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Abstract

The search for dependable, low-cost portfolio tail protection or hedge from exogenous events such as the 1987 crash, the 2000 dot-com bubble, the 2008 credit crisis, and the 2011 European crisis continues. This study assesses the performance of a systematic VIX call buying strategy with a defined cost to hedge an equity portfolio from systemic risk. A portfolio manager must weigh these costs against those of hedging strategies that have potentially undefinable costs, for example, protective puts or shorting equity index futures. The analysis shows that a passive allocation to VIX calls has proven effective in large drawdown periods and can be accomplished by spending a relatively small defined percentage of capital when the hedge is not needed. The study applies a set of fixed rules to empirical data with the goal of optimizing ex-post the moneyness and expiry of VIX call options over the period studied. For the period of analysis, the systematic purchase of properly placed VIX calls tends to provide sufficient protection in tail risk events for minimal cost when hedging is not needed.

Introduction

The past fifteen years have been marked by two devastating bear markets that have resulted in minimal to negative returns in real dollars across major U.S. indexes. The search for a low-cost, systematic portfolio tail-risk hedge continues. A variety of strategies can provide capital protection for asset-based portfolios; however, these strategies produce considerable negative excess returns during up-trending markets and over the past several years would have been cost-prohibitive. This paper examines ex-post performance with available empirical data to determine the optimal cost-effective placement of VIX calls to protect against tail risk within a portfolio. As spot VIX is not directly investable, this analysis considers the benefits of a long exposure to VIX call options from VIX futures that are investable. The fact that VIX is not directly tied to the level of the SPX,[1] like an option on the S&P 500, makes hedging equity exposure with VIX very difficult.

VIX

A product of the Chicago Board of Options Exchange® (CBOE®), the CBOE Volatility Index® (VIX® Index) is a popular measure of the market's expectation of the thirty-day volatility implied by S&P 500® Index options annualized. The CBOE introduced the VIX Index in 1993. In March 2004, CBOE introduced the first exchange-traded futures contract on VIX on the CBOE Futures Exchange and later introduced VIX options in February 2006. A detailed explanation of the calculation and characteristics of VIX can be found in Whaley (2000, 2009).

Historical Studies

Research suggests that holding long volatility exposure in a portfolio produces negative excess return over the long term. DeLisle et al. (2014) discusses the benefits of spot VIX as a natural hedge to a portfolio; however, one cannot invest in spot VIX. Stanton (2011) examines the benefit of using various products such as VIX futures, options, or exchange-traded products as a hedge and concludes that the translation between realized and implied volatility along with the tracking error inherent in these products reduces their value to short-term market timing. Szado (2009) examines investing in the front-month VIX futures and options, rolling them on expiration, and finds considerable value during the 2008 credit crisis. However, the allocation to VIX futures is substantial, causing considerable negative excess return during periods when a tail hedge is not needed. Furthermore, purchasing front-month VIX futures or options becomes extremely expensive during periods of high volatility.

Other popular strategies such as VXX (iPath® S&P 500 VIX Short-Term Futures™ Index TR ETN), which holds a thirty-day constant maturity through the first two months of VIX futures, creates a large tracking error when spot VIX moves into backwardation as well as a large negative roll cost due to steep contango in normal- to low-volatility environments. Lehman and McMillan (2011) evaluated the benefits of changing the moneyness of VIX call options through the credit crisis because of the asymmetrical relationship between VIX and the S&P 500 evaluating the optimal notional exposure and thirty-day expiry. Furthermore, Lehman and McMillan (2011) discusses the advantages of VIX calls over S&P put options. Rhoads (2011) uses calendar spreads on VIX futures and also utilizes VIX put options to limit the exposure on the front-month contracts. This strategy dampens the desired convexity and exponential beta response due to the back-month contract.

Alexander and Korovilas (2011) looks at using VIX futures within a modern portfolio theory framework over three time periods: before the credit crisis, during the credit crisis, and during the

European crisis. Alexander and Korovilas (2011) examines if exposure to VIX futures would have been value added as part of the allocation process. The authors look at different expirations and determine whether rolling to the one-month, three-month, or furthest-dated futures contract provided optimal returns. Alexander and Korovilas (2011) determines that using volatility products to hedge portfolios within an institutional framework should be done with caution; the article states: "Most of the time, volatility's negative carry and roll yield heavily erodes equity performance, and the only time volatility diversification is optimal is at the onset of a stock market crisis. … Perfect foresight would seldom justify the purchase of VIX futures as a long equity diversification tool." However, Alexander and Korovilas (2011) only examines futures and uses a very limited array of tools to make broad conclusions. The CBOE published an index to cope with extreme downward movements in stock indexes, called the CBOE VIX Tail Hedge Index℠ (VXTH℠). The index uses a tactical allocation to one-month 30 delta VIX call options on top of a portfolio holding the S&P 500 Index. The number of VIX calls allocated in any one month is dependent on the level of spot VIX. Table 1 shows the VXTH allocation to VIX calls based on the level of VIX.

In 2009 and 2010, total VIX calls purchased for the VXTH Index amounted to 900 basis points and 1,150 basis points, respectively. The variability of the percentage allocation to a tail hedge in this approach makes it challenging for a portfolio manager to justify such a heavy allocation to a hedge that carries a negative expected return.

The purpose of this study, unlike other studies, is to determine whether systematic exposure to VIX calls could help diversify a portfolio during crisis periods as well as reduce the carrying cost of holding long volatility exposure in non-crisis periods. Because long volatility positions are expected to earn a negative excess return over the long term, many studies use a quantitative trigger to determine when to invest in VIX options. The question becomes: Can passive long volatility exposure be value added over the long term with minimal cost? In other words, can the portfolio continuously wear a seat belt in all types of markets with a minimal cost to carry?

Methodology

The goal of this study is to determine the optimal moneyness, expiry, and minimal capital required through the time period examined to determine the most effective positioning of VIX call options within a portfolio framework. We will look at how this optimization would have performed on a 60-percent/40-percent stock/bond mix through the period examined, as well as on an 80-percent/20-percent stock/bond mix and a 100-percent stock portfolio, which will be compared to the CBOE VIX Tail Hedge Index (VXTH). The initial value of this portfolio, including VIX call options, was $10 million in January 2008.[2] This study attempts to minimize the negative roll and hold the options to expiration to reduce the tracking error associated with selling the options before expiration.

Finally, we use a set of reasonable assumptions to look at this methodology in an out-of-sample (OOS) test through the October 1987 market crash to understand its viability in different time periods.

The stock/bond portfolio is represented by the SPDR® S&P 500 ETF Trust (SPY) and the iShares 7–10 Year Treasury Bond ETF (IEF). Table 2 shows the performance from January 2008 through December 2013 of the SPY and an unhedged 60-percent/40-percent (SPY/IEF) portfolio rebalanced to the desired weighting (60/40) each month.

An allocation of VIX calls is examined from the period January 2008 through December 2013 to optimize the moneyness and expiry.

This study solved for the highest Sortino ratio due to the fact that the returns of option-based strategies are not normally distributed. The Sharpe ratio, developed in 1966 by Stanford finance professor William F. Sharpe, PhD, examines the risk premium (return minus the risk-free rate) over the standard deviation of returns. The Sharpe ratio tends to punish option-based strategies that look to produce asymmetrical returns (positively skewed). The Sharpe ratio will punish upside volatility, increasing the denominator, which will reduce the ratio. The Sortino ratio examines the risk premium over the downside deviation (volatility of return less than

Table 1: VXTH Allocation to VIX Calls Based on VIX Level

F = One-Month Forward Value of VIX	Portfolio Weight of VIX Calls
F < = 15%	0%
15% < F <= 30%	1%
30% < F <= 50%	½%
F > 50%	0%

Table 2: SPY and 60/40 (SPY/IEF) Performance January 2008–December 2013

2008–2013	S&P 500 (SPY)	60/40 Mix (SPY/IEF)
Annualized Return	6.23%	6.39%
Beta	1.00	0.55
Standard Deviation	19.00%	10.28%
Downside Deviation	13.67%	8.61%
Sharpe Ratio	0.33	0.62
Sortino Ratio	0.46	0.74
Media VIX Strike Median % Above Future		
Maximum Drawdown	–48.22%	–28.49%
Time of Maximum Drawdown	2/28/2009	2/28/2009
October 2008 Drawdown	–16.51%	–10.24%
Flash Crash Drawdown	–7.94%	–3.59%
Euro Crisis Drawdown (04/11–09/11)	–16.22%	–5.44%

zero). In this way the Sortino ratio can give a better picture of the true risk-adjusted return of an option-based strategy.

Each month, on the day before expiration, the options are rolled to the appropriate expiry. The base portfolio is rebalanced monthly. Returns are calculated for each portfolio on a monthly basis. Given the low cost of institutional trading, transaction costs are not considered. VIX call options are purchased at the offer and sold at the bid to keep the assumptions conservative. This likely would account for any commission and/or transaction costs of implementing this strategy in real trading.

All historical VIX data were obtained through Live-Vol, a third-party vendor that gets its data from the Chicago Board of Options. This study uses the empirical data to determine if systematic purchasing of VIX call options can be value added in tail events such as 2008 while minimizing the negative excess return during non-market stress periods. For this reason, the exposure to VIX will be based on allocating a fixed percentage of the portfolio value each month, not on a notional amount. Investing a fixed percentage into VIX call options each month can affect the number of contracts purchased. When VIX is higher the number of options being purchased will be lower and when VIX is lower the number of options being purchased will be higher. The thinking is that volatility tends to cluster and mean-revert. A fixed percentage per month allows more options to be purchased when VIX is below the mean and fewer options to be purchased when VIX is above the mean. This study examines whether a rules-based approach within a portfolio is viable. The placement of VIX calls (i.e., moneyness and expiry) is repeated each and every month through the period with the fixed percentage allocation. The quantity of contracts will change because the price of the option is not constant; however, the option's moneyness relative to the underlying futures contract, as well as expiry, will not change. If an option is not available at the desired moneyness, the strike price used will be rounded up to the nearest available VIX call option with observed data.

The study initially invests 25 basis points (bps) in the desired VIX call option, then allocates 60 percent of the portfolio to the SPY and the remaining 40 percent to the IEF. Twenty-five basis points is an arbitrary percentage that is not large enough to create a prohibitive negative excess return to the portfolio (defined as approximately 300 bps/year) in nonevent periods. The study examines VIX call options purchased at-the-money (ATM), 120 percent, 135 percent, and 145 percent of the moneyness of the underlying futures price. The options are held to maturity and closed the Tuesday afternoon before the Wednesday morning of VIX futures and options expiration. If the contracts have any intrinsic value, they are sold at the bid price and the cash is used at the end of the month to rebalance the stock/bond portion of the portfolio. The benchmark is the SPY and the initial client portfolio represents a 60-percent/40-percent stock/bond mix without the VIX call overlay.

The study assesses systematically purchasing one-month, two-month, three-month, and four-month VIX call options each month from the VIX futures. No more than 25 bps of the portfolio value is invested each month. For example, the four-month VIX call ladder invests 25 bps in a four-month VIX call option approximately every thirty days. This means the portfolio holds the four-month, three-month, two-month, and one-month (current expiring month) VIX call options on the roll date. On the roll date, 25 bps of the current portfolio value is invested in the four-month VIX call at the predetermined moneyness. The process is repeated on the close of the market on the Tuesday before the Wednesday morning expiration of VIX options each month.

To ensure that readers understand the VIX call ladder strategy, I provide an example of the process of entering into a four-month, 120-percent moneyness VIX call ladder. Table 3 shows the first four purchase dates for the four-month VIX call ladder along with associated futures prices and expiration dates, approximate call strikes (based on 120-percent moneyness), actual call strikes that had observed data on the date, and call prices. The final two columns describe the number of contracts purchased based on 25 bps of the portfolio value and the cost of VIX calls on the purchase date.

The approximate call strike is calculated by taking the price of the fourth-month futures contract on the purchase date and multiplying it by 1.2 (e.g., for 135-percent moneyness, multiply by 1.35). The actual call strike represents the strike price of a VIX call option with observed data on the purchase date that is as close to the approximate call strike as possible. If there is not a VIX call struck at the approximate call strike, we round up to the nearest call strike. The price is based on the ask price on the close of the purchase date. Thus, the number of contracts purchased is based on taking 25 bps of the portfolio value on the purchase date and

Table 3: Four-Month VIX Call Ladder

Purchase Date	Expiration Date	Futures Price	Approx. Call Strike	Actual Call Strike	Call Price	# of Contracts	Cost
1/15/2008	5/21/2008	24.95	29.94	30.00	$2.35	106	$24,910.00
2/15/2008	6/18/2008	24.86	29.83	30.00	$1.65	147	$24,255.00
3/18/2008	7/16/2008	25.51	30.61	32.50	$1.25	191	$23,875.00
4/15/2008	8/20/2008	24.52	29.42	30.00	$1.45	165	$23,925.00

Table 4: Four-Month VIX Call Ladder

Purchase Date	Expiration Date	Futures Price	Approx. Call Strike	Actual Call Strike	Points OTM	% OTM from Future	Pts. Above Approx. Strike
1/15/2008	5/21/2008	24.95	29.94	29.94	30.00	120%	0.06
2/15/2008	6/18/2008	24.86	29.83	29.85	30.00	121%	0.17
3/18/2008	7/16/2008	25.51	30.61	30.61	32.50	127%	1.89
4/15/2008	8/20/2008	24.52	29.42	29.42	30.00	122%	0.58

Table 5: 100-Percent Moneyness VIX calls with One- to Four-Month Ladder, January 2008–December 2013

VIX Call Ladder	60/40 Mix	1	2	3	4
Moneyness		100%	100%	100%	100%
Annualized Returns	6.39%	5.75%	5.98%	6.13%	6.61%
Beta	0.55	0.47	0.44	0.42	0.39
Standard Deviation	10.28%	9.00%	8.70%	8.34%	7.96%
Downside Deviation	8.61%	6.93%	6.58%	6.16%	5.62%
Sharpe Ratio	0.62	0.64	0.69	0.73	0.83
Sortino Ratio	0.74	0.83	0.91	1.00	1.17
Median VIX Strike		24.00	25.00	25.00	25.00
Median % Above Future		102.78%	102.69%	104.12%	102.43%
Maximum Drawdown	–28.49%	–25.54%	–23.29%	–21.79%	–19.36%
Time of Maximum Drawdown	2/28/2009	2/28/2009	2/28/2009	2/28/2009	2/28/2009
October 2008 Drawdown	–10.25%	–0.73%	0.51%	1.30%	2.05%
Flash Crash Drawdown	–3.59%	–1.99%	–2.14%	–2.42%	–2.16%
Euro Crisis Drawdown (04/11–09/11)	–5.44%	–3.9%	–3.01%	–2.1%	–1.83%

allocating as much of that capital toward VIX calls without exceeding 25 bps of the portfolio value.

Table 4, column 7 shows that the actual call strike sometimes can result in the strategy being long VIX calls that are greater than 120-percent moneyness. This is again due to the assumption that we round up to the nearest VIX call strike with observed price data on the purchase date.

For example, on 4/16/08, the VIX call portion of the portfolio holds the May 2008 30.00 call strike (purchased on 1/15/08), the June 2008 30.00 call strike (purchased on 2/15/08), the July 2008 32.50 call strike (purchased on 3/18/08), and the August 2008 30.00 call strike (purchased on 4/15/08).

Next we examine an 80-percent/20-percent stock/bond mix that invests in VIX calls[3] and a 100-percent equity portfolio that invests in VIX calls. When increasing our equity exposure in both the 80-percent/20-percent allocation and the 100-percent allocation, we don't increase the percentage allocation to VIX calls, consistent with the goal of maintaining a low cost of carry and continuous exposure to a long volatility hedge.

Lastly, we examine how a 100-percent allocation to the S&P 500 with a laddered VIX call strategy compares to the CBOE VXTH Index, which overlays the returns of its VIX call option strategy on the returns of the S&P 500 (SPX Index). Note that the results represent returns of the VIX call ladder strategy overlaid on returns of the SPX Index to keep the methodology consistent with the VXTH Index. This differs from the methodology used earlier, which allocated 60 percent and then 80 percent of the hypothetical portfolio to the ETF counterpart (i.e., the SPY).

Results

Performance of the one-, two-, three-, and four-month VIX call ladders purchased systematically at various levels of moneyness over the six-year period is described here. Table 5 describes the systematic purchase of VIX calls at 100-percent moneyness with expiries ranging from one to four months. Note that the "VIX Call Ladder" column in tables 5, 6, 9, and 10 refers to the amount of different expiries held in the VIX call ladder.

Table 5 data show results from January 2008 through December 2013. The four-month ATM VIX call ladder has the best results in all categories except the Flash Crash. The Flash Crash occurred in May 2010, when the one-month ATM VIX call ladder showed the least drawdown. All other data show an improvement, most notably the downside deviation and Sortino ratio going from 8.61 percent and 0.74 percent, respectively, with a straight 60-percent/40-percent mix to 5.62 percent and 1.17 percent for a four-month ATM VIX call

Table 6: 120-Percent Moneyness VIX Calls with One- to Four-Month Ladder, January 2008–December 2013

VIX Call Ladder	60/40 Mix	1	2	3	4
Moneyness		120%	120%	120%	120%
Annualized Returns	6.39%	6.32%	7.05%	7.23%	7.86%
Beta	0.55	0.43	0.38	0.35	0.32
Standard Deviation	10.28%	8.64%	8.51%	8.24%	7.94%
Downside Deviation	8.61%	6.43%	6.43%	6.13%	5.59%
Sharpe Ratio	0.62	0.73	0.82	0.87	0.99
Sortino Ratio	0.74	0.98	1.10	1.18	1.41
Median VIX Strike		29.00	30.00	30.00	30.00
Median % Above Future		123.29%	122.75%	124.22%	123.15%
Maximum Drawdown	–28.49%	–22.77%	–17.44%	–15.71%	–12.71%
Time of Maximum Drawdown	2/28/2009	2/28/2009	2/28/2009	2/28/2009	2/28/2009
October 2008 Drawdown	–10.25%	–0.79%	2.27%	3.68%	4.71%
Flash Crash Drawdown	–3.59%	–1.11%	–2.16%	–2.6%	–2.33%
Euro Crisis Drawdown (04/11–09/11)	–5.44%	–3.83%	–2.95%	–1.96%	–1.53%

Table 7: Prices of One-Month 120-Percent Moneyness VIX Calls in 2008

Date	Futures Date	Futures Price	Approx. Call Strike	Real Call Strike	Call Price	# of Contracts
12/18/2007	1/31/2008	24.60	29.52	30.00	$0.85	294
1/15/2008	2/29/2008	25.32	30.38	32.50	$0.75	332
2/15/2008	3/31/2008	25.83	31.00	32.50	$0.75	324
3/18/2008	4/30/2008	26.34	31.61	32.50	$0.55	436
4/15/2008	5/31/2008	24.46	29.35	30.00	$0.60	398
5/20/2008	6/30/2008	20.83	25.00	25.00	$0.85	286
6/17/2008	7/31/2008	22.69	27.23	27.50	$0.85	285
7/15/2008	8/31/2008	26.20	31.44	32.50	$0.75	308
8/19/2008	9/30/2008	22.95	27.54	30.00	$0.55	420
9/16/2008	10/31/2008	25.23	30.28	32.50	$0.60	390
10/21/2008	11/30/2008	44.00	52.80	55.00	$2.80	78
11/18/2008	12/31/2008	57.32	68.78	70.00	$3.20	67

ladder. The benefit of laddering four-month VIX calls along the belly of the term structure is the netting effect observed in the mark-to-market values of the nonexpiring VIX call options. When compared to a one-month VIX call ladder, similar netting effects are not relevant due to not holding the back-month options.

Table 6 contains one significant change: Instead of purchasing VIX calls ATM from the underlying futures contract, it shows VIX call options that are 20-percent out-of-the money (OTM) from the corresponding VIX future on the roll date. By allocating a fixed percentage each month to purchase VIX calls OTM, more contracts can be purchased for the same amount. This leverage effect has a direct benefit during the October 2008 drawdown period, which showed an improvement over the ATM strategy in all cases except the one-month VIX call ladder. The reason leveraging was not better in the one-month call ladder has to do with the nature of volatility. Volatility is front-loaded in that it responds to exogenous events, affecting nearer-term option contracts more than back-month option contracts as the horizontal skew moves into backwardation and the vertical skew of OTM options becomes very steep. Given this steep horizontal and vertical skew, buying a contract expiring in thirty days during volatile periods makes those contracts very expensive, diminishing the effect of the one-month VIX calls as a hedge. Table 7 shows the price of a thirty-day option through 2008 at 120-percent moneyness. As volatility picked up through 2008, the price of the thirty-day VIX call rose considerably. For example, on October 21, 2008, a VIX call expiring in November 2008 at a strike price of 55.00 (120-percent moneyness) cost $2.80 per contract. Due to allocating a fixed percentage of the portfolio, only seventy-eight contracts are purchased.

In comparison, table 8 shows the four-month laddered strategy that purchases the October and November 2008 VIX calls four months prior (June and July 2008, respectively) when the strike

Table 8: Prices of Four-Month 120-Percent Moneyness VIX Calls in 2008

Date	Futures Date	Futures Price	Approx. Call Strike	Real Call Strike	Call Price	# of Contracts
12/28/2007	4/30/2008	24.40	29.28	30.00	$2.10	119
1/15/2008	5/31/2008	24.95	29.94	30.00	$2.35	106
2/15/2008	6/30/2008	24.86	29.83	30.00	$1.65	147
3/18/2008	7/31/2008	25.51	30.61	32.50	$1.25	191
4/15/2008	8/31/2008	24.52	29.42	30.00	$1.45	165
5/20/2008	9/30/2008	22.66	27.19	27.50	$1.30	187
6/17/2008	10/31/2008	23.26	27.91	30.00	$1.30	186
7/15/2008	11/30/2008	25.47	30.56	32.50	$1.25	185
8/19/2008	12/31/2008	22.95	27.54	30.00	$1.05	219

Table 9: 135-Percent Moneyness VIX Calls with One-to Four-Month Ladder

VIX Call Ladder	60/40 Mix	1	2	3	4
Moneyness		135%	135%	135%	135%
Annualized Returns	6.39%	6.47%	7.92%	7.87%	8.63%
Beta	0.55	0.41	0.34	0.32	0.26
Standard Deviation	10.28%	8.62%	8.98%	8.67%	8.44%
Downside Deviation	8.61%	6.52%	6.44%	6.22%	5.40%
Sharpe Ratio	0.62	0.75	0.88	0.90	1.02
Sortino Ratio	0.74	0.99	1.23	1.27	1.60
Median VIX Strike		33.00	35.00	35.00	35.00
Median % Above Future		138.72%	138.89%	138.59%	138.67%
Maximum Drawdown	–28.49%	–21.43%	–13.08%	–12.36%	–10.47%
Time of Maximum Drawdown	2/28/2009	2/28/2009	2/28/2009	2/28/2009	9/30/2008
October 2008 Drawdown	–10.25%	–0.98%	4.27%	5.65%	6.29%
Flash Crash Drawdown	–3.59%	–1.14%	–2.59%	–2.69%	–2.46%
Euro Crisis Drawdown (04/11–09/11)	–5.44%	–4.1%	–3.52%	–2.45%	–1.89%

and cost of a four-month VIX call was in the low 30s at a price of $1.30 to $1.25, respectively. Although a four-month VIX call has much more time value than a shorter-dated option, the nature of volatility being front-loaded allows for dampened volatility on the back months helping to normalize cost. Considerably more options were purchased in June and July 2008 (186 and 185) with a fixed dollar amount versus only seventy-eight and sixty-seven contracts in the one-month VIX call ladder.

The best result for the Flash Crash period was the one-month VIX call ladder with a drawdown of –1.11 percent as compared to the 60-percent/40-percent mix, which was down –3.59 percent, and the S&P 500, which was down –7.94 percent. This is because the front-month contracts were in contango a month before the Flash Crash period, making those contracts inexpensive compared to further down the term structure.

Table 9 uses 135-percent moneyness of the futures price while evaluating the one- through four-month VIX call ladders. The annualized return of the four-month VIX call ladder jumps to 8.63 percent compared to 6.39 percent on the straight 60-percent/40-percent stock/bond mix. Figure 1 illustrates the three portfolios using the four-month VIX call ladder strategy at 135-percent moneyness.

The four-month VIX call ladder strategy boosts the Sortino ratio to 1.60 and the October 2008 drawdown to a positive 6.29 percent compared to the straight 60-percent/40-percent stock/bond mix of –10.25 percent. Further OTM purchasing of VIX calls shows a dramatic benefit during large drawdown periods such as October 2008. During the European crisis and Flash Crash periods, the returns are all worse than the strategies purchasing VIX calls using options closer to the money. The 120-percent moneyness performed better during the Flash Crash and European crisis periods. Data analysis reveals a definite tradeoff between the moneyness of VIX calls and the leverage effect of holding a large number of VIX call options. This can be seen by examining the median VIX strikes in tables 5, 6, 9, and 10.

Table 10 examines 145-percent moneyness across all four VIX call ladders. The four-month VIX call ladder shows the best annualized

return and Sortino ratio across all studies, coming in at 9.44 percent and 1.73 percent, respectively. In this example, VIX calls are purchased further out-of-the-money, resulting in a more leveraged position. Three out of four expiries showed higher downside deviations at 145-percent moneyness; the two-month VIX call ladder is the exception, coming in at 6.43 percent compared to the 135-percent moneyness two-month VIX call ladder, coming in at 6.44 percent. Purchasing further OTM options increases the volatility, due to the price fluctuations on a greater number of options. The October 2008 drawdown showed the best results, with a positive 8.18-percent return. Although the downside deviation is higher than the 125-percent moneyness returns, three out of four strategies show a higher Sortino ratio; except for the one-month 135-percent moneyness, at 0.99 vs. 0.95, respectively. The Flash Crash period and the European crisis with the 145-percent moneyness VIX call ladders showed even less hedge benefit than lower moneyness VIX call ladders, with the median VIX strike ranging from 35.00 on the one-month ladder to 38.00 on the four-month ladder.

Table 11 and figure 2 examine an 80-percent/20-percent stock/bond mix with a four-month VIX call ladder strategy at 135-percent moneyness that allocates 25 bps of the

Figure 1: Performance of 135-Percent Four-Month VIX Call Ladder Strategy

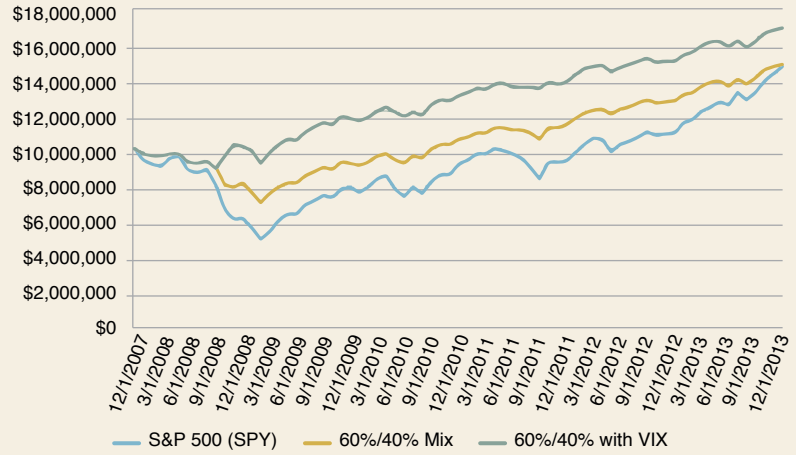


Figure 2: 80/20 Mix with VIX Call Ladder (25 bps/month, 4m Call Options, 135-Percent Moneyness) vs. 60/40 Mix and 100-Percent SPY

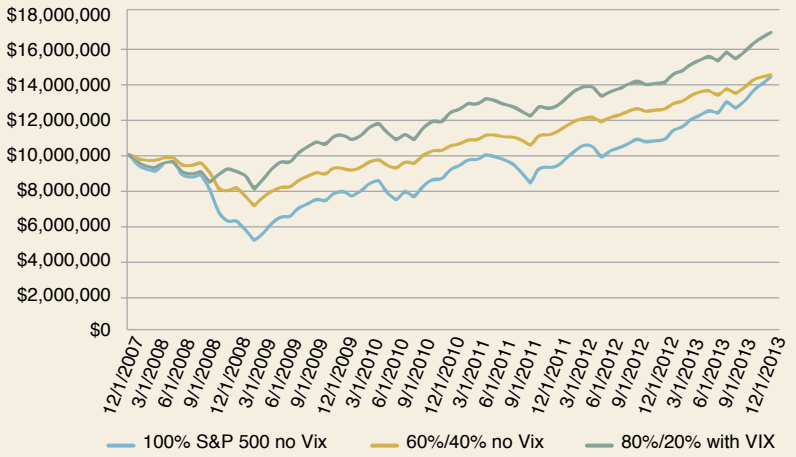


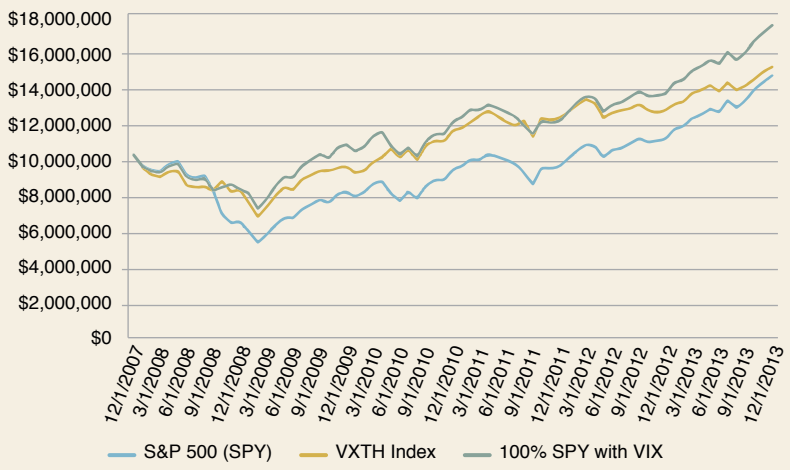
Table 10: 145-Percent Moneyness VIX Calls with One- to Four-Month Ladder

VIX Call Ladder	60/40 Mix	1	2	3	4
Moneyness		145%	145%	145%	145%
Annualized Returns	6.39%	6.20%	8.73%	8.61%	9.44%
Beta	0.55	0.42	0.29	0.27	0.22
Standard Deviation	10.28%	8.69%	9.76%	9.49%	9.41%
Downside Deviation	8.61%	6.53%	6.43%	6.23%	5.45%
Sharpe Ratio	0.62	0.71	0.89	0.90	1.00
Sortino Ratio	0.74	0.95	1.36	1.38	1.73
Median VIX Strike		35.00	38.00	38.00	38.00
Median % Above Future		148.85%	147.87%	149.08%	149.70%
Maximum Drawdown	–28.49%	–22.02%	–13.08%	–12.67%	–10.58%
Time of Maximum Drawdown	2/28/2009	2/28/2009	2/28/2009	2/28/2009	9/30/2008
Oct. 2008 Drawdown	–10.25%	–1.32%	5.75%	7.53%	8.18%
Flash Crash Drawdown	–3.59%	1.31%	–2.6%	–2.66%	–2.64%
Euro Crisis Drawdown (04/11–09/11)	–5.44%	–4.48%	–4.36%	–3.26%	–2.26%

Table 11: 80/20 Mix with VIX Call Ladder (25 bps/month, 4m Call Options, 135-Percent Moneyness) vs. 60/40 Mix and 100-Percent SPY

2008–2013	S&P 500 (SPY)	60/40 Mix	80/20 w/VIX
Annualized Return	6.23%	6.39%	9.08%
Beta	1.00	0.55	0.47
Standard Deviation	19.00%	10.28%	11.03%
Downside Deviation	13.68%	8.61%	7.34%
Sharpe Ratio	0.33	0.62	0.82
Sortino Ratio	0.46	0.74	1.24
Media VIX Strike			35.00
Median % Above Future			138.67%
Maximum Drawdown	–48.222%	–28.49%	–19.32%
Time of Maximum Drawdown	2/28/2009	2/28/2009	2/28/2009
October 2008 Drawdown	–16.52%	–10.26%	4.09%
Flash Crash Drawdown	–7.95%	–3.59%	–4.62%
Euro Crisis Drawdown (04/11–09/11)	–16.23%	–5.45%	–7.39%

Figure 3: 100-Percent SPY with 25 bps/month Allocated to VIX Call Ladders (4m, 135-Percent Moneyness)



portfolio to VIX calls each month. Although the equity allocation was increased, the static allocation to VIX calls (25 bps/month) shows a promising increase in the Sortino ratio from 0.74 in the 60-percent/40-percent mix with no VIX exposure to 1.24 in the 80-percent/20-percent mix with the VIX calls. The October 2008 drawdown period also shows an improvement from –10.26 percent in the non-hedged 60-percent/40-percent mix to 4.09 percent in the 80-percent/20-percent mix with VIX calls.

Figure 3 and table 12 examine a 100-percent SPY portfolio with the four-month VIX call ladder strategy at 135-percent moneyness versus the CBOE VXTH Index, which could be considered an appropriate benchmark for the strategy. The allocation is kept at 25 bps in the VIX call ladder strategy. The 100-percent SPY with the VIX call ladder strategy shows a better annualized return, Sharpe ratio, downside deviation, and Sortino ratio. The VXTH Index does perform better in October 2008 (6.09 percent versus 1.98 percent in the VIX call ladder strategy) and in the Flash Crash and the European crisis. This can be attributed to the VXTH Index allocating 100 bps to one-month VIX calls in the month before these events due to the quantitative trigger discussed in table 1.

Case Study: Black Monday 1987

The OOS test data support the hypothesis that if an equity portfolio manager had a 25 bps monthly exposure to a four-month VXO call ladder on Black Monday 1987 it could have provided significant value and helped to mitigate much of the loss taken on an equity portfolio, given the assumptions made. Details of this analysis are given in the appendix.

Consider the case where the average and median price of VIX call options were used as a proxy for the price paid for VXO call options from January 2008 through December 2013. The idea is to establish the number of VXO contracts and the price necessary to hedge off the October 1987 crash, then compare that price with the average and median price of VIX calls through the study period. Extrapolating the shape of the term structure for a similar period (see appendix) helps us evaluate the efficacy of the VIX call ladder strategy in the OOS period.

The data show that if the cost of a 145-percent moneyness four-month VXO call had been $2.78, then the strategy would have mitigated the October 1987 drawdown. When comparing the average and median price for VIX calls, which were $1.26 and $1.15, respectively (see table A9), the cost of the VXO call ($2.78) becomes reasonable to justify. The data show that by evaluating just the average call price, a significant positive portfolio gain of 16.90 percent, 21.29 percent, and 25.33 percent for the 135-percent, 140-percent, and 145-percent moneyness ladders, respectively, resulted through the crash. These results would appear to represent a best-case scenario. How unlikely would exposure to a VXO call ladder strategy provide these types of returns in a tail event such as Black Monday? The break-even assumption of paying $2.78 for a four-month VXO call, especially at 145-percent moneyness, is very conservative and would have mitigated the loss through the crash. The difference between the average cost of $1.26 per contract and the break-even cost of $2.78 gives a sufficient confidence level that the laddered

Table 12: 100-Percent SPY Portfolio with the Four-Month VIX Call Ladder Strategy at 135-Percent Moneyness vs. the CBOE VXTH Index

January 2008–December 2013	S&P 500 (SPY)	60/40 Mix	80/20 w/VIX
Annualized Return	6.23%	6.82%	9.38%
Beta	1	0.59	0.68
Standard Deviation	17.85%	14.47%	14.30%
Downside Deviation	13.67%	10.09%	9.55%
Sharpe Ratio	0.35	0.47	0.65
Sortino Ratio	0.46	0.68	0.98
Media VIX Strike			35.00
Median % Above Future			138.67%
Maximum Drawdown	–48.22%	–34.04%	–29.71%
Time of Maximum Drawdown	2/28/2009	2/28/2009	2/28/2009
October 2008 Drawdown	–16.52%	6.09%	1.93%
Flash Crash Drawdown	–7.95%	4.94%	–6.78%
Euro Crisis Drawdown (04/11–09/11)	–16.22%	–11.29%	–12.64%

strategy would have helped to mitigate the 1987 tail event.

Note, however, that various assumptions were made to conduct the OOS test (see appendix: Out-of-Sample Test). These assumptions were intended to be conservative in nature, yet there is no guarantee that the results of the OOS test would have simulated actual performance. The purpose of performing the OOS test was to determine the validity of holding VIX/VXO call exposure in a portfolio during a tail event. The fact that the VIX/VXO futures were not tradable products at the time nor were they available to the broad market reduces the ability to verify the validity of this OOS test.

The test was performed using the best data available at the time and is intended to show how a VIX call ladder strategy could have performed during one of financial history's most extreme black swan events. Until the next flash crash event, however, it is extremely difficult to determine whether exposure to a VIX call ladder strategy would provide a significant hedge on an equity portfolio under these conditions.

Conclusion

The empirical data show that using an out-of-the-money laddered VIX strategy with a nominal dollar value approach provided a strong diversifier within a portfolio with an acceptable cost of carry when the VIX calls were not needed. The moneyness of VIX calls shows a tradeoff between the magnitude of the drawdown and VIX calls providing value. During tail events, a portfolio manager may choose to monetize not only the front-month contracts but all the contracts held in the ladder because the mark-to-market values of all the contracts held in the portfolio had increased. Although the back-month contracts may not contain any intrinsic value, the implied volatility during stress market periods has shown a rise in the mark-to-market value because of the effect of Vega[4] as well the benefit from a movement in the back-month futures (Delta[5]). The strength of this study is that it shows that a small systematic allocation of properly placed options (25 bps/month) can have a substantial benefit to a tail event for a minimum cost to carry. The study shows that, unlike other methodologies that use quantitative triggers to time the use of VIX calls, a continuous allocation to VIX calls can define a maximum allocation to a hedge and a maximum cost of 25 bps per month or approximately 300 bps per year. In contrast, a portfolio manager using VXTH, which is based on a quant trigger, could allocate up to 100 bps in any one month. This could lead to extreme allocations in years such as 2009, when approximately 900 bps of the portfolio would have been allocated to VIX calls without any tail event.

Using a systematic monthly VIX call ladder strategy, an 80-percent/20-percent stock/bond portfolio with a VIX call overlay can achieve lower downside volatility and a higher Sortino ratio than a 60-percent/40-percent stock/bond allocation. Thus, a portfolio manager could make the case to allocate more capital to alpha-generating assets (equity) and less to traditional diversifiers (debt). Allocating 25 bps per month to a VIX call ladder strategy could be justified if it allows the portfolio manager to shift capital into assets that can generate more than 25 bps of excess return per month.

This strategy has shown ex-post with empirical data to substantially improve a 100-percent equity allocation mix using a VIX call ladder strategy through a tail risk event (i.e., 2008) while producing a drag of approximately 300 bps per year in years without tail events.

Finally, with many portfolio managers inherently being short volatility either through long equities, short puts, long calls, etc., this strategy could be invaluable to manage gap risk and tail events.

This study examines only the period from January 2008 through December 2013 using ex-post data, containing one major bear market, the Flash Crash, and the European crisis. Further research should be done to examine how this strategy works on an ex-ante basis as well as other periods, e.g., the 2000 dot-com bubble. This study does not address further enhancements that could reduce the cost to carry such as VIX put bearspreads, backspreads, calendar strangles, etc. that could take advantage of the persistent contango term structure inherent in VIX during stable market conditions. The fact that this study does address a defined capital expenditure creates a strong foundational framework with which to explore such enhancements.

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Endnotes

1. SPX is the index on the Standard and Poor's 500 Index.
2. With an initial value of $10 million, the actual portfolio allocation is 59.85-percent SPY, 39.90-percent IEF, and 0.25-percent VIX calls. For simplicity, it is referred to as the 60/40 stock/bond mix for the duration of the paper.
3. To simplify, this portfolio is referred to as 80/20 stock/bond mix; in reality, the initial $10 million is allocated 79.8 percent to stock, 19.95 percent to bonds, and 0.25 percent to the desired VIX call option.
4. Vega is the amount that an option contract's price changes in reaction to a 1-percent change in the implied volatility.
5. Delta represents the change in the option value due to a change in the underlying.

References

Alexander, Carol, and Dimitris Korovilas. 2011. The Hazards of Volatility Diversification. International Capital Market Association Centre (ICMA) Discussion Paper in Finance DP2011-04 (January). http://www.icmacentre.ac.uk/files/discussion-papers/DP2011-04.pdf.

DeLisle, Jared, James S. Doran, and Kevin Krieger. 2014. Volatility as an Asset Class: Holding VIX in a Portfolio. Working paper (December 4). http://ssrn.com/abstract=2534081.

Lehman, R., and L. McMillan. 2011. *Options for Volatile Markets: Managing Volatility and Protecting Against Catastrophic Risk*. Hoboken, NJ: John Wiley & Sons, Inc.

Rhoads, Russell. 2011. *Trading VIX Derivatives: Trading and Hedging Strategies Using VIX Futures, Options, and Exchange Traded Notes*. Hoboken, NJ: John Wiley & Sons, Inc.

Stanton, Clifford W. 2011. Volatility as an Asset Class: The Potential of the VIX as a Hedging Tool and the Shortcomings of VIX Exchange-Traded Notes. *Journal of Investment Consulting* 12, no. 1: 23–30.

Szado, Edward. 2009. VIX Futures and Options: A Case Study of Portfolio Diversification during the 2008 Financial Crisis. *Journal of Alternative Investments* 12, no. 2 (fall): 68 –85.

Whaley, Robert E. 2000. The Investor Fear Gauge. *Journal of Portfolio Management* 26, no. 3 (spring): 12–17.

——. 2009. Understanding the VIX. *Journal of Portfolio Management* 35, no. 3 (spring): 98–105.

Appendix

Out-of-Sample Test: Black Monday 1987

Introduction

To determine the viability of a laddered out-of-the-money (OTM) VIX call strategy, an out-of-sample (OOS) test was performed. The time period chosen was the Black Monday crash of October 19, 1987. Due to a lack of data and to keep the test relatively simple, the test assumes that the VIX call ladder strategy had been purchased in the four months previous and that the remainder of the hypothetical portfolio was allocated 100-percent to the OEX (S&P 100). Note that the study is not concerned with examining the portfolio for the time period leading up to the event; rather, it examines how a portfolio exposed to the VIX call ladder strategy would have performed in one of the most extreme tail events in recorded history.

Figure A1: VXO Calls (July 1987 through November 1987)

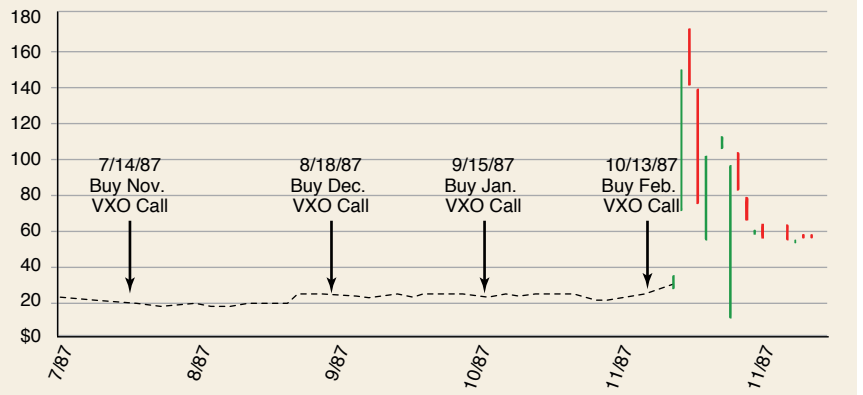

Table A1: VXO Open, High, Low, and Closing Values

VXO (The OEX "VIX")	Open	High	Low	Close
Tuesday, July 14, 1987	18.19	18.35	16.64	17.10
Tuesday, August 18, 1987	22.91	24.93	22.59	22.59
Tuesday, September 15, 1987	23.11	23.44	21.40	21.81
Tuesday, October 13, 1987	24.58	25.26	23.71	24.32

Table A2: VXO Call Strike Prices

Date	135%	140%	145%
Tuesday, July 14, 1987	25.00	26.00	27.00
Tuesday, August 18, 1987	34.00	35.00	37.00
Tuesday, September 15, 1987	32.00	33.00	34.00
Tuesday, October 13, 1987	35.00	36.00	37.00

Assumptions

Due to a lack of data from the time period, various assumptions were necessary to determine the outcome of the VIX call ladder strategy. Note that VIX options and futures were not trading in 1987. For this reason, the OEX Index was used as a proxy for the SPX Index and the VXO (CBOE S&P 100 volatility index) Index as a proxy for the VIX Index.

Figure A1 shows the VXO in the four months leading up to Black Monday and calls out the four dates when VXO calls would have been purchased leading up to October 19, 1987.

Table A1 outlines the open, high, low, and closing values for the VXO on the four purchase dates, which represents the hypothetical last day of trading for VXO calls (based on the expiration schedule of VIX futures and options).

The OOS test covers three scenarios: (1) purchase the VXO calls at 135-percent of the high value of the VXO on the purchase date, (2) purchase at 140-percent of the high value on the VXO purchase date, and (3) purchase at 145-percent of the high value on the VXO purchase date. Table A2 represents the strike price of the VXO calls on the four dates leading up to October 19, 1987.

Note that VIX options are priced off the corresponding futures contract. VXO futures data were not available at the time, so the high value of the VXO spot price on the date that the option contracts were purchased was used. Simulating the term structure of the VXO on these dates is

Table A3: VXO Call Term Structure Assumption, September 28, 2008 (TARP Fails to Pass)

	Spot	1st Month	2nd Month	3rd Month	4th Month
Term Structure	46.72	32.46	29.93	28.01	27.72
% Disc. (Spot)		–30.52%	–35.94%	–40.05%	40.67%
10/19/1987	150.19	104.35	96.22	90.04	89.11

Table A4: OEX Values

Date	OEX
10/16/1987	274.13
10/19/1987	216.12
% Loss	–21.16%

outside the scope of this study and would require a deeper examination of market conditions at the time; however, it is necessary to extrapolate the shape of the term structure at the close of the market on October 19, 1987.

In this vein, the extrinsic value at the date of purchase of the VXO call options contracts was evaluated to be the cost to break even using the average and median cost over the period studied in this paper. The extrinsic value at the close on Black Monday was ignored, due to the lack of information available to determine accurate option pricing. It can be argued that the four VXO calls would have negligible amounts of extrinsic value relative to the intrinsic value of the contracts because they were all very deep in the money on October 19, 1987. When focusing on the intrinsic value of the VXO call contracts instead, an idea of the hedge they would have provided can be determined.

The study ignored the term structure when purchasing the VXO calls in the four months leading up to Black Monday; however, it is necessary to assess the term structure of the VXO on October 19, 1987. For a proxy, the study used the term structure on September 29, 2008, the day the Troubled Asset Relief Program (TARP) bailout vote failed to pass the U.S. House of Representatives. This was a conservative assumption because the S&P 500 closed down a little more than 5 percent on that day, but fear was very prevalent in the market at the time. Considering the value of the VIX and the percentage discount of the first-, second-, third-, and fourth-month futures and applying those discounts to spot VXO on Black Monday, provides an idea of what the term structure may have looked like, as shown in table A3.

Table A5: Intrinsic Value of VXO Calls on October 19, 1987

	135%	140%	145%
1m VXO Call Intrinsic Value	79.35	78.35	77.35
2m VXO Call Intrinsic Value	62.22	61.22	59.22
3m VXO Call Intrinsic Value	58.04	57.04	56.04
4m VXO Call Intrinsic Value	54.11	53.11	52.11

Table A6: 135-Percent Moneyness Four-Month VXO Call Ladder

135% Moneyness	Intrinsic Value	Contracts	$ Value of VXO Calls
1m VXO Call	79.35	9	$71,413.76
2m VXO Call	62.22	9	$55,993.92
3m VXO Call	58.04	9	$52,238.95
4m VXO Call	54.11	9	$48,699.92
		Total VXO CALL Value	$228,346.55
		OEX Portfolio Loss	($211,614.93)
		Net Gain	$16,731.62
		% Gain (on $1m)	1.67%

The final assumption made was determining the number of VXO calls held in the hypothetical portfolio. For consistency, 25 bps of the portfolio per month was spent on four-month VXO calls and the number of contracts held for each month of the four-month VXO call ladder was the same. The number of calls held in each month of the VXO call ladder is determined below.

Results

Instead of trying to assume the price that would have paid for the four-month VXO calls in each of the four months leading up to Black Monday, the number of contracts was backed into, which determined the amount needed to deliver flat performance for the hypothetical portfolio on October 19, 1987. Table A4 shows the values of the OEX.

For a worst-case scenario, the hypothetical portfolio was 100-percent invested in securities that replicated the performance of the OEX. If this portfolio had an initial value of $1 million, the portfolio would have been down $211,614.93 on October 19, 1987. This means that the VXO calls must provide at least $211,614.93 when monetizing them on October 19, 1987, to give the hypothetical portfolio a flat return that day.

Now that the value has been determined, VXO calls must cover a $211,614.93 loss. By backing into the number of contracts needed to provide that value, the contract price can be determined. Recall that only the intrinsic value of these contracts is used because they are deep in-the-money. Based on the term structure and moneyness assumptions above, the contracts have the intrinsic values shown in Table A5.

Recall that the contracts held in each month are the same because the VXO calls are all purchased with four months to expiration and the spot price of VXO was flat prior to October 1987 (figure A1). Solving for the minimum number of calls needed for each

Table A7: 140-Percent Moneyness Four-Month VXO Call Ladder

140% Moneyness	Intrinsic Value	Contracts	$ Value of VXO Calls
1m VXO Call	78.35	9	$70,513.76
2m VXO Call	61.22	9	$55,093.92
3m VXO Call	57.04	9	$51,338.95
4m VXO Call	53.11	9	$47,799.92
		Total VXO CALL Value	$224,746.54
		OEX Portfolio Loss	($211,614.93)
		Net Gain	$13,131.61
		% Gain (on $1m)	1.31%

Table A8: 145-Percent Moneyness Four-Month VXO Call Ladder

145% Moneyness	Intrinsic Value	Contracts	$ Value of VXO Calls
1m VXO Call	77.35	9	$69,613.76
2m VXO Call	59.22	9	$53,293.92
3m VXO Call	56.04	9	$50,438.95
4m VXO Call	52.11	9	$46,899.92
		Total VXO CALL Value	$220,246.55
		OEX Portfolio Loss	($211,614.93)
		Net Gain	$8,631.62
		% Gain (on $1m)	0.86%

Table A10: 135-Percent Moneyness Four-Month VXO Call Ladder Using Average Purchase Price of $1.57

135% Moneyness	Intrinsic Value	Contracts	$ Value of VXO Calls
1m VXO Call	79.35	15	$119,022.93
2m VXO Call	62.22	15	$93,323.20
3m VXO Call	58.04	15	$87,064.92
4m VXO Call	54.11	15	$81,166.53
		Total VXO CALL Value	$380,577.58
		OEX Portfolio Loss	($211,614.93)
		Net Gain	$168,962.65
		% Gain (on $1m)	16.90%

Table A11: 140-Percent Moneyness Four-Month VXO Call Ladder Using Average Purchase Price of $1.41

140% Moneyness	Intrinsic Value	Contracts	$ Value of VXO Calls
1m VXO Call	78.35	17	$133,192.65
2m VXO Call	61.22	17	$104,066.30
3m VXO Call	57.04	17	$96,973.57
4m VXO Call	53.11	17	$90,288.73
		Total VXO CALL Value	$424,521.25
		OEX Portfolio Loss	($211,614.93)
		Net Gain	$212,906.32
		% Gain (on $1m)	21.29%

Table A9: Average and Median Prices Paid for Four-Month VIX Calls, January 2008–December 2013

Moneyness	Average	Median
135%	$1.57	$1.45
140%	$1.41	$1.35
145%	$1.26	$1.15

month to provide at least $211,614.93 on Black Monday can now be achieved. Tables A6–A8 show the minimum number of calls needed to provide a hedge that would put the portfolio at a flat to slightly positive return on Black Monday, as well as the percent gained based on the $1-million portfolio.

In all of the different moneyness scenarios, it was required to purchase nine contracts in each month of the ladder to provide at least $211,614.93. This is the minimum number of contracts in each VXO call ladder needed to hedge a 100-percent OEX portfolio on Black Monday. Recall that only 25 bps of the overall portfolio value was spent on VXO calls each month in the four months leading up to Black Monday. For the sake of simplicity, 25 bps per month of the portfolio value equates to $2,500 per month.

The question now becomes, can the hypothetical price paid for the nine VXO contracts each month be justified as a reasonable cost? If $2,500 is allocated to spend each month on VXO calls, approximately $277.78 ($2,500 / 9 = $277.78) can be spent on each VXO call contract. Applying the multiplier of 100 for options contracts leads to this option being priced at $2.78, as would be seen on an options chain. Due to the lack of data from the OOS testing period, it is difficult to determine whether $2.78 is a reasonable price for the four-month VXO call options at various levels of moneyness.

As a proxy, given no exogenous events between the one- and four-month period before the 1987 crash, the results of this white paper study are referenced and consideration is given to the average and median prices paid for four-month VIX calls from January 2008 to December 2013

at 135-percent, 140-percent, and 145-percent moneyness, as shown in table A9.

Both average and median prices at each level of moneyness were well below the $2.78 available to spend on VXO calls in the four months preceding Black Monday. The data show that a portfolio manager likely would have been able to purchase at least nine VXO call contracts in each of the four months preceding Black Monday. As evidenced by the intrinsic value of these contracts, the data support the hypothesis that a portfolio manager who had implemented a four-month VXO call ladder strategy at any of the listed levels of moneyness would have been able to achieve flat to slightly positive returns on Black Monday.

Using the average price of VIX calls throughout the backtest as a proxy for the price that would have been paid for VXO calls in the four months preceding Black Monday allows for the purchase of even more contracts. At 135-percent moneyness, with an average price of $1.57, fifteen contracts could be purchased in each month of the VXO call ladder. At 140-percent moneyness, with an average price of $1.41, seventeen contracts could be purchased in each month of the VXO call ladder. At 145-percent moneyness, with an average price of $1.26, nineteen contracts could be purchased in each month of the VXO call ladder. Using those assumptions Tables A10–A12 show the performance for Black Monday.

Table A12: 145-Percent Moneyness Four-Month VXO Call Ladder Using Average Purchase Price of $1.26

145% Moneyness	Intrinsic Value	Contracts	$ Value of VXO Calls
1m VXO Call	77.35	19	$146,962.37
2m VXO Call	59.22	19	$112,509.39
3m VXO Call	56.04	19	$106,482.23
4m VXO Call	52.11	19	$99,010.94
		Total VXO CALL Value	$464,964.93
		OEX Portfolio Loss	($211,614.93)
		Net Gain	$253,350.00
		% Gain (on $1m)	25.33%

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