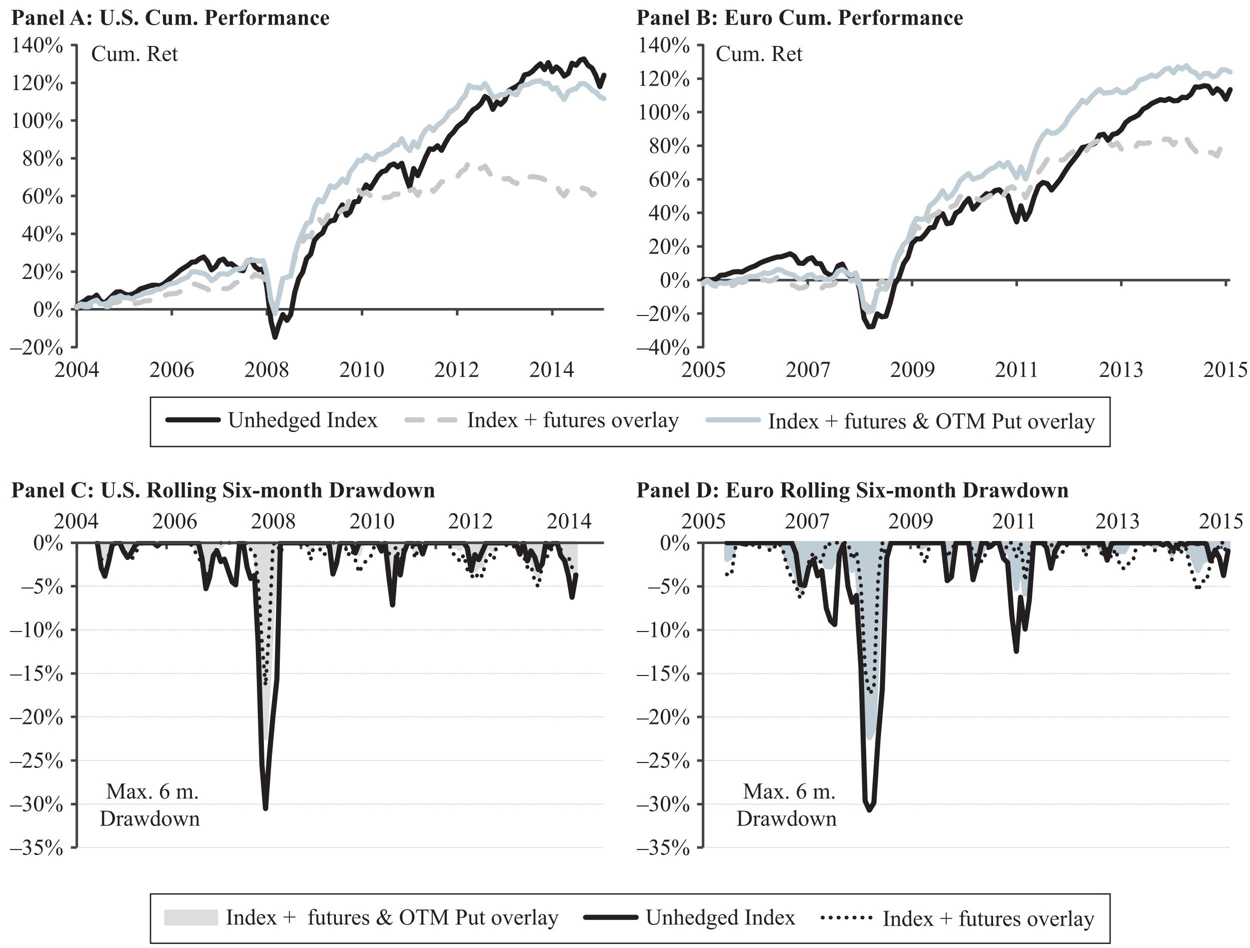
In this section, we incorporate the level of a manger's skill into our framework and examine its effect on our prior conclusions. We first conduct a simulation study using imperfect foresight where skill is defined as the probability of a manager's making the correct hedging call (which we explain in greater detail below). We then examine the performance of the different hedging strategies for different levels of skill. The simulation approach allows us to easily compare the efficacy of the different overlays without the need to formulate an actual set of signals a manager would use in practice to form her views. In the second part of the section we show that a hedging rule based on the simple spread widening indicator we introduced in Exhibit 4 corresponds to a skill level of 10% and results in substantial improvement in performance of both high yield indexes.

Simulating Skill with Imperfect Foresight

More than a decade ago we introduced a framework for representing a manager's skill in making investment

Exhibit 10

Cumulative Performance and Drawdown with Equity Overlays



Note: A constant hedge ratio of 50% was used during the analysis period between September 2004 (September 2005 for Euro) and October 2015. Drawdown represents the percentage decline in cumulative returns from peak to the end-of-period level over any six-month period.

Source: Barclays Research, Bloomberg.

decisions using 'Imperfect Foresight', based on Grinold and Kahn [1999] "Fundamental Law of Active Management."[10] Grinold and Kahn [1999] showed that under certain assumptions the information ratio of any active strategy regardless of its formulation or asset class, depends only on a manager's skill defined as the correlation between his return forecasts and the actual realization, and the number of independent investment decision he can make (i.e., "breadth").

In our framework, every investment decision is structured to have two possible outcomes defined as either "correct" or "incorrect" with skill being defined as the probability of making the correct call *directionally* minus the probability of making an incorrect call. Hence, the magnitude of the market move timed by the manager and the resulting loss or profit is not taken into consideration. The return time-series for a given strategy employed by a manager with a certain skill level amounts to calculating the expected return each period with hindsight when the probabilities of the "correct" decisions are likelier than "incorrect" decisions by the assumed level of skill. We showed empirically that the "Fundamental Law" continued to hold with our new definition of skill, and different strategies with the same level of skill and breadth boasted very similar information ratios.

In the context of our study, we define skill as the probability of making a correct call regarding the performance (negative or positive) of the U.S. or Euro high yield market (as represented by the respective index). It varies from 0% (no skill or random chance) to 100% (perfect foresight). At the beginning of each month, the manager would hedge the portfolio if the performance of the high yield index is expected to be negative and would leave it unhedged otherwise. Hence, an unskilled manager selects whether to hedge or not with equal probability. For skill levels between 0% and 100%, the probability of the correct decision equals the sum of 0.5 and one half of the skill level. Notice that our definition of skill pertains only to the ability to correctly forecast the directional return (positive or negative) of the high yield market. Skill does not capture the behavior of the overlay in relation to the high yield index. Since the correlation of the overlays with the index is less than perfect, it is possible that even if the overlay is deployed correctly (i.e., in a month when the index declines in value) it might not have reduced the loss.

Exhibit 11 presents the return, volatility and Sharpe Ratio of the hedged U.S. and Euro indexes as a function of skill assuming a 100% notional hedge ratio. The results are reported separately for the hedging schemes we presented earlier: credit default swaps, futures, and futures + options. The results for the swaps overlay indicate that in both markets it led to better (average) returns and Sharpe Ratios (compared with the unhedged indexes) only for skill levels above 30%, significantly

EXHIBIT 11

Performance of Hedged Indexes by Overlay Type and Skill Level

		Avg. Ret (%/mo)			Volatility (%/mo)			Sharpe Ratio		
Skill Level	Prob. of 'Correct' Call	Credit Default Swaps	Futures	Futures + Option	Credit Default Swaps	Futures	Futures + Option	Credit Default Swaps	Futures	Futures + Option
Panel A: U.S. HY Index			**0.65**			**2.9**			**0.6**	
0%	50%	0.40	0.36	0.59	2.49	2.91	2.30	0.36	0.26	0.67
10%	55%	0.48	0.48	0.66	2.47	2.86	2.25	0.48	0.41	0.80
20%	60%	0.57	0.60	0.73	2.45	2.81	2.21	0.60	0.57	0.93
30%	65%	0.65	0.72	0.81	2.43	2.75	2.18	0.72	0.73	1.06
40%	70%	0.73	0.85	0.88	2.41	2.69	2.15	0.84	0.91	1.19
50%	75%	0.81	0.97	0.96	2.38	2.61	2.13	0.97	1.09	1.32
60%	80%	0.89	1.09	1.03	2.35	2.54	2.12	1.10	1.29	1.45
70%	85%	0.97	1.21	1.10	2.32	2.45	2.11	1.24	1.51	1.58
80%	90%	1.05	1.33	1.18	2.28	2.35	2.11	1.38	1.75	1.70
90%	95%	1.13	1.45	1.25	2.24	2.24	2.11	1.53	2.03	1.82
100%	100%	1.22	1.58	1.32	2.20	2.12	2.12	1.69	2.34	1.93
Panel B: Euro HY Index			**0.69**			**3.50**			**0.54**	
0%	50%	0.38	0.50	0.70	2.99	3.73	2.83	0.29	0.34	0.69
10%	55%	0.46	0.65	0.79	2.99	3.67	2.78	0.38	0.49	0.81
20%	60%	0.54	0.80	0.87	2.98	3.61	2.74	0.47	0.64	0.93
30%	65%	0.62	0.95	0.95	2.98	3.54	2.71	0.56	0.79	1.05
40%	70%	0.70	1.09	1.03	2.97	3.47	2.68	0.66	0.96	1.16
50%	75%	0.77	1.24	1.12	2.95	3.38	2.66	0.75	1.14	1.28
60%	80%	0.85	1.39	1.20	2.94	3.29	2.65	0.85	1.32	1.40
70%	85%	0.93	1.54	1.28	2.93	3.18	2.64	0.94	1.53	1.51
80%	90%	1.01	1.69	1.37	2.91	3.07	2.65	1.04	1.75	1.61
90%	95%	1.09	1.83	1.45	2.89	2.95	2.66	1.15	2.00	1.71
100%	100%	1.17	1.98	1.53	2.87	2.81	2.68	1.25	2.28	1.81

Source: Bloomberg, Barclays Research.

higher than the level of skill a typical manager possesses.[11] With respect to futures, in the Euro market they dominated the swaps overlay in terms of both average return and Sharpe Ratio irrespective of skill level. This reflects the significant underperformance of the Stoxx 50 index relative to the iTraxx.XO over the sample (see Exhibit 2). In the more likely scenario represented by the U.S. market (Panel A), where equities outperform credit default swaps in a period of an overall upward trending market, the futures overlay was superior to the swaps overlay but only for skill levels over 20%. The reason is that deploying the overlay incorrectly is "costlier" when futures are used as opposed to credit default swaps. Hence, only at a relatively high level of skill the efficacy of the futures overlay (i.e., the higher correlation during down markets) starts to outweigh the costs resulting from untimely hedging.

The futures + OTM options overlay proves once again to be superior to the other two overlays in terms of return, volatility and Sharpe Ratio for skill levels below 50% and 30% in the U.S. and Euro markets, respectively. Even with no skill, using this overlay results in higher Sharpe Ratio than the unhedged index in either market. Moreover, even improving the average return themselves required only a moderate level of skill in the U.S. market (10%) and no skill in the Euro market.

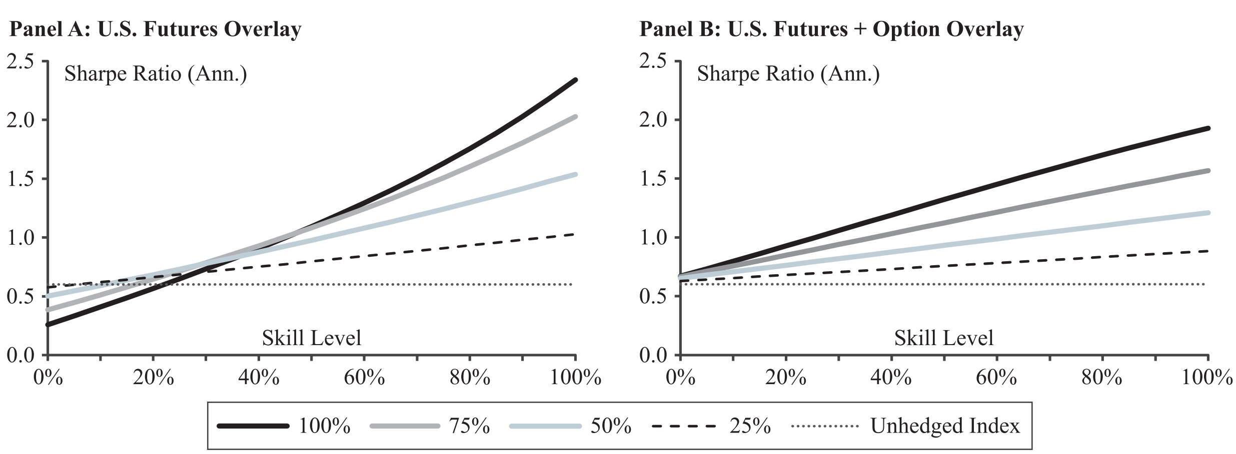
The advantage of the futures + OTM options overlay is unchanged if we consider partial hedging. Exhibit 12, which plots the Sharpe Ratio as a function of skill for different hedge ratio levels, indicates that the optimal hedge ratio when using the futures overlay depends on the level of skill with higher skill warranting a higher hedge ratio. A manager with 10% skill might have still improved the Sharpe Ratio of her portfolio by using a hedge ratio of 0.25. In contrast, when it comes to the futures + OTM options overlay it is always optimal to fully hedge regardless of the level of skill a portfolio manager possesses (the results for the Euro market are almost identical and are omitted for brevity).

Active Hedging with a Spread Signal

The imperfect foresight framework, while providing insights about the relation between the level of skill, optimal hedge ratio and efficacy of the different overlays is somewhat abstract in that it does not directly tie into actual signals or indicators that portfolio managers would be using in practice. We therefore repeat the analysis using the simple spread widening indicator we introduced earlier.

The relative illiquidity of the high yield market results in auto-correlation of monthly returns as new information cannot be incorporated into prices instantaneously. This in turn leads to predictable market dynamics anytime large negative adjustments to prices are needed. The gradual price adjustment may also be reinforced by investors' behavior. Once the

EXHIBIT 12
Sharpe Ratio as a Function of Skill and Hedge Ratio



Note: Sharpe Ratios are calculated using returns over 1-month LIBOR.
Source: Bloomberg, Barclays Research.

EXHIBIT 13
Relation between Spread Signal and High Yield Market Behavior

		U.S.			Euro		
		Ret. < 0	**Ret. >= 0**	**Overall**	**Ret. < 0**	**Ret. >= 0**	**Overall**
Total		39	95	134	35	87	122
Signal (months)	'Hedge'	10	13	23	11	12	23
	'Don't Hedge'	29	82	111	24	75	99
Prob. Conditional on	Correct call	26%	86%	69%	31%	86%	70%
Ret. Realization	Incorrect call	74%	14%	31%	69%	14%	30%
'Skill' equivalent			37%			41%	
'Skill' with equal 'up' and 'down' months			12%			18%	

Source: Barclays Research.

adjustment process has begun, those who anticipate the continued downtrend in the market may sell their holdings, resulting in negative flows, which would tend to increase the down pressure.

The illiquidity that leads to predictable market patterns also prevents investors from exploiting them directly by trading high yield bonds due to high transaction costs. Nevertheless, a synthetic overlay can be deployed quickly and cheaply based on a quantitative signal and may effectively limit the losses of the underlying high yield portfolio. We therefore consider a case where the overlay is deployed in any month that was preceded by a spread widening of more than one standard deviation (based on the DTS concept) during the previous month.

Exhibit 13 reports the signal behavior in up and down (high yield) markets in the United States and Euro area. The table demonstrates that unlike in the simulated skill case, where skill was assumed to be uniform across markets states, the spread signal exhibits different success rates in up and down markets. The signal was quite effective in up markets with a success rate of 86% (i.e., 14% of the months with positive high yield market performance were preceded by a "large" spread widening). In down months, the signal was less successful: identifying only 26% of these periods in the U.S. market and 31% in the Euro market. Notice that despite, the lower "hit" rates identifying "down" markets, the overall success rates (69% and 70%, respectively) were still much higher than a 50%–50% random chance produced by an uninformative signal.

The success of our spread signal can be converted into a skill level by combining the *empirical* frequency of up and down months in the sample with the conditional probability of the signal being correct. The resulting skill levels of 37% and 41% reflect the fact that most sample months were "up" months during which the signal has higher success rates. If instead, we assume that the percentage of positive and negative months in the sample was equal as was the case in the simulated skill setup, the resulting skill levels would be 12% and 18% in the United States and Euro area respectively.

Next, we examine the performance of the different overlays based on the spread widening signal assuming partial (50%) or full hedging. The results, reported in Exhibit 14, offer several interesting insights. First, the futures + OTM options overlay continues to dominate the other overlays when the portfolio is fully hedged in both markets in terms of return and Sharpe Ratio. Furthermore, the Sharpe Ratios (0.78 and 0.85 in the U.S. and Euro markets, respectively) correspond very closely to the Sharpe Ratios from Exhibit 11 for skill levels of 10% and 15% (U.S. and Euro), very similar to the empirical skill levels we documented in Exhibit 13. On a standalone basis (i.e., the hedged index returns minus the unhedged index) the overlay generated an information ratio of 0.16 and 0.42 in the U.S. and Euro markets, respectively. Second, with partial hedging (50%) the Sharpe Ratio of the futures + OTM options declines to 0.71 in both markets, consistent with the results in Panel B of Exhibit 12 that the highest Sharpe Ratios for this overlay is achieved with full hedging. Third, while the futures overlay generated equal or slightly higher Sharpe Ratios than the futures + OTM options overlay for partial hedging, overall performance and information ratios were lower. Lastly, deploying the credit default swaps

Exhibit 14

Performance of Active Overlay Strategy with Spread Signal

	High Yield Index	Partial Hedging (HR = 0.5) Credit Default Swaps	Partial Hedging (HR = 0.5) Equity Futures	Partial Hedging (HR = 0.5) Equity Futures + OTM Put	Full Hedging (HR = 1) Credit Default Swaps	Full Hedging (HR = 1) Equity Futures	Full Hedging (HR = 1) Equity Futures + OTM Put
U.S.		**CDX.HY**	**S&P 500**	**S&P 500**	**CDX.HY**	**S&P 500**	**S&P 500**
Avg. Ret. (%/mo)	0.65%	0.63%	0.66%	0.68%	0.60%	0.68%	0.72%
Volatility (%/mo)	2.90%	2.58%	2.42%	2.62%	2.45%	2.54%	2.55%
Sharpe Ratio	0.60	0.64	0.74	0.71	0.65	0.73	0.78
Inf. Ratio (Hedged-Unhedged)		–0.10	0.04	0.16	–0.10	0.04	0.16
Euro		**iTraxx.XO**	**Stoxx 50**	**Stoxx 50**	**iTraxx.XO**	**Stoxx 50**	**Stoxx 50**
Avg. Ret (%/mo)	0.69%	0.68%	0.76%	0.79%	0.68%	0.84%	0.89%
Volatility (%/mo)	3.50%	3.23%	3.03%	3.18%	3.11%	3.19%	3.07%
Sharpe Ratio	0.54	0.58	0.71	0.71	0.60	0.76	0.85
Inf. Ratio (Hedged-Unhedged)		–0.02	0.19	0.42	–0.02	0.19	0.42

Source: Barclays Research, Bloomberg.

overlay led to lower returns than the unhedged index in all cases as was also shown in Exhibit 11, but still resulted in better Sharpe Ratios (compared with the unhedged indexes) due to the reduction in volatilities.

Panels A and B of Exhibit 15 plot the cumulative performance of the unhedged index alongside its return when the futures + OTM options overlay is used in both markets (months when the overlay was deployed based on the spread signal are marked by grey bars). Not surprisingly, the charts indicate that performance started to diverge in early 2007, at the beginning of the financial crisis. The overlay was deployed multiple times between 2007 and 2009 and generated an outperformance that increased steadily in the following years. Another observation made clear when looking at both charts is the high degree of similarity between the two markets. The correlation between the returns of the two high yield indexes was 0.91, while the signals exhibited a correlation of 0.67[12] (i.e., between the "hedge" and "don't hedge" calls).

The spread signal accuracy corresponds to "skill" levels of 37% and 41% in terms of the simulation framework we employed earlier. However, as we discussed before, with an equal frequency of "up" and "down" months, the skill level would have been 12% and 18%, respectively. Indeed, the results of employing the futures + options overlay in Exhibit 14 (based on the actual frequency) resembled the results in Exhibit 11 for skill levels of 10% and 15% in the U.S. and Euro markets.

Exhibit 16 compares the cumulative performance of the indexes hedged with the equity futures + OTM option overlay using the spread signal to results based on the simulation framework assuming skill levels of 12% and 37% (U.S.) and 18% and 41% (Euro). In both markets, the line representing the returns based on spread signal is nestled between the two dashed lines reflecting the simulation results for the "low" and "high" skill levels. This pattern provides a nice confirmation to the simulation framework we used, which limits the definition of skill to success in predicting directional moves and disregards the magnitude of returns. Furthermore, the simulation results can be seen as offering an upper and lower boundary to the performance that can be expected from a certain signal given the fact that in practice most signals are likely to have uneven success rates across markets states.

SUMMARY

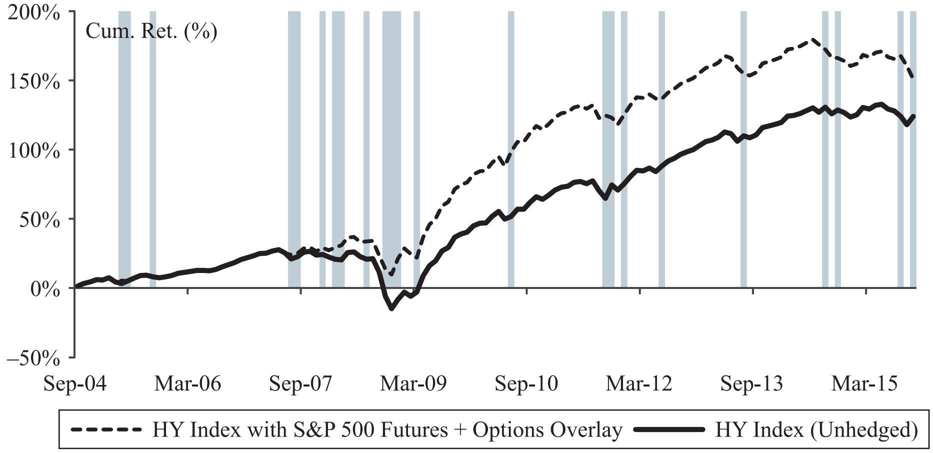
Using a synthetic overlay to hedge systematic downturns in the cash high yield market looks like a straightforward proposition in light of the asset class risk properties and relative illiquidity. The article offers three key insights that high yield portfolio managers should be aware of if they consider using such an approach.

First, the large basis risk between the cash and synthetic market makes index credit default swaps ineffective exactly at times when they are most needed.

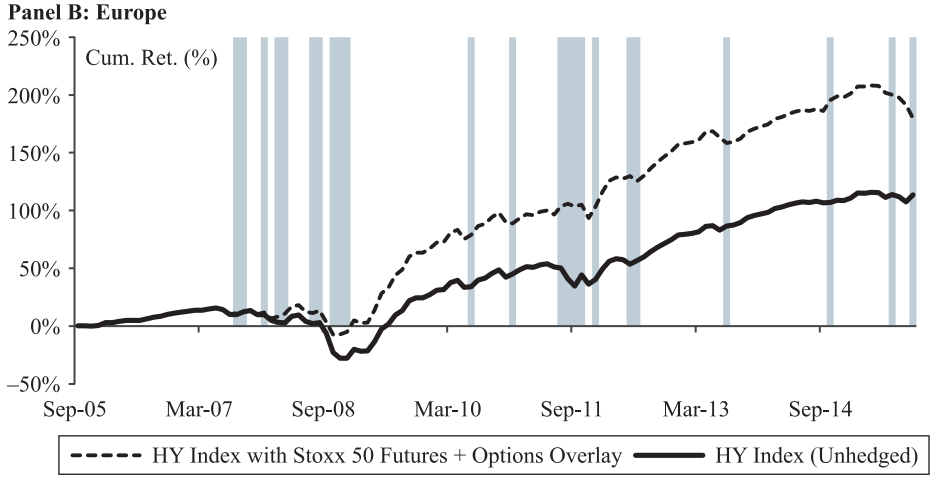
Exhibit 15

Cumulative Performance with an Active Overlay

Panel A: U.S.



Panel B: Europe



Note: The grey areas represent months where the spread signal made a 'hedge' call.
Source: Barclays Research, Bloomberg.

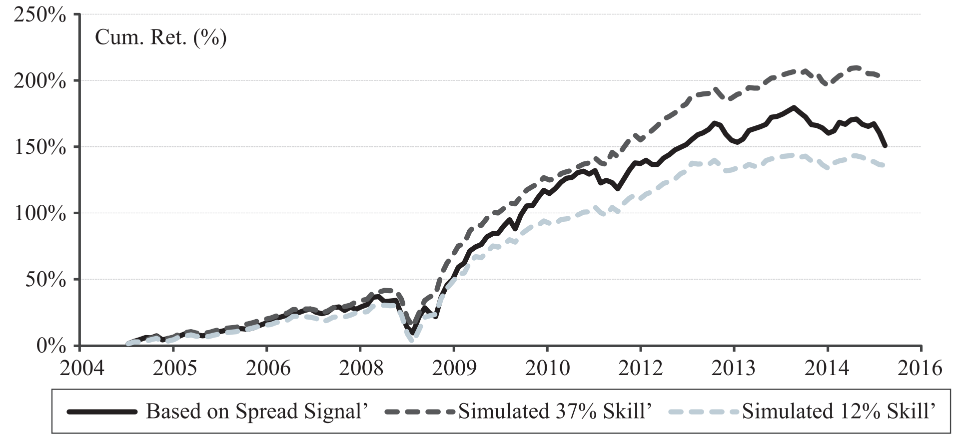
Surprisingly, equity futures prove to be better hedges irrespective of the risk measure and hedge ratio used in both U.S. and Euro markets. Second, combining the futures with OTM option "writing" generates income that reduced the hedging costs significantly, with limited effect on risk. As a result, risk adjusted performance increased and superseded that of the unhedged index even when the overlay was deployed passively. Third, our results hold even when we extend the analysis to encompass a manager's level of skill in deploying the hedges tactically. Furthermore, we demonstrate that the predictability of the high yield market allows even a simple signal to be the basis for an active hedging strategy that generates consistent outperformance versus the unhedged index.

While the results may be affected to some extent by the formulation of our analysis, we believe that the general conclusions should broadly apply to any well diversified high yield portfolio. The choice of the S&P 500 index in the U.S. market for example was motivated by the ease (and cost) of trading the corresponding futures and options. Other indexes such as the Russell 2000 may track the high yield market dynamics more closely, given the characteristics of their constituents, but they may be more difficult to employ in practice.[13] Regardless, the advantage of the equity futures was not driven by the

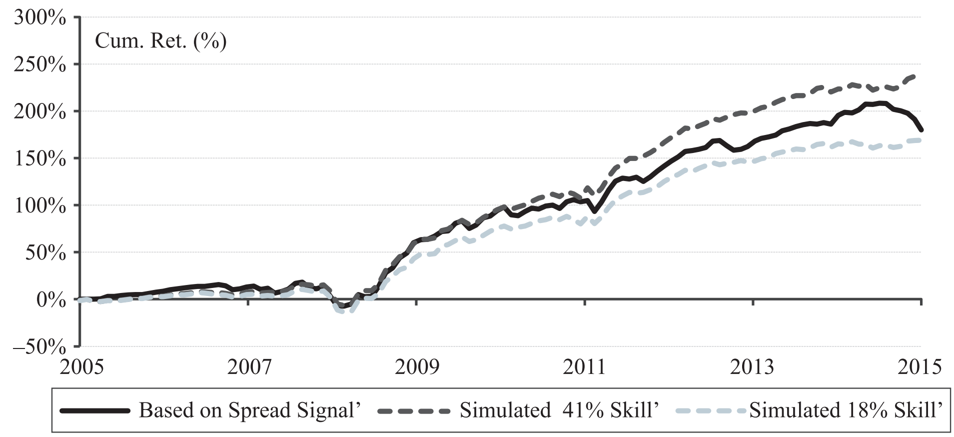
Exhibit 16

Actual vs. Simulated Performance of Index Hedged with Futures + Options Overlay

Panel A: U.S.



Panel B: Euro



Note: The exhibits display the actual cumulative performance of the high yield indexes hedged using the futures + OTM put overlay based on the spread signal or simulated assuming different skill levels.

Source: Barclays Research, Bloomberg.

identity of the underlying index but by the fact that the link between cash and synthetic equity markets was not severed in episodes of market stress as was the case in fixed income markets.

Similarly, our use of the spread-based signal was only meant to illustrate that the results we found using the simulation approach are indeed realistic. Clearly, this simple indicator can be augmented with additional market or economic indicators in order to generate a more powerful signal with various numeric values. Rather than a binary signal resulting in a hedge being deployed or not, such a signal can be used to vary the hedge ratio over time.

Finally, it is important to note that while the magnitude of market dynamics in the financial market played a large role in our sample (and affected the results), our findings remain qualitatively similar even if that period was removed from our analysis.

ENDNOTES

[1]Scaling down risk can be achieved either by selling positions and switching to cash or replacing 'high beta' names with 'low beta' names.

[2]The combined net assets of the two largest high yield exchange traded funds (tickers: HYG and JNK) as of October

2015 was only $21bn compared with a market value of $1.2trn for the Bloomberg Barclays U.S. High Yield Index.

[3]Unlike investment grade bonds, the 'empirical duration' of high yield bonds is often close to zero or even negative, similar to the effect interest rates have on the performance of equities (see Ambastha et al. [2010] for a detailed analysis).

[4]The spread widening was deemed large if it exceeded the product of spread level at the beginning of the month and 10%. See Ambastha, Ben Dor, and Dynkin [2009] for an illustration of this approach during the financial crisis.

[5]This result by Desclee, Maitra, and Polbennikov [2016] contradicts an earlier report by Dhande and Phelps [2007] who compared the Bloomberg Barclays Credit Index returns to those of the CDX.IG between April 2004 and August 2007.

[6]To see why changes in liquidity can lead to performance differences between a derivative and the underlying cash security, consider a futures position on a bond. In the absence of transaction costs, the futures price is linked to the underlying index through the cost-of-carry arbitrage condition. An investor holding a long futures position earns interest paid on his margin account but foregoes coupon payments on the underlying bond position. If prices deviate, then an arbitrageur will sell (buy) the underlying bond and buy (sell) the futures contract to earn an arbitrage profit. However, during periods of reduced liquidity, such as the 2008–2009 financial crisis, the increase in transaction costs and the lack of sufficient funding prevented arbitrageurs from closing the gap between the prices of derivatives and the underlying cash securities. Once the market bounced back in 2009, the liquidity on cash instruments improved and their prices recovered. Thus, during the sharp recovery that followed, cash instruments earned higher returns than their derivative counterparts.

[7]The costs associated with deploying a futures' hedge at the 'wrong' time may be larger, for example, than those resulting from using credit default swaps.

[8]The S&P 500 and Euro Stoxx 50 options are hypothetical contracts priced at the beginning of each month using the contemporaneous implied volatility curve. Their strike prices are set to 95% of the then-current respective index spot level.

[9]The annual figures correspond to quarterly values of 1.37% and 1.19% (U.S. and Euro, respectively) compared with the average premium of 2.11% and 2.67% from Exhibit 8. The difference reflects the empirical distribution of the underlying futures returns and the fact that the options are not held to expiration but are rolled monthly.

[10]For more details see Dynkin, Hyman, and Wu [2000].

[11]We consider skill levels above 20% as unlikely based on actual investors' track records of their investment calls and when comparing the simulated information ratios to those observed in practice in real portfolios.

[12]The correlation between the signals was calculated by assigning values of 0 and 1 to the decision to hedge or not in each market.

[13]The U.S. High Yield Index constituents are more similar to firms included in the Russell 2000 than in the S&P 500 in terms of size for example.

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