

Endowment Risk Management and Return Enhancement with Listed Index and ETF Options

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Executive Summary

This study provides an important extension of existing research on the performance of options-based strategies by considering the impact of the inclusion of option-based equity strategies in diversified institutional portfolios. Specifically, the analysis assesses the historical impact of the application of rules-based passive buy-write or put spread collar overlays to hypothetical endowment portfolios. In addition, the study considers the choice of physically settled QQQ ETF options versus cash settled NDX index options from the perspective of risk-adjusted performance and various option characteristics such as settlement type, volume, open interest and tracking error.

The buy-write (or covered call) strategy involves the writing of a call option against a long position in the underlying. The buy-write essentially exchanges some or all of the participation in the underlying's upside for a fixed (at the time of option roll in) premium collection. The buy-write is generally considered a return enhancement strategy since the written call can provide extra income in flat market environments. While the buy-write does not limit the portfolio downside, the collected call premium does provide some mitigation of losses. On average, the buy-write strategy is expected to outperform the underlying if the implied volatility of the short calls tends to exceed the realized volatility of the underlying over the life of the calls. This study considered 1-month 2% and 5% OTM buy-writes on the QQQ ETF and NDX index.

The put spread collar (or covered combo) strategy involves the writing of a call and purchase of a bear put spread against a long position in the underlying. The particular characteristics of a put spread collar implementation will depend on the choice of initial moneyness and tenor of each option. The put spread collar may be implemented as a net premium collection or net premium payment strategy. The implementations in this study were net premium collection strategies where the premium collected from the written call and written put exceeded the premium paid for the purchased put. In a put spread collar, the written call limits upside participation while the written put limits the protection provided by the long put. The put spread collar is generally considered a risk management strategy since the bear put spread can provide buffered downside exposure. In contrast to a protective put or collar strategy, the put spread collar does not provide a floor for downside protection since the written put counteracts the protection provided by the long put for losses approaching and beyond the written put's strike price. In general, one would expect that a put spread collar would reduce volatility by limiting upside participation and mitigating downside participation. The put spread collars considered in this study utilized 1-month calls and 6-month puts held to expiration. The first implementation used 2% OTM written calls, 5% OTM long puts and 10% OTM written puts, while the second implementation utilized 5% OTM written calls, 10% OTM long puts and 15% OTM written puts.

In order to implement the analysis, the historical returns for three hypothetical endowment portfolios were generated based on the historical time series of average asset allocations of small (<\$25 million), mid-sized (\$100-500 million) and very large (>\$1 billion) endowments reported in the NACUBO-Commonfund Study of Endowments (2002 - 2018). In order to assess the theoretical impact of the Nasdaq options-based strategies, the equity allocations of the hypothetical endowments were replaced with Nasdaq-100 QQQ or NDX buy-write or put spread collar strategies.

Over the full 18+ years of the study (April 1999 to December 2018), the buy-writes on the QQQ and NDX provided meaningful increases in returns relative to the corresponding underlying. The improvements in raw annualized returns averaged 2.4%, while standard deviations were reduced by an average of 5.8%. Risk-adjusted returns were also improved. The information ratios (return per unit of risk) of the buy-writes were almost double those of their underlying and the alphas of the buy-writes averaged 3.3% (compared to zero for the underlying). The put spread collar implementations provided slightly less return improvements than the buy-writes, along with larger reductions in standard deviations. From a risk-adjusted return perspective, the put spread collars performed similarly to the buy-writes with generally similar information ratios and alphas. There was no clear dominance in performance between the QQQ and NDX implementations. The differences due to choice of moneyness were greater than those due to choice of QQQ versus NDX.

Since the option strategy overlay was only applied to the equity portion of the endowments, the impact of adding the options was somewhat mitigated in the endowment implementations, but still meaningful. This was particularly the case for the larger endowments due to their smaller equity allocations. For the small endowment portfolio (<\$25 million in assets), the addition of the buy-write overlay increased raw returns by an average of 0.8%, while reducing standard deviations by 2.2%, on average. Alpha improvements averaged 1.5%, while information ratios increased by 0.17, on average. The put spread collar overlays provided smaller return and standard deviation improvements to small endowment performance than the buy-write overlays. In fact, one of the put spread collar overlays slightly reduced returns. However, the risk-adjusted returns were improved by all of the put spread collar overlays with alphas increasing by an average of 1.3% and information ratios increasing by an average of 0.17. Thus all of the option overlays provided meaningful improvements for the small endowment portfolio.

Results for the mid-sized endowment (\$100-\$500 million in assets) were generally similar to those of the small endowment. The buy-write overlays increased returns an average of 0.7% while reducing standard deviations by 1.6%, on average. Information ratios and alphas were also meaningfully improved by the buy-write overlays. The put spread collar overlays also improved the mid-size endowment performance with returns increasing by an average of 0.4% while standard deviations dropped by 2.2%, on average. Information ratios were also improved while alphas increased by an average of 1.1%.

The buy-write and put spread collar overlays also improved raw returns and risk-adjusted performance of the very large endowment portfolio (>\$1 billion in assets), although the improvements were somewhat smaller than those for the small and mid-sized endowments. The buy-write overlays increased returns by an average of 0.6% while reducing standard deviations by an average of 1.0%. Information ratios and alphas were also improved by the buy-write overlays. The put spread collar overlays improved the very large endowment performance, increasing returns by an average of 0.4% while reducing standard deviations by 1.4%, on average. Information ratios and alphas were improved, with alphas increasing by an average of 0.9%.

In summary, the QQQ and NDX buy-write and put spread collar overlays improved risk-adjusted performance for small, mid-sized and very large endowments, with the largest benefits occurring for the small endowment portfolio. While the return improvements were relatively small from an annualized return perspective, these improvements were averaged over a period of 18+ years so the cumulative impact is meaningful. Furthermore, the reductions in standard deviations and maximum drawdowns were also economically significant. While the choice between NDX and QQQ options had little impact on performance, other option characteristics such as cash versus physical settlement, contract size and American versus European exercise may result in different preferences across investors.

Abstract

This article assesses the theoretical effectiveness of put spread collar and buy-write strategies as risk management and return enhancement strategies from a standalone perspective and as endowment overlays. We found meaningful benefits to passive 6-month put/1-month call put spread collar and 1-month call buy-write implementations on the QQQ ETF and NDX index compared to a long underlying position.

We examined the effectiveness of implementing the strategies using QQQ ETF options and NDX cash settled index options and found few performance differences between the two alternatives.

We constructed indices representing the historical returns to three hypothetical endowments and applied the passive 6-month put/1-month call put spread collar and 1-month call buy-write as overlays to the endowment portfolios and found performance enhancements, suggesting that there may possibly be an opportunity for significant performance enhancements if implemented actively, particularly in times of low transaction costs.

Introduction

The purpose of this article is to examine the theoretical effectiveness of buy-writes and put spread collars (also referred to as covered calls and covered combos, respectively) as return enhancement and risk management investment strategies from the perspective of institutional investors, both as standalone alternatives to long equity exposure and as overlays for endowment portfolios.

This study provides an important extension of existing research on the performance of options-based strategies by considering the impact of the inclusion of option-based equity strategies in diversified institutional portfolios. Specifically, the analysis assesses the impact of the application of rules-based passive buy-write or put spread collar overlays to hypothetical endowment portfolios.

While many studies have focused on the buy-write strategy, few have focused on collar strategies and even fewer on put spread collars, despite the great advantages of the put spread collar strategy. This study extends the findings of previous studies on buy-write and collar strategies including work by Whaley (2002), Kapadia and Szado (2012), Szado and Schneeweis (2012), Lehman Brothers (2005) and Hill et al (2006). Furthermore, we extend the extant research by comparing the performance of physically settled option strategies implemented on an exchange traded fund underlying (QQQ) to cash settled option strategies implemented on an equity index underlying (NDX index). In addition, we assess the historical performance of option overlays for endowment portfolios by replacing the equity allocation of a theoretical policy weight-based passive endowment

portfolio with equity plus options portfolios representing various buy-write and put spread collar implementations.

Options are available both on the NDX Nasdaq-100 index and on the Nasdaq-100 tracking Invesco QQQ Trust ETF. Since the specifications of options on the QQQ ETF and NDX index differ in a number of ways, an investor interested in implementing a Nasdaq-100 buy-write or put spread collar strategy faces considerations beyond the moneyness and tenor of options used in a passive implementation.

Since QQQ options have a shorter history than NDX options, we focused the study on the period since the inception of QQQ options (March 10, 1999) to allow a comparison of the different implementations over a common time period.

In general, a put spread collar strategy involves the purchase of a bear put spread against a long position in the underlying, combined with the writing of a call on the same underlying. The purpose of the put spread is to provide a buffering of downside moves of the long underlying position. The call is written to cover the cost of the purchased put spread, at the expense of limiting the strategy's participation in upside moves of the underlying. In this study, we implemented the put spread collar passively in the sense that it is a rules-based strategy with no market timing component. We expected that our choice of option moneyness and tenor would result in a net collection of premiums.

A put spread collar strategy may be particularly appealing for investors that are seeking some protection from a potential down side move, or a reduction in the market exposure of their portfolio without incurring a significant net payment of option premiums.

Ultimately, the put spread collar strategy is expected to offer an investor an opportunity to reduce the volatility of their returns, relative to a long position in the underlying index. This is due to the fact that the payoff of the bear put spread may reduce the losses of the long index position in downward market moves, while the short call may reduce the gains of the long index position in upward market moves.

From an absolute return perspective, the ideal return situation for a standard (put and call maturity matched) put spread collar is for the underlying to gradually increase over the life of the call, ending at the short call's strike price at expiration. However, when compared to the returns of a long position in the underlying index, the put spread collar strategy has the highest relative advantage when the market experiences a downward move, ending at the short put's strike price at expiration.

The buy-write strategy involves the writing of a call against a long position in the underlying. The buy-write essentially exchanges some or all of the participation in the underlying's upside for a fixed (at the time of option roll in) premium collection. As with the put spread collar, the ideal return situation for buy-write is for the underlying to gradually increase over the life of the call, ending at the short call's strike price at expiration. On average, the buy-write strategy is expected to outperform the underlying if the implied volatility of the short calls tends to exceed the realized volatility of the underlying over the life of the calls.

Data and Methodology

In this paper, we utilized the underlying NDX index and QQQ ETF as benchmarks for the corresponding option-based strategies and the NDX index as a benchmark for the

endowment implementations. The analysis spanned the period from March 10, 1999 to December 31, 2018. The majority of the analysis was based on daily data, although the endowment-based portion of the analysis utilized monthly data from April 1999 to December 2018 due to data limitations of the hedge fund data required for the construction of the hypothetical endowment portfolio returns. In addition to analyzing performance over the full period of study, we considered annual performance over each year of the study and in the best and worst three-year period for the NDX index to assess performance in differing markets environments. In addition to varying the choice of underlying type (cash settled index options versus physically settled ETF options), we varied the moneyness of the short call of the buy-write and the short call, long put and short put of the put spread collar. The moneyness of the long and short puts largely determines the degree of downside protection of the put spread collar, while the moneyness of the short call determines the degree of upside participation of both strategies.

Option prices, QQQ and NDX prices and total returns and total return indices for the hypothetical endowment construction were provided by Optionmetrics and Bloomberg. We utilized the daily highest closing bid and lowest closing offer across all exchanges for options, and daily closing prices, dividend payouts and/or total return indices for the underlying QQQ ETF and NDX index and the other indices utilized in the study. The historical time series of average asset allocations of small (<\$25 million), mid-sized (\$100-500 million) and very large (>\$1 billion) endowments were based on the NACUBO-Commonfund Study of Endowments for the years 2002 to 2018. The asset allocations for 1999 to 2001 were set at 2002 levels due to data limitations.

For the sake of clarity, we limited the number of strategy implementations considered in the analysis. The buy-write strategies were limited to 2% OTM and 5% OTM 1-Month short calls while the put spread collars utilized either 2% OTM 1-Month short calls with 5% OTM long puts 6-Month and 10% OTM short 6-Month puts or 5% OTM 1-Month short calls with 10% OTM long puts 6-Month and 15% OTM short 6-Month puts. These choices are consistent with the extant literature on buy-writes and collar strategies. All options were held until the market close on the day before expiration since NDX index options settle based on the special opening quotation (SOQ) at the market open and our option price dataset only provided closing bids and offers, requiring us to roll our positions at the close. We incorporated transaction costs by purchasing options at the ask price and writing them at the bid price on the roll in date. We rolled out of the options at the mid-point between the bid and ask since we could avoid the bid ask spread on the roll out transaction if we chose to roll out at expiration. For all days in between the roll in and roll out days, we calculated returns using the mid-point price between the closing bid and ask.

Call tenor was held at one-month and initial put tenor was set at six months to take advantage of the fact that time decay tends to increase as options approach expiration so the long puts might tend to decay slower on average than the short calls. The intention here was to attempt to improve on the standard put spread collar by selling a set of six sequential rapidly decaying one-month calls while purchasing a single relatively slower decaying six-month put spread for each six-month period.

Index Construction

We created indices to reflect the return streams of the various theoretical implementations of the put spread collar and buy-write strategies. The returns of each put spread collar index were determined by the combined returns of the QQQ or NDX total return index (incorporating the impact of reinvested dividends), the returns of the long put positions, the returns of the short put positions and the returns of the short call positions.

To calculate the total return index for the QQQ, we assumed that all dividends disbursed were fully reinvested in the QQQ. For the NDX index, we utilized the total return index provided by Bloomberg. We used daily option prices and the daily QQQ or NDX total return index to create a daily put spread collar or buy-write return index.

For the buy-write, we only utilized one-month calls so a new call position was established each month utilizing the nearest available strike price to the desired moneyness level. Each month, generally at the close on the Thursday preceding the Friday expiration date of QQQ or NDX options, a new one-month call was written at the closing bid and the old short call was closed at the mid-point between the closing bid and ask. For the put spread collar, the short calls were treated similarly while the put spread was rolled once each six months, with the long put purchased at the closing ask and the short put sold at the closing bid. Thus, we valued the put at the bid/ask midpoint in the months in which we were not purchasing a new put. In the cases where we had to substitute one-month puts for the desired six-month puts due to missing data points, we

did so at the bid/ask midpoint to reflect the fact that we would not normally intend to roll on those days.

We did not explicitly include all transaction costs and the impacts of taxes in our calculations, however, we provided a reasonable adjustment for the impact of transaction costs by purchasing the puts at the ask and selling the calls at the bid when rolling into the new option positions as indicated above. This methodology is consistent with the extant literature and reflects the fact that the investor may use market orders to fill their call sales and put purchases.

Each month, on the roll date, the next month's strike prices were set based on the contemporaneous level of the QQQ or NDX. The desired strikes were calculated and rounded to the nearest available strike. Thus, the strikes utilized in the analysis deviate from the desired strikes due to rounding of the calculated strikes to the discrete strikes available. In addition, if quotes were not available for these rounded strikes, we substituted the next available strike.

Since the underlying sometimes dropped significantly over the life of the 6-month puts, there were some cases in which the strike of the new short call of the put spread collar was below the remaining long put strike. In these cases, we rolled the put spread downward to its desired moneyness level based on the contemporaneous underlying level at the bid/ask midpoints.

The remainder of the paper will proceed as follows: The next section will discuss a selection of quantitative and qualitative characteristics of NDX and QQQ options that

may be of importance to investors. We then consider the stand alone theoretical performance of NDX and QQQ buy-writes and put spread collars relative to their corresponding underlying benchmarks for the full period of study. We then focus the performance analysis on two three-year sub-periods based on NDX index performance. Finally, we consider option overlays for three hypothetical endowment portfolios.

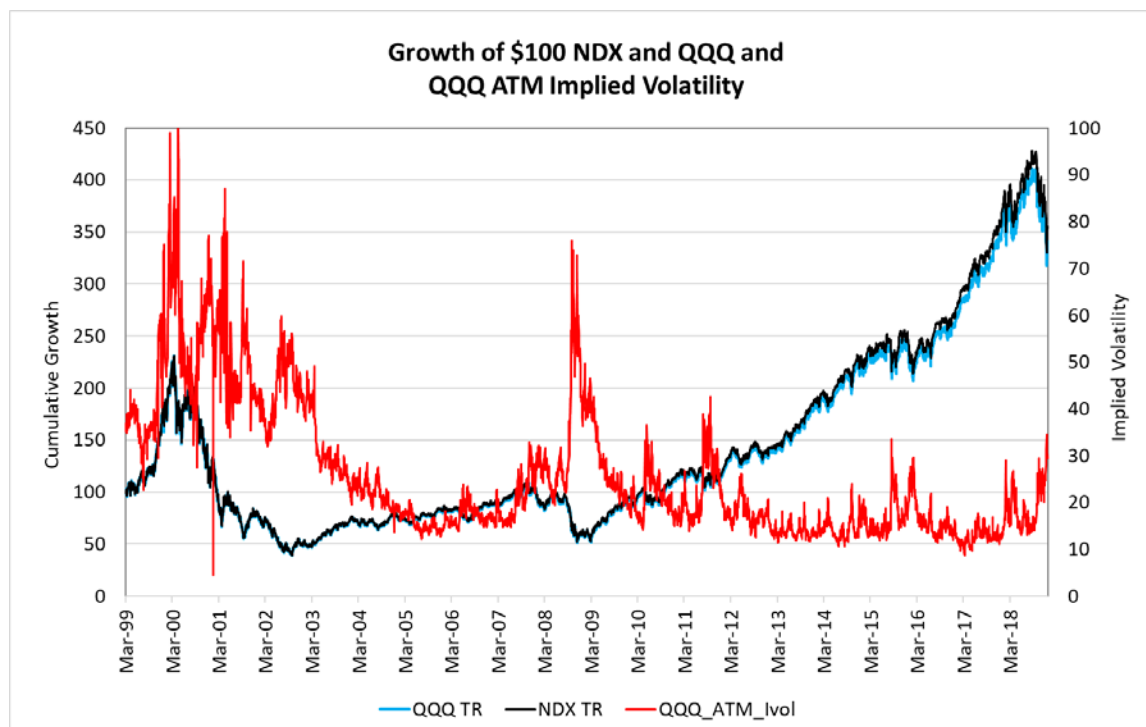
Characteristics of QQQ and NDX Options

There are a number of possible considerations for an investor choosing between implementing an option-based strategy using ETF options versus using cash-settled index options on the same index. Performance of options-based strategies may be impacted significantly by volume, open interest and bid/ask spreads of options as well as tracking error of an option's underlying with the investor's portfolio or with the corresponding index. Other important considerations include cash versus physical settlement, American versus European settlement, AM versus PM settlement, margin requirements, tax considerations and exchange considerations.

Exhibit 1 provides an illustration of the cumulative total return of the NDX index and the QQQ ETF as well as the implied volatility for QQQ ATM options over the full period of study. While it is possible for the level of an ETF such as the QQQ to deviate from the level of the corresponding index (NDX index) over the period of study these deviations were generally quite small and tended not to persist due to the arbitrage mechanism inherent in the ETF structure. While index ETFs often have very low fees, the impact of

fees can be seen in the slight deviation over time between the NDX and QQQ total return series.

**Exhibit 1: QQQ and NDX Cumulative Growth and QQQ ATM Implied Volatility
Full Period — March 1999 to December 2018**



Source: Optionmetrics, Bloomberg

Summary statistics for the full period are provided in Exhibit 2. Once again, the slight difference between NDX and QQQ performance, primarily due to fees, is evident.

Option volume may be an important consideration when implementing an option-based strategy, particularly for investors with exceptionally large portfolios who may be especially sensitive to options liquidity.

Exhibit 2: QQQ and NDX Summary Statistics Full Period — March 1999 to December 2018

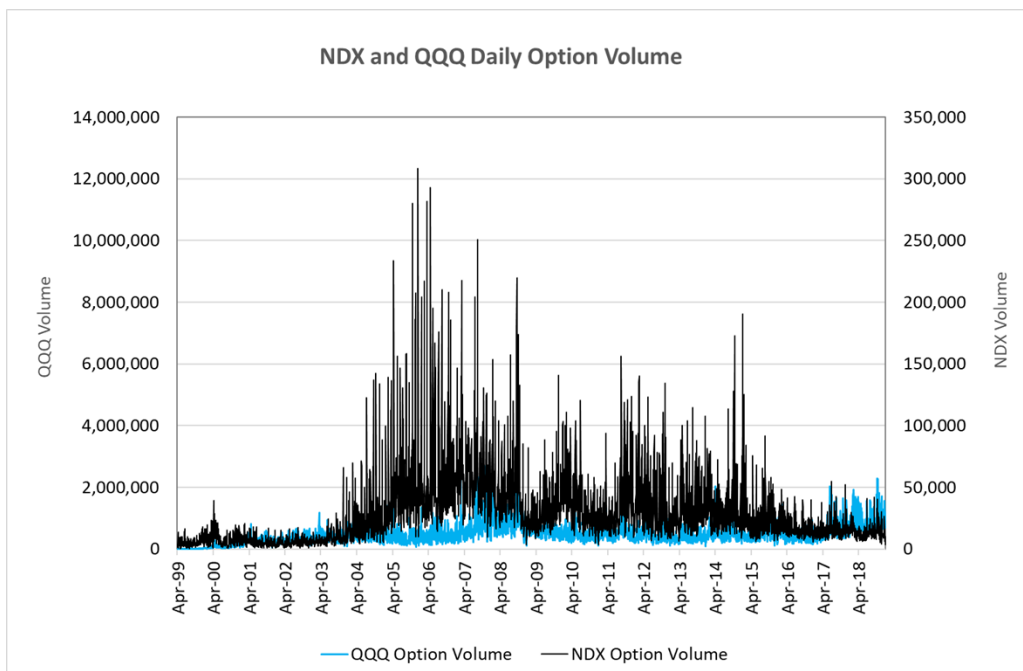
3/10/1999 to 12/29/2018	NDX TR Index	QQQ TR
Annualized Return	6.6%	6.4%
Annualized Standard Deviation	28.5%	27.9%
Information Ratio	0.23	0.23
Maximum Drawdown	-83%	-83%
Skewness	0.38	0.33
Kurtosis	7.30	6.95
Correlation w NDX	1.00	0.98
Beta wrt NDX	1.00	0.96
Alpha wrt NDX	0.0%	0.1%
% Up Days	54%	54%
% Down Days	46%	46%
Alpha P-Value	0.051	0.963

Source: Optionmetrics, Bloomberg

Exhibit 3 provides an illustration of historical daily volume of QQQ and NDX options over the period of study. While the volume is presented as the number of contracts traded and was not scaled to reflect the relative notional size of the option contracts or their deltas, the exhibit is generally representative of the broad historic trend of volume. The significant increase in QQQ option volume towards the end of the period is quite clear.

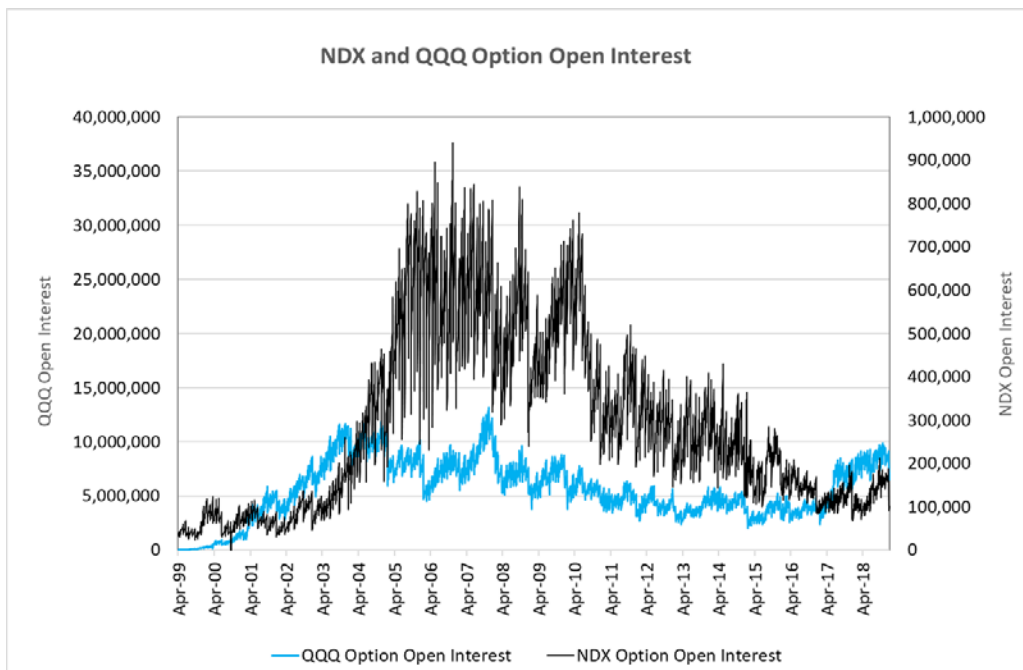
A generally similar pattern can be found in the open interest of NDX and QQQ options provided in Exhibit 4. Since open interest may provide an indication of the liquidity of the option contracts, it may be an important consideration for investors.

Exhibit 3: QQQ and NDX Options Volume Full Period — March 1999 to December 2018



Source: Optionmetrics, Bloomberg

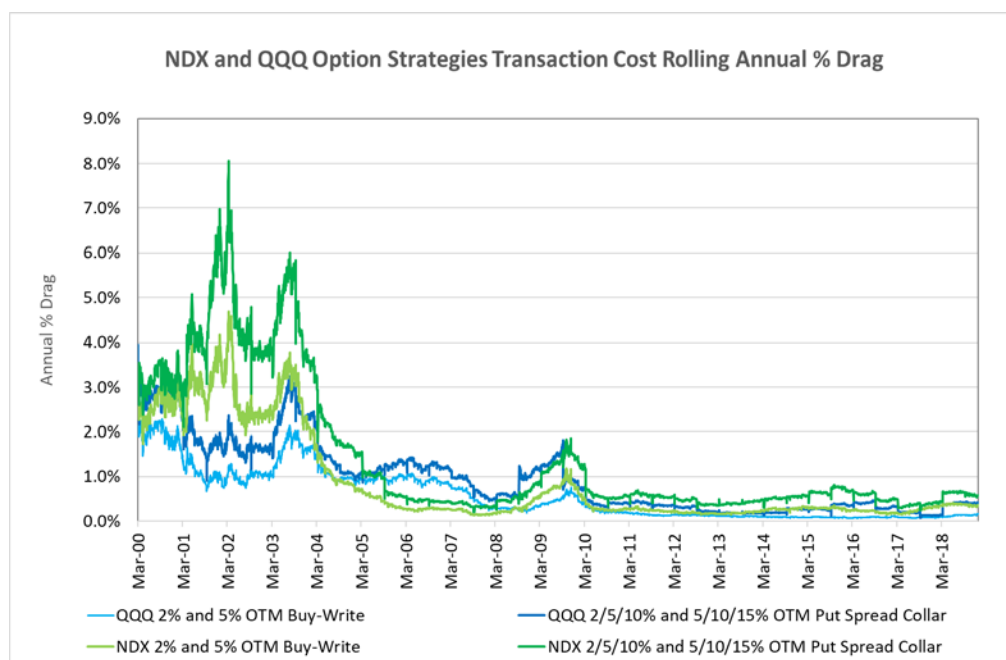
Exhibit 4: QQQ and NDX Options Open Interest Full Period — March 1999 to December 2018



Source: Optionmetrics, Bloomberg

Transaction costs can have a meaningful impact on the performance of options-based strategies, particularly a strategy such as a put spread collar which requires the purchase or writing of three separate options. Exhibit 5 illustrates the historical rolling annual transaction costs of the put spread collars and buy-writes on the NDX and QQQ. While the NDX strategies experienced meaningfully higher annual drag at the start of the period of study due to transaction costs than the QQQ strategies, the difference and the overall level for all implementations decreased significantly towards the end of the period. This finding also has an important implication for the performance analysis in the paper, suggesting that the average transaction cost drag reflected in the performance measures presented in the paper may possibly overstate the drag experienced at the end of the period.

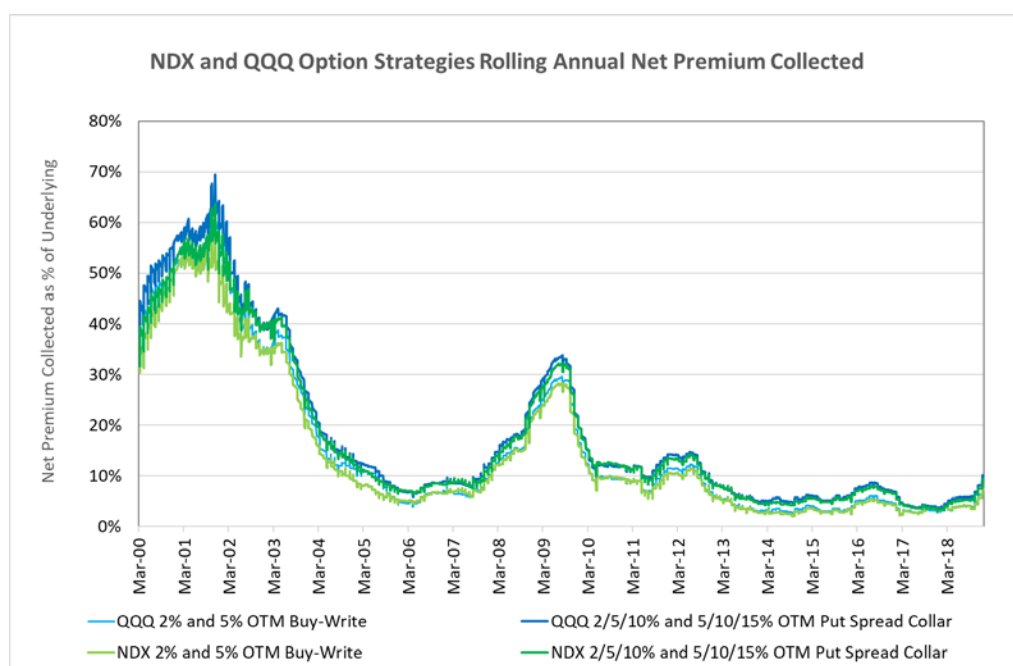
Exhibit 5: QQQ and NDX Transaction cost as % of Underlying for Buy-Writes and Put Spread Collars Full Period — March 1999 to December 2018



Source: Optionmetrics, Bloomberg

Exhibit 6 illustrates the net premium collected for NDX and QQQ buy-writes and put spread collars. The premium collected was largely driven by the level of implied volatility, the volatility skew and the tenor and moneyness of the options. The net premium collected was generally higher for the QQQ strategies, but the difference was usually quite small.

Exhibit 6: QQQ and NDX Buy-Writes and Put Spread Collars Premium Paid as % of Underlying Full Period — March 1999 to December 2018



Source: Optionmetrics, Bloomberg

Other considerations may or may not be of concern to particular investors. For example, QQQ options settle for the physical ETF resulting in the investor making or taking delivery of the underlying ETF while the NDX options are cash settled, simply resulting in a transfer of cash if the option is exercised. This difference may result in an inconvenience or undesirable tax implications for the investor. ETF options including

QQQ options are American style options while NDX options are European style. In addition to pricing differences of American and European options, American calls may require additional considerations, particularly around ex-dividend dates. In these circumstances, long call holders may have to determine whether early exercise is appropriate. Call writers may have to consider how to anticipate, prepare for and react to an assignment on their short call positions. QQQ options have a PM settlement (at the market close) whereas NDX options have an AM settlement settling at the special opening quotation (SOQ) at the market open. Contract size may also be an issue for investors, particularly for investors with relatively small portfolios or investors who require a more granular degree of divisibility since the NDX index level is currently approximately forty times the QQQ ETF price level. While some of these differences may be of little significance to some investors, they may have a meaningful impact on other investors. Finally, other considerations include any differences in margin requirements, and exchange and tax considerations.

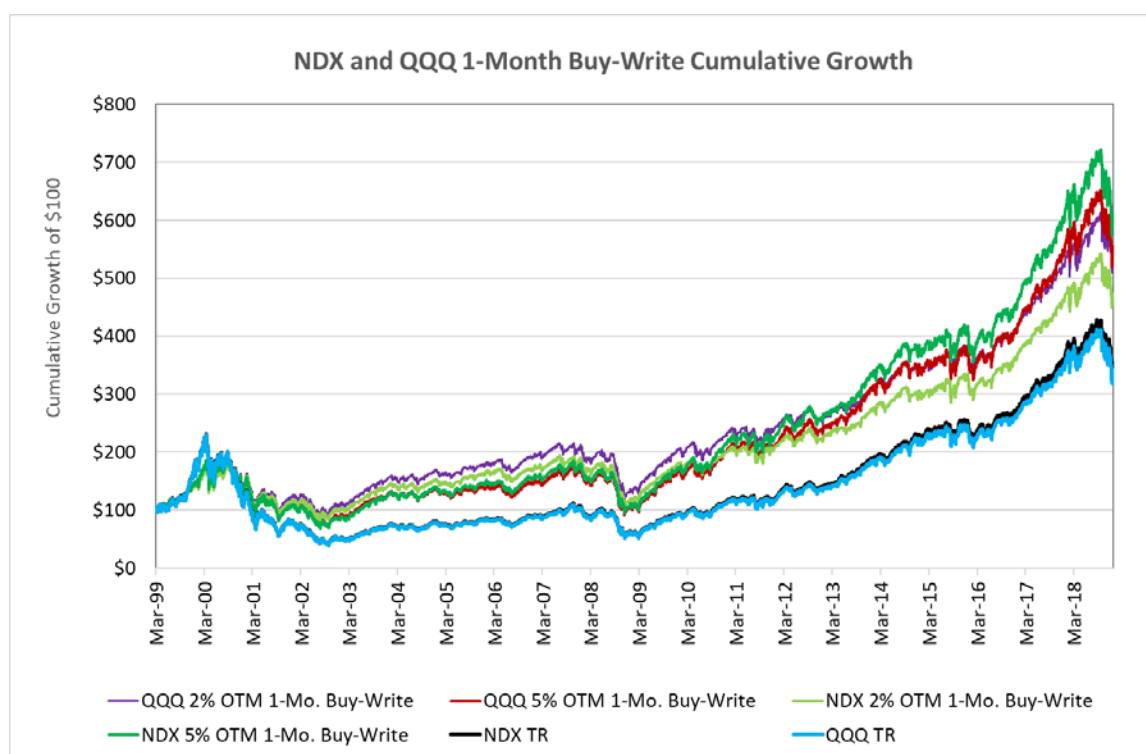
Stand Alone Risk and Return Characteristics

Full Sample Stand Alone Results

Exhibit 7 illustrates the cumulative growth of the QQQ, NDX index and the 2% OTM and 5% OTM 1-month buy-writes on the QQQ and NDX over the full period of study. The results in Exhibit 7 are augmented by the corresponding summary statistics provided in Exhibit 8. All of the buy-write implementations provided meaningful increases in raw returns and reductions in standard deviations. On average, the buy-writes increased

returns by 2.4% and decreased standard deviations by 5.8%. The results for the NDQ and QQQ implementations were very similar. From a risk-adjusted perspective, the information ratio (annualized return over annualized standard deviation) was almost doubled for all of the buy-write implementations versus the corresponding underlying while the buy-writes generated an average annual alpha of 3.3% (compared to zero for the underlying).

Exhibit 7: QQQ, NDX and 1-Mo. Buy-Writes 2% and 5% OTM Cumulative Growth Full Period — March 1999 to December 2018



Source: Optionmetrics, Bloomberg

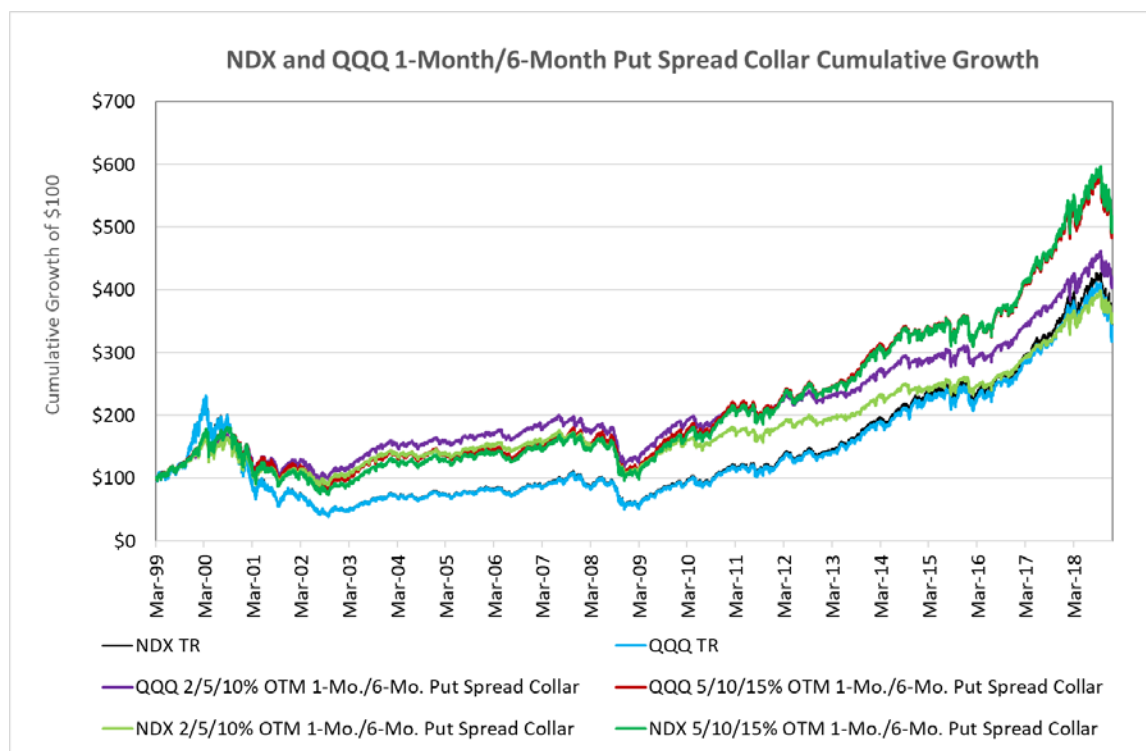
Exhibit 8: QQQ, NDX and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Full Period — March 1999 to December 2018

3/10/1999 to 12/29/2018	QQQ TR	QQQ 2% OTM 1-Mo. Buy-Write	QQQ 5% OTM 1-Mo. Buy-Write	NDX TR	NDX 2% OTM 1-Mo. Buy-Write	NDX 5% OTM 1-Mo. Buy-Write
Annualized Return	6.4%	8.9%	9.0%	6.6%	8.2%	9.6%
Annualized Standard Deviation	27.9%	21.0%	23.3%	28.5%	21.7%	23.9%
Information Ratio	0.23	0.42	0.39	0.23	0.38	0.40
Maximum Drawdown	-83%	-53%	-63%	-83%	-54%	-64%
Skewness	0.33	0.46	0.37	0.38	0.57	0.43
Kurtosis	6.95	13.22	9.84	7.30	13.89	10.11
Correlation w Underlying	1.00	0.94	0.96	1.00	0.94	0.97
Beta wrt Underlying	1.00	0.70	0.80	1.00	0.72	0.81
Alpha wrt Underlying	0.0%	3.6%	3.3%	0.0%	2.7%	3.5%
% Up Days	54%	58%	56%	54%	57%	56%
% Down Days	46%	42%	44%	46%	43%	44%
Alpha P-Value	0.086	0.028	0.022	0.051	0.099	0.010

Source: Optionmetrics, Bloomberg

Exhibits 9 and 10 provide the full period results for the NDX and QQQ put spread collar implementations. The returns were generally similar to those of the buy-write strategies. Once again, the options-based strategy increased returns and decreased standard deviations. While the returns were increased by an average of 1.4%, the standard deviations were reduced by about 1/3 (8.3% on average) relative to the underlying benchmark. From a risk-adjusted return perspective, the information ratio was increased meaningfully for all the put spread collar strategies from 0.23 to an average of 0.40, while the put spread collar alphas averaged 2.7%, although the NDX 2/5/10% OTM put spread collar alpha was not statistically significant.

Exhibit 9: QQQ, NDX and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Cumulative Growth Full Period — March 1999 to December 2018



Source: Optionmetrics, Bloomberg

Exhibit 10: QQQ, NDX and 1-Mo/6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Summary Statistics Full Period — March 1999 to December 2018

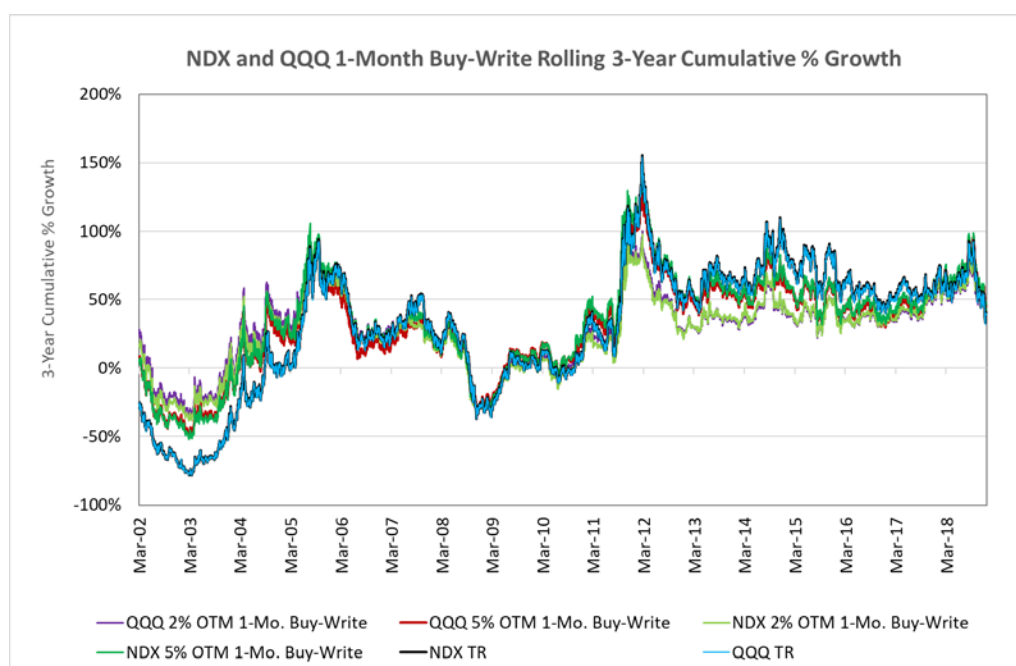
3/10/1999 to 12/29/2018	QQQ TR	QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar	NDX TR	NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar
Annualized Return	6.4%	7.5%	8.6%	6.6%	6.7%	8.7%
Annualized Standard Deviation	27.9%	17.8%	20.7%	28.5%	19.2%	21.9%
Information Ratio	0.23	0.42	0.42	0.23	0.35	0.40
Maximum Drawdown	-83%	-43%	-56%	-83%	-47%	-59%
Skewness	0.33	0.40	0.28	0.38	0.74	0.50
Kurtosis	6.95	13.34	8.36	7.30	17.60	11.33
Correlation w Underlying	1.00	0.93	0.96	1.00	0.93	0.96
Beta wrt Underlying	1.00	0.59	0.71	1.00	0.63	0.74
Alpha wrt Underlying	0.0%	2.8%	3.2%	0.0%	1.8%	3.0%
% Up Days	54%	58%	56%	54%	57%	56%
% Down Days	46%	42%	44%	46%	43%	44%
Alpha P-Value	0.086	0.055	0.015	0.051	0.262	0.027

Source: Optionmetrics, Bloomberg

Sub-Period Stand Alone Results

In order to assess the standalone performance of the options-based strategies relative to their underlying benchmarks, the following section considers theoretical options-based strategy performance over two three-year sub-periods in which the NDX index experienced its highest and lowest cumulative growth.

Exhibit 11: QQQ, NDX and 1-Mo. Buy-Writes 2% and 5% OTM Rolling 3-Year Returns Full Period — March 1999 to December 2018



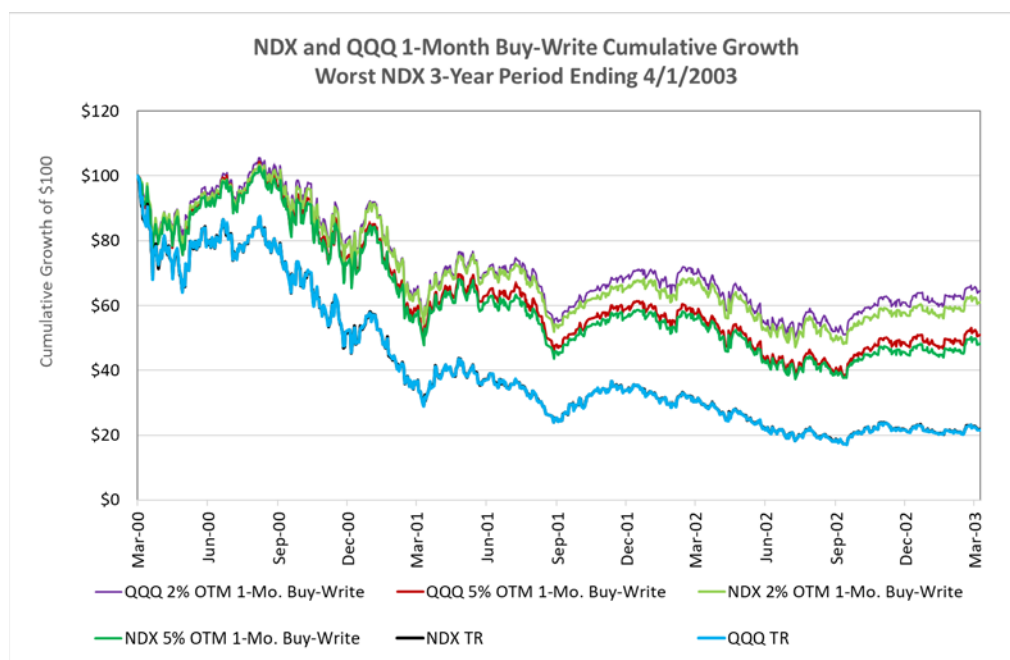
Source: Optionmetrics, Bloomberg

Exhibit 11 illustrates the rolling three-year cumulative returns of the NDX and QQQ and the corresponding buy-write strategies. The results provided in the exhibit indicate that the lowest three-year cumulative raw return for the NDX occurred in the three-year period ending on 4/1/2003. This three-year period was used as the “worst” sub-period for

the analysis. One would expect that the options-based strategies would have outperformed the underlying benchmark in this sub-period.

The highest three-year cumulative raw return for the NDX index occurred in the three-year period ending on 3/7/2012. This three-year period was used as the “best” sub-period for the analysis, in which one would expect the options-based strategies would have underperformed the underlying benchmark on a raw return basis.

Exhibit 12: QQQ, NDX and 1-Mo. Buy-Writes 2% and 5% OTM Cumulative Growth Worst 3-Year Period for NDX



Source: Optionmetrics, Bloomberg

Exhibits 12 and 13 illustrate the theoretical historical performance of the buy-write strategies on the NDX and QQQ in the worst three-year period for the NDX over the period of study. The buy-writes cut losses by about $\frac{1}{2}$ to $\frac{1}{3}$ (increasing returns by 22%,

on average) while also reducing standard deviations by about 1/5 (decreasing standard deviations by 10%, on average). From a risk-adjusted return perspective, the alphas of the buy-writes ranged from 15% to 21% and they were all statistically significant at the 5% level. Once again, little performance difference was seen between the NDX and QQQ implementations.

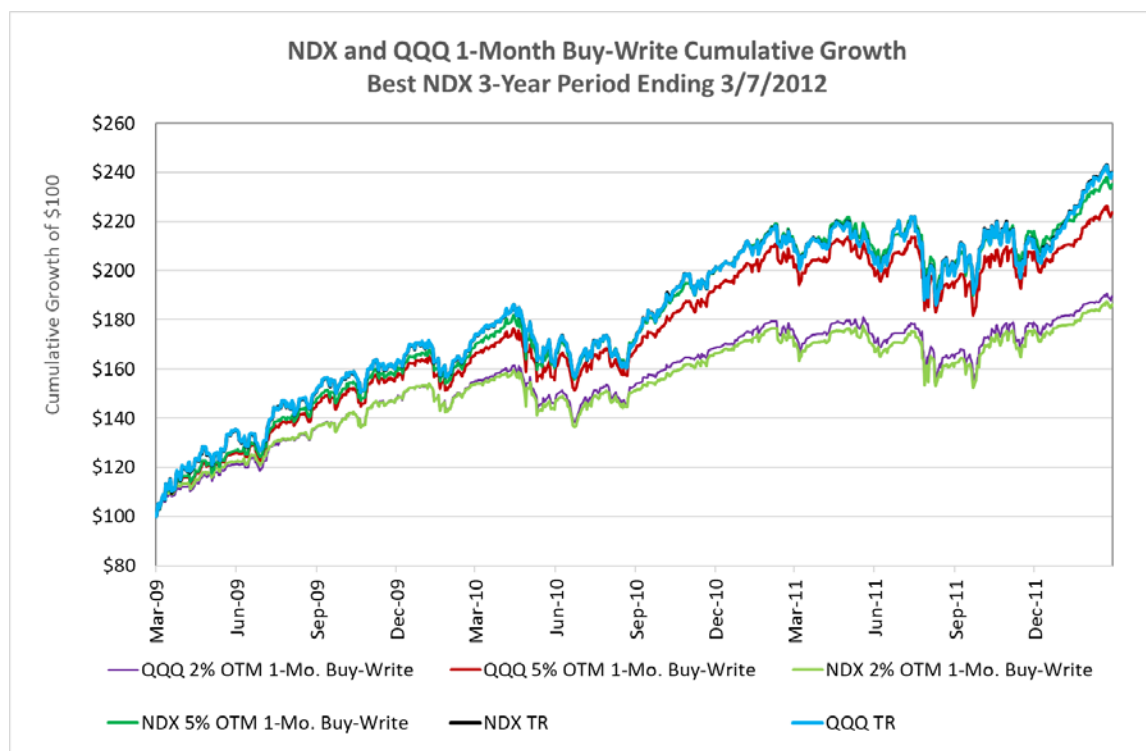
Exhibit 13: QQQ, NDX and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Worst 3-Year Period for NDX

3 Years Ending 4/1/2003	QQQ TR	QQQ 2% OTM 1-Mo. Buy-Write	QQQ 5% OTM 1-Mo. Buy-Write	NDX TR	NDX 2% OTM 1-Mo. Buy-Write	NDX 5% OTM 1-Mo. Buy-Write
Annualized Return	-39.9%	-13.6%	-20.2%	-39.8%	-15.2%	-21.6%
Annualized Standard Deviation	50.1%	38.5%	41.5%	51.3%	39.9%	42.5%
Information Ratio	-0.80	-0.35	-0.49	-0.78	-0.38	-0.51
Maximum Drawdown	-83%	-53%	-63%	-83%	-54%	-64%
Skewness	0.49	0.57	0.54	0.57	0.70	0.64
Kurtosis	1.69	4.02	3.20	1.92	4.27	3.44
Correlation w Underlying	1.00	0.95	0.97	1.00	0.95	0.97
Beta wrt Underlying	1.00	0.73	0.80	1.00	0.74	0.80
Alpha wrt Underlying	0.0%	21.0%	17.0%	0.0%	19.5%	15.1%
% Up Days	48%	52%	51%	48%	49%	49%
% Down Days	52%	48%	49%	52%	51%	51%
Alpha P-Value	0.245	0.002	0.004	0.261	0.005	0.012

Source: Optionmetrics, Bloomberg

Exhibits 14 and 15 provide an analysis the performance of the buy-write strategies on the NDX and QQQ in the best three-year period for the NDX index over the period of study. While the 2% OTM buy-writes cut gains by about 1/3 they reduced standard deviations by almost as much, slightly reducing the information ratios. However, the 5% OTM buy-writes only slightly reduced returns with a much larger decrease in standard deviations, resulting in increased information ratios. While all of the alphas were positive, only the NDX 5% OTM buy-write alpha were statistically significant at 10%.

Exhibit 14: QQQ, NDX and 1-Mo. Buy-Writes 2% and 5% OTM Cumulative Growth Best 3-Year Period for NDX



Source: Optionmetrics, Bloomberg

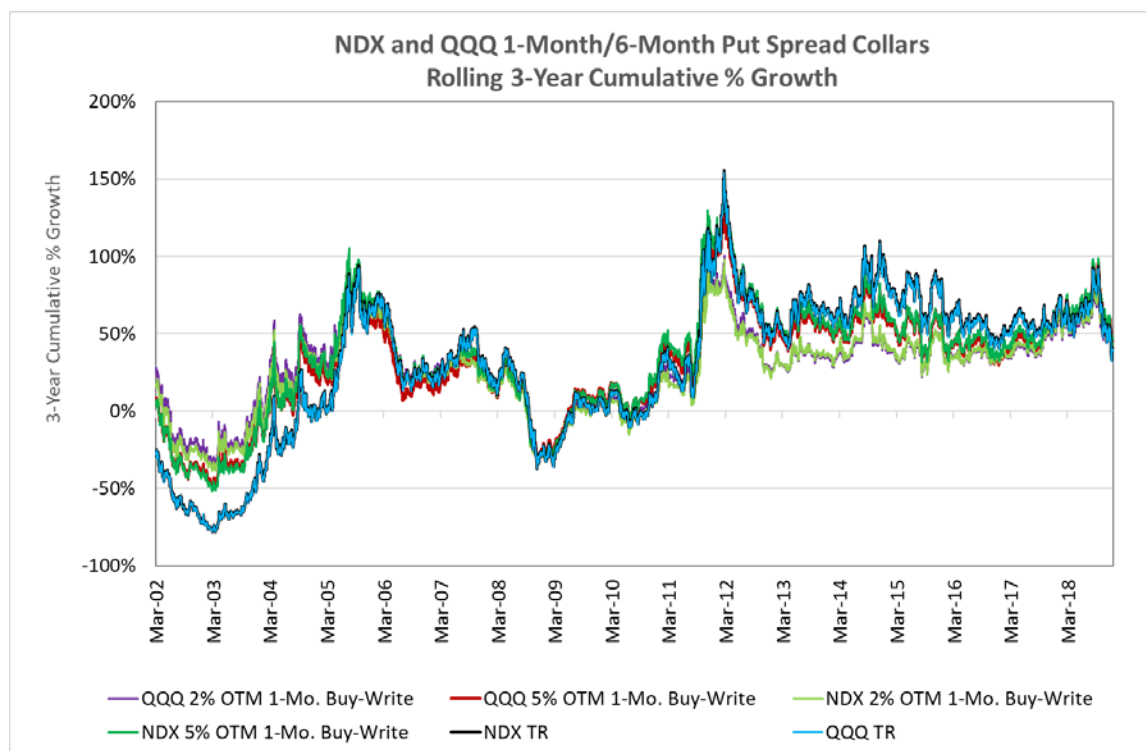
Exhibit 15: QQQ, NDX and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Best 3-Year Period for NDX

3 Years Ending 3/7/2012	QQQ TR	QQQ 2% OTM 1-Mo. Buy-Write	QQQ 5% OTM 1-Mo. Buy-Write	NDX TR	NDX 2% OTM 1-Mo. Buy-Write	NDX 5% OTM 1-Mo. Buy-Write
Annualized Return	33.8%	23.7%	30.8%	33.9%	23.0%	33.0%
Annualized Standard Deviation	21.4%	15.8%	18.3%	21.7%	15.9%	18.6%
Information Ratio	1.58	1.50	1.68	1.56	1.45	1.77
Maximum Drawdown	-16%	-14%	-15%	-16%	-14%	-14%
Skewness	-0.03	-0.29	-0.23	0.01	-0.22	-0.18
Kurtosis	2.45	7.14	4.30	2.56	7.87	4.30
Correlation w Underlying	1.00	0.93	0.97	1.00	0.93	0.97
Beta wrt Underlying	1.00	0.68	0.83	1.00	0.68	0.84
Alpha wrt Underlying	0.0%	1.5%	2.9%	0.0%	1.1%	4.2%
% Up Days	58%	63%	61%	58%	63%	62%
% Down Days	42%	37%	39%	42%	37%	38%
Alpha P-Value	0.000	0.655	0.291	0.003	0.741	0.099

Source: Optionmetrics, Bloomberg

Exhibit 16 illustrates the rolling three-year cumulative returns of the NDX and QQQ and the corresponding put spread collar strategies. The rolling returns of the put spread collars over the period were generally similar to those of the buy-writes illustrated in Exhibit 11.

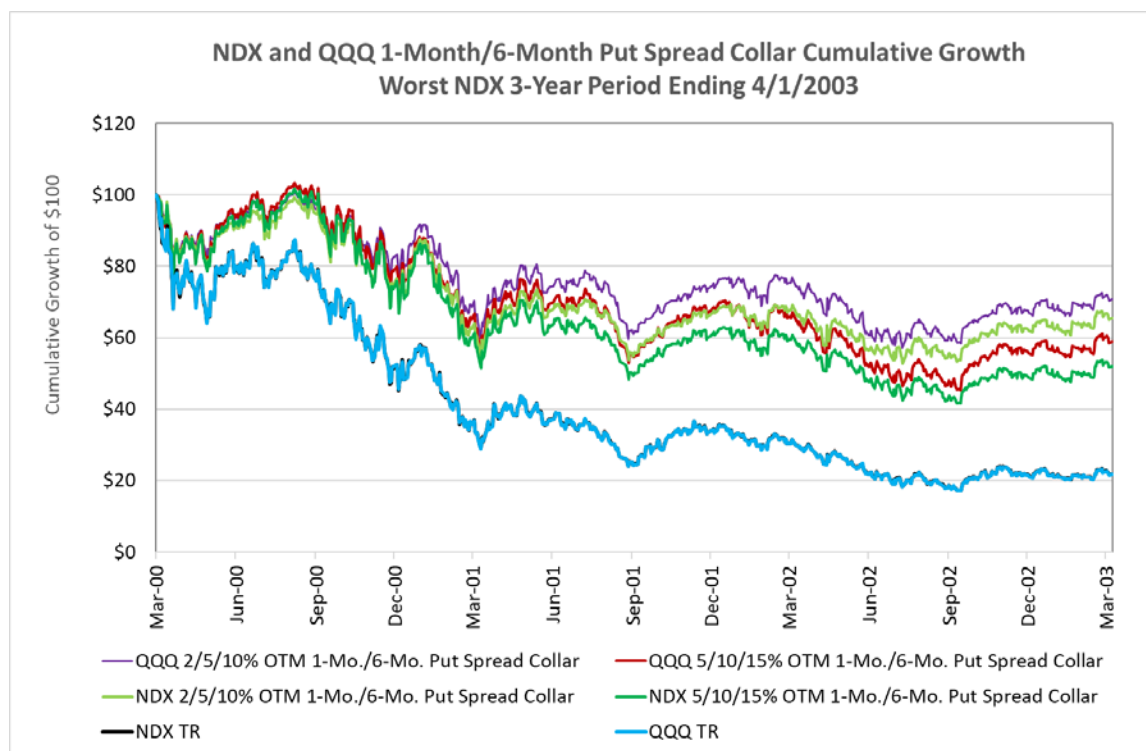
Exhibit 16: QQQ, NDX and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Rolling 3-Year Returns Full Period — March 1999 to December 2018



Source: Optionmetrics, Bloomberg

Exhibits 17 and 18 describe the performance of the put spread collar strategies on the NDX and QQQ in the worst three-year period for the NDX index over the period of study. The put spread collars cut losses by about 1/3 to 2/3 (on average, increasing returns by 25%) while also reducing standard deviations by 1/5 or more (on average, decreasing standard deviations by 15%). While the performance was generally similar between the NDX and QQQ put spread collars, the QQQ put spread collars reduced losses and reduced standard deviations by a somewhat larger margin than the NDX strategies. The alphas of the put spread collars ranged from 13% to 17% and all were statistically significant at the 5% level.

Exhibit 17: QQQ, NDX and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Cumulative Growth Worst 3-Year Period for NDX



Source: Optionmetrics, Bloomberg

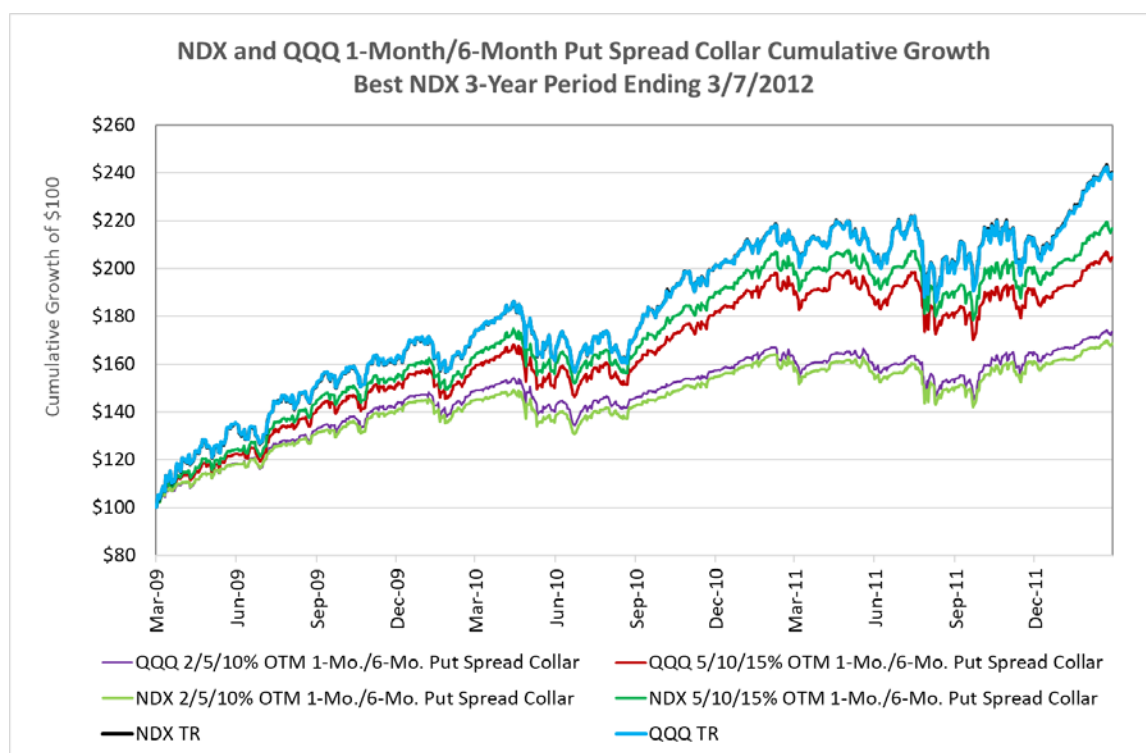
Exhibit 18: QQQ, NDX and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Summary Statistics Worst 3-Year Period for NDX

3 Years Ending 4/1/2003	QQQ TR	QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar	NDX TR	NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar
Annualized Return	-39.9%	-10.9%	-16.2%	-39.8%	-13.2%	-19.7%
Annualized Standard Deviation	50.1%	32.5%	36.2%	51.3%	36.2%	39.0%
Information Ratio	-0.80	-0.34	-0.45	-0.78	-0.36	-0.50
Maximum Drawdown	-83%	-43%	-56%	-83%	-47%	-59%
Skewness	0.49	0.52	0.49	0.57	0.85	0.75
Kurtosis	1.69	4.07	2.84	1.92	5.89	4.44
Correlation w Underlying	1.00	0.94	0.97	1.00	0.94	0.96
Beta wrt Underlying	1.00	0.61	0.70	1.00	0.67	0.73
Alpha wrt Underlying	0.0%	17.4%	15.8%	0.0%	17.6%	13.3%
% Up Days	48%	51%	51%	48%	49%	49%
% Down Days	52%	49%	49%	52%	51%	51%
Alpha P-Value	0.245	0.005	0.003	0.261	0.013	0.031

Source: Optionmetrics, Bloomberg

Exhibits 19 and 20 illustrate the historical performance of the buy-write strategies on the NDX and QQQ in the best three-year period for the NDX over the period of study. Once again, similar to the buy-writes the 2% OTM buy-writes cut gains by about 1/3 while reducing standard deviations by almost as much, resulting in lower information ratios. In contrast, the 5% OTM buy-writes reduced returns by less than the reduction in standard deviations, resulting in improved information ratios. Once again, the alphas were positive, but statistically significant.

Exhibit 19: QQQ, NDX and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Cumulative Growth Best 3-Year Period for NDX



Source: Optionmetrics, Bloomberg

Exhibit 20: QQQ, NDX and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Summary Statistics Best 3-Year Period for NDX

3 Years Ending 3/7/2012	QQQ TR	QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar	NDX TR	NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar
Annualized Return	33.8%	20.1%	26.9%	33.9%	19.0%	29.4%
Annualized Standard Deviation	21.4%	13.7%	16.4%	21.7%	13.4%	16.9%
Information Ratio	1.58	1.47	1.64	1.56	1.42	1.74
Maximum Drawdown	-16%	-13%	-14%	-16%	-13%	-14%
Skewness	-0.03	-0.37	-0.36	0.01	-0.35	-0.26
Kurtosis	2.45	6.00	3.50	2.56	6.55	3.67
Correlation w Underlying	1.00	0.92	0.96	1.00	0.92	0.97
Beta wrt Underlying	1.00	0.59	0.74	1.00	0.57	0.76
Alpha wrt Underlying	0.0%	1.0%	1.9%	0.0%	0.7%	3.4%
% Up Days	58%	64%	61%	58%	63%	62%
% Down Days	42%	36%	39%	42%	37%	38%
Alpha P-Value	0.000	0.746	0.472	0.003	0.826	0.150

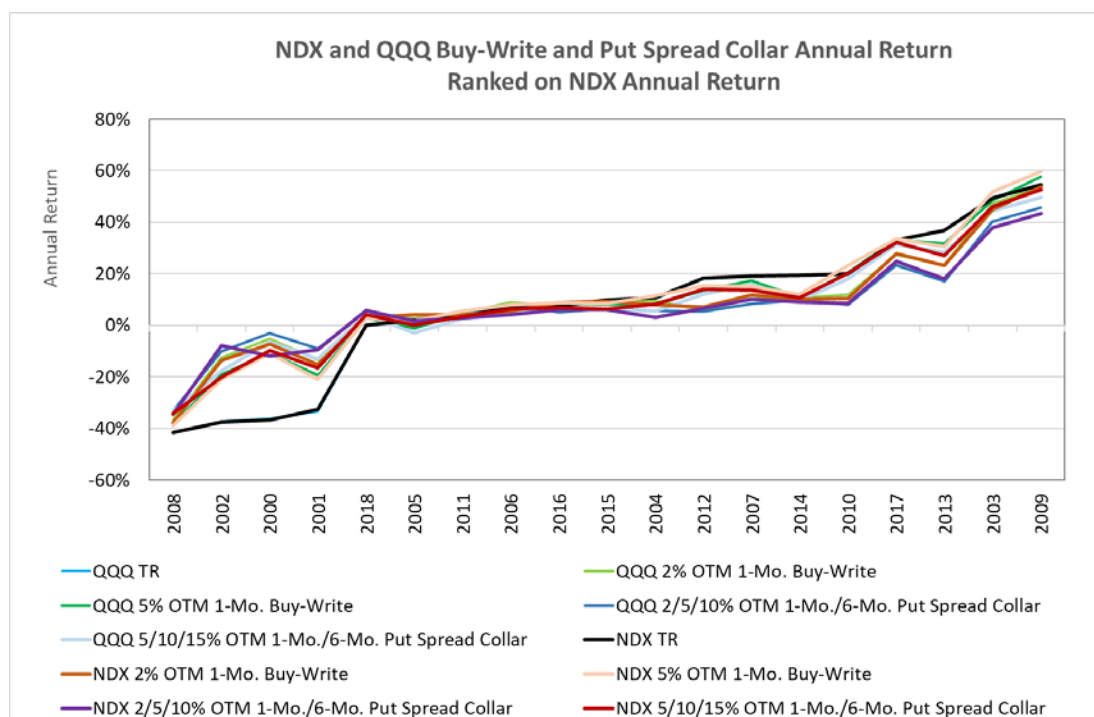
Source: Optionmetrics, Bloomberg

In summary, in the worst three-year period for the NDX index over the period of study, the buy-writes and put spread collars provided exceptionally large improvements in returns and standard deviations, with the put spread collars outperforming the buy-writes. In the best three-year period for the NDX index over the period of study, the buy-writes and put spread collars significantly reduced returns. However, they also significantly reduced standard deviations and betas, resulting in positive alphas (although the alphas were generally not statistically significant). It is worth noting that information ratios were not compared in periods of negative returns since negative information ratios are not instructive.

Exhibit 21 provides the standalone year-by-year returns of the buy-write and put spread collar strategies ranked on the returns of the NDX. While the returns of the option-based strategies were somewhat similar to the underlying benchmark returns at the extremes and near the median return, the options-based strategies generally outperformed the

underlying in mildly bad years for the NDX index and slightly underperformed in mildly good years for the NDX index.

Exhibit 21: QQQ, NDX and Buy-Writes 2% and 5% OTM and 1Mo/6-Mo. Put Spread Collars 2/5/10% and 5/15/15% OTM Raw Return by Year Ranked on NDX Return



	2008	2002	2000	2001	2018	2005	2011	2006	2016	2015	2004	2012	2007	2014	2010	2017	2013	2003	2009
QQQ TR	-42%	-37%	-36%	-33%	0%	2%	3%	7%	7%	9%	11%	18%	19%	19%	20%	33%	37%	50%	55%
QQQ 2% OTM 1-Mo. Buy-Write	-37%	-13%	-5%	-13%	3%	3%	5%	9%	8%	10%	9%	6%	10%	11%	12%	27%	23%	47%	54%
QQQ 5% OTM 1-Mo. Buy-Write	-38%	-19%	-11%	-19%	3%	-1%	5%	7%	8%	8%	8%	13%	17%	11%	21%	33%	32%	48%	58%
QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	-33%	-10%	-3%	-9%	6%	0%	4%	8%	5%	6%	6%	5%	8%	10%	8%	23%	17%	40%	46%
QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar	-33%	-18%	-6%	-13%	4%	-3%	3%	5%	6%	6%	5%	12%	16%	9%	18%	31%	28%	44%	50%
NDX TR	-42%	-38%	-37%	-33%	0%	2%	4%	7%	7%	10%	11%	18%	19%	19%	20%	33%	37%	49%	55%
NDX 2% OTM 1-Mo. Buy-Write	-38%	-14%	-7%	-15%	3%	4%	4%	5%	9%	9%	8%	7%	12%	10%	10%	28%	23%	45%	54%
NDX 5% OTM 1-Mo. Buy-Write	-39%	-21%	-11%	-21%	3%	2%	5%	8%	9%	8%	11%	15%	15%	12%	23%	34%	30%	52%	60%
NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar	-35%	-8%	-12%	-10%	6%	2%	3%	4%	6%	6%	3%	7%	10%	9%	8%	25%	18%	38%	43%
NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar	-34%	-20%	-10%	-17%	4%	0%	3%	6%	7%	6%	8%	14%	14%	11%	20%	32%	27%	46%	52%

Source: Optionmetrics, Bloomberg

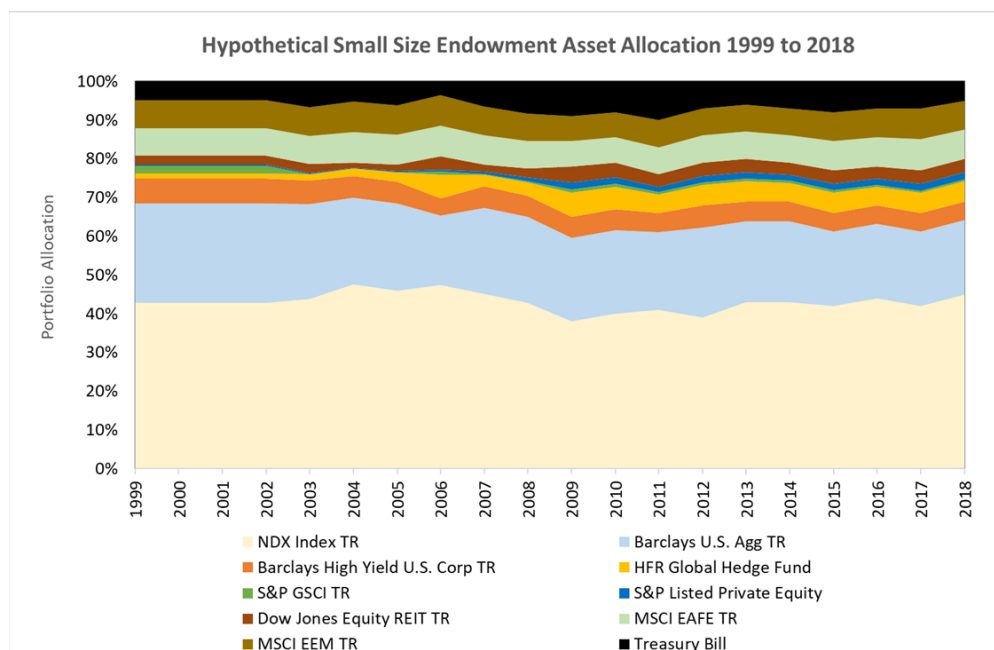
Endowment Overlay Risk and Return Characteristics

Small Endowment (<\$25 Million in Assets)

The remainder of the paper considers performance in an endowment setting. For the purposes of this analysis, we created three indices of theoretical endowment returns based on the policy returns to hypothetical small (<\$25 million in assets), mid-sized (\$100 - \$500 million in assets), and very large (>\$1 billion in assets) endowments based on the annual average asset allocations reported in the publically available NACUBO-Commonfund Study of Endowments reports for the years from 2002 to 2018. The endowment asset allocations for 1999 to 2001 were based on the allocations reported in the 2002 report. Exhibits 22 to 24 illustrate the asset allocation weights that were applied to the following indices to generate theoretical monthly time series of returns: NDX Total Return Index, Bloomberg Barclays U.S. Corporate High Yield Total Return Index, S&P Listed Private Equity Total Return Index, MCSI EAFE Total Return Index, 3-Month Treasury Bill, Bloomberg Barclays U.S. Aggregate Total Return Index, HFRX Global Hedge Fund Index, S&P GSCI Total Return Index, Dow Jones Equity REIT Total Return Index, and MSCI Emerging Market Total Return Index.

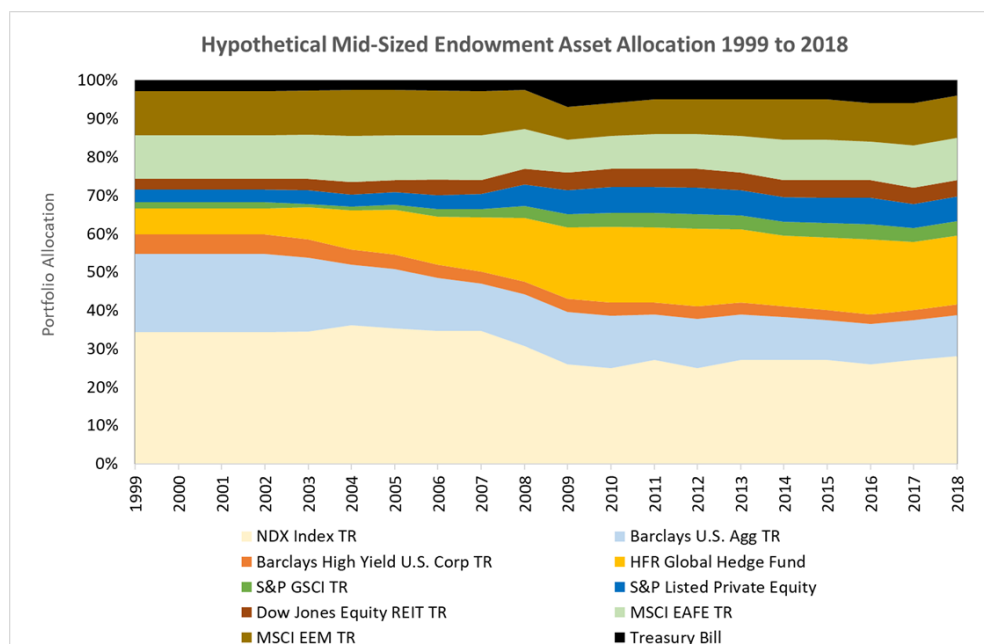
Due to data limitations for hedge fund returns, this section utilized monthly returns (as opposed to daily returns for the previous sections in the paper), so some full period results may be slightly inconsistent with previous results in the paper. Furthermore, the history of the S&P Private Equity Index history begins in 2003 so we constructed the index history from 1999 to 2003 using the list of index constituents at inception.

Exhibit 22: Hypothetical Small (<\$25 Million) Endowment Annual Asset Allocation —1999 to 2018



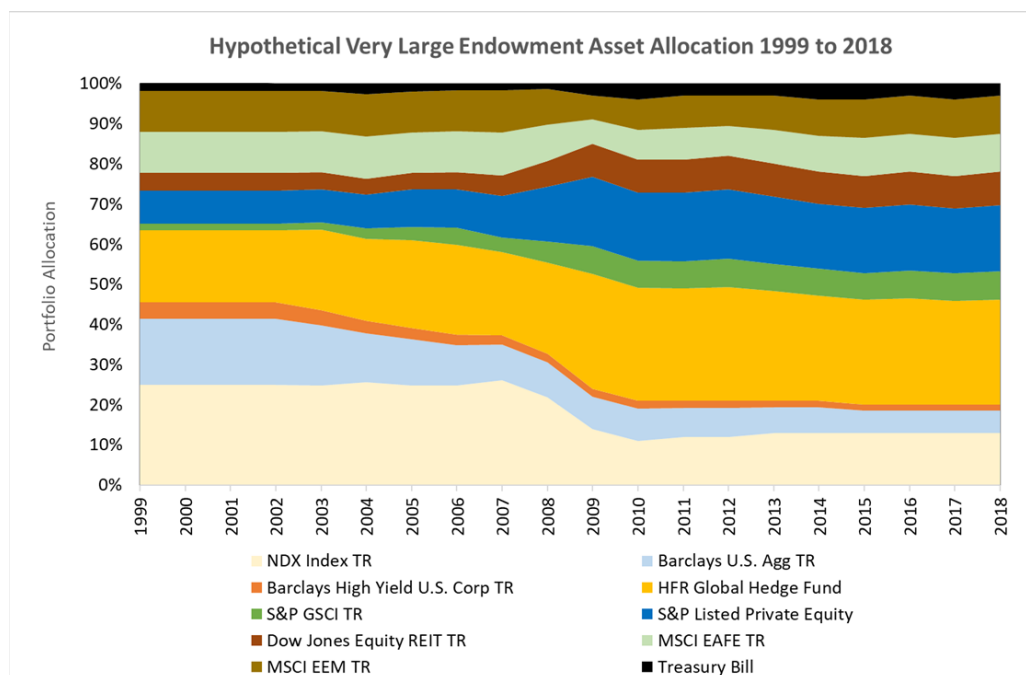
Source: NACUBO-Commonfund Study of Endowments 2002-2018

Exhibit 23: Hypothetical Mid-Sized (\$100 - \$500 Million) Endowment Annual Asset Allocation —1999 to 2018



Source: NACUBO-Commonfund Study of Endowments 2002-2018

Exhibit 24: Hypothetical Very Large (>\$1 Billion) Endowment Annual Asset Allocation —1999 to 2018



Source: NACUBO-Commonfund Study of Endowments 2002-2018

Exhibit 25 provides full-period summary statistics for the hypothetical small, mid-sized and very large endowment portfolios alongside the NDX and QQQ. For the overall period, the raw return of the small endowment was very similar to the QQQ and NDX returns while the very large endowment and mid-sized endowments underperformed the QQQ and NDX. However, the endowment portfolios experienced close to ½ the standard deviation of the NDX and QQQ. The maximum drawdowns of the endowments were also far superior to that of the NDX and QQQ. The benefits of diversification in the endowment portfolios are clearly evident.

**Exhibit 25: Hypothetical Endowments, QQQ and NDX Summary Statistics
Full Period — April 1999 to December 2018**

April 1999 to December 2018	NDX Index TR	QQQ TR	Very Large Endowment > \$1 Billion	Medium Endowment \$100-\$500 Million	Small Endowment > \$25 Million
Annualized Return	6.4%	6.3%	5.4%	5.7%	6.5%
Annualized Standard Deviation	24.3%	24.2%	13.1%	13.3%	13.3%
Information Ratio	0.26	0.26	0.41	0.43	0.49
Maximum Drawdown	-81%	-81%	-49%	-45%	-48%
Skewness	-0.38	-0.40	-0.66	-0.58	-0.46
Kurtosis	2.00	1.78	2.64	1.78	1.37
Correlation w NDX	1.00	1.00	0.88	0.94	0.97
Beta wrt NDX	1.00	1.00	0.48	0.52	0.53
Alpha wrt NDX	0.0%	-0.1%	1.7%	1.7%	2.2%
% Up Days	57%	57%	61%	60%	60%
% Down Days	43%	43%	39%	40%	40%
Alpha P-Value	0.093	0.552	0.223	0.109	0.001

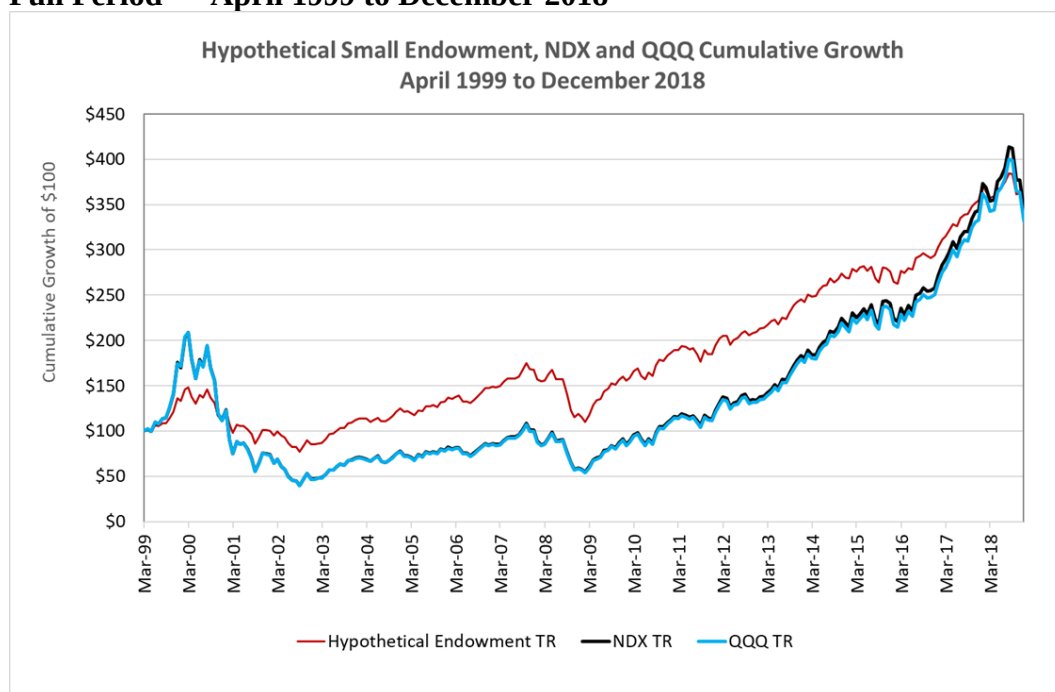
Source: Optionmetrics, Bloomberg

Exhibit 26 provides a graphical representation of the theoretical full-period performance of the small endowment, NDX, QQQ and the buy-write overlays. It is evident in Exhibit 26 that the small endowment outperformed the NDX and QQQ over much of the period despite the similarity in their full-period returns.

Since the equity allocation of the endowment portfolios was represented by the NDX total return index, the analysis presented in this section of the paper essentially created the theoretical returns to the endowment portfolio with an option overlay on the equity allocation by replacing the equity allocation with an equivalently sized allocation to a buy-write or put spread collar strategy. Of course, there is an added inaccuracy for the QQQ options-based strategies since the NDX index was replaced with a QQQ-based strategy, however, the correlation between QQQ and NDX suggests that the QQQ results should be generally representative of a QQQ overlay. Since the equity allocation was

relatively small, particularly in the end of the period (as illustrated in Exhibits 22 through 24) the impact of the option-based strategies was relatively small relative to the impact on the equity portfolios presented earlier. However, as illustrated in the following exhibits, the option overlays did improve risk-adjusted performance.

Exhibit 26: Hypothetical Small Endowment, QQQ and NDX Cumulative Growth Full Period — April 1999 to December 2018



Source: Optionmetrics, Bloomberg

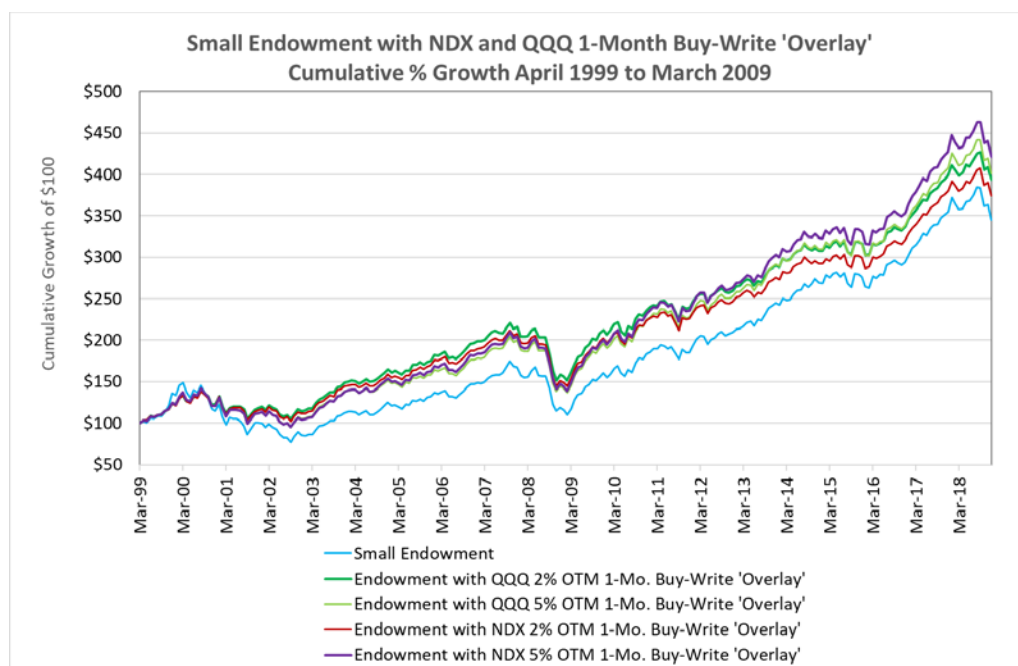
Exhibits 27 and 28 illustrate the performance of the hypothetical small endowment portfolio with and without the buy-write overlays for the full period from April 1999 to December 2018. The buy-write overlays all provided small increases in annualized returns and reductions in standard deviations. On average, the buy-write overlays increased annualized returns by 80 bps, with the NDX 5% OTM buy-write providing the largest increase of 1.1%. The average decrease in standard deviations for the buy-writes

was 2.2% with the QQQ 2% OTM buy-write providing the largest decrease of 2.7%.

From the perspective of risk-adjusted returns, the average increase in the information ratios was 0.17 (up by about 1/3) while the average increase in alphas was 1.5% per year.

Once again, the NDX and QQQ implementations performed very similarly.

Exhibit 27: Small Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Cumulative Returns Full Period — April 1999 to December 2018



Source: Optionmetrics, Bloomberg

Exhibit 28: Small Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Full Period — April 1999 to December 2018

April 1999 to December 2018	Small Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	6.5%	7.2%	7.3%	6.9%	7.5%
Annualized Standard Deviation	13.3%	10.5%	11.5%	10.6%	11.6%
Information Ratio	0.49	0.68	0.63	0.65	0.65
Maximum Drawdown	-48%	-31%	-33%	-32%	-34%
Skewness	-0.46	-0.83	-0.70	-0.84	-0.70
Kurtosis	1.37	2.06	1.37	2.24	1.53
Correlation w NDX	0.97	0.91	0.93	0.90	0.93
Beta wrt NDX	0.53	0.39	0.44	0.40	0.45
Alpha wrt NDX	2.2%	3.9%	3.6%	3.6%	3.8%
% Up Days	60%	65%	63%	65%	63%
% Down Days	40%	35%	37%	35%	37%
Alpha P-Value	0.001	0.000	0.000	0.001	0.000

Source: Optionmetrics, Bloomberg

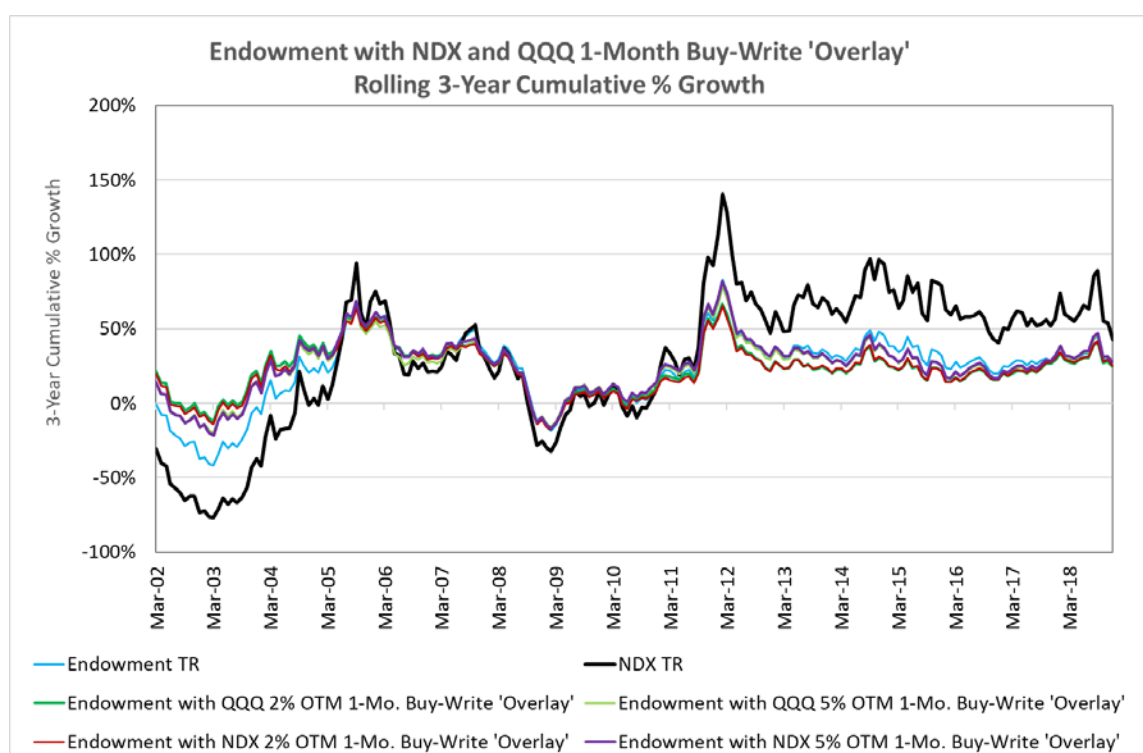
Endowment Risk Management and Return Enhancement with Listed Index and ETF Options

E. Szado, April 2019.

Please see last page for important disclosures.

Exhibit 29 illustrates the three-year rolling cumulative returns of the NDX total return index, the small endowment portfolio and the small endowment with the buy-write overlays. The exhibit clearly illustrates the reduced volatility of the buy-write overlay portfolios over the period of study. Furthermore, the exhibit illustrates the greater impact of the buy-write overlay at the start of the period when the equity allocation was larger.

Exhibit 29: Small Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Rolling 3-Year Returns Full Period — April 1999 to December 2018

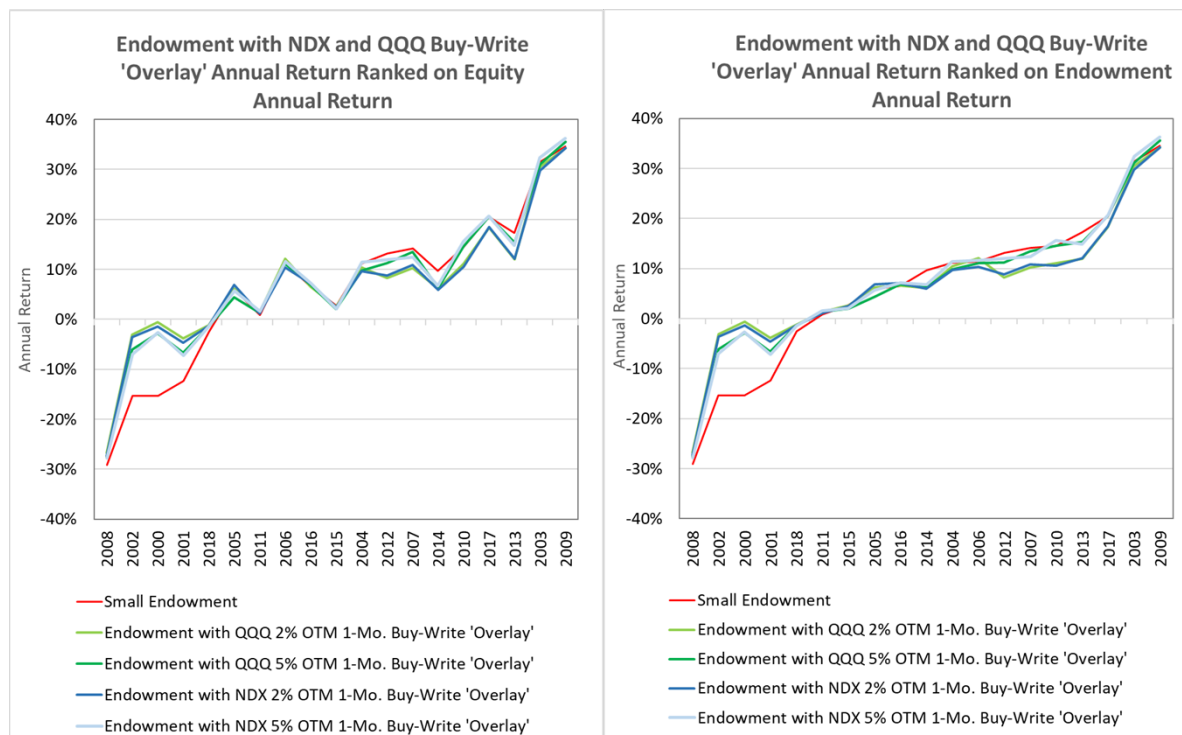


Source: Optionmetrics, Bloomberg

The following section considers the buy-write overlay performance on a year-by-year basis. Exhibits 30 and 31 illustrate annual returns of the small endowment with and without the buy-write overlays with the years sorted by the annual NDX index total

return and by the annual small endowment total return. This presentation of the data allows one to compare performance on a raw return basis across a wide range of market conditions. The left panel of Exhibit 30 and the top panel of Exhibit 31 provide the small endowment and buy-write overlay annual returns sorted on NDX returns while the right panel of Exhibit 30 and the lower panel of Exhibit 31 sort on the annual small endowment returns. The buy-write overlays generated returns that were very similar to those of the small endowment in years with extremely high or extremely low NDX and endowment returns; they tended to somewhat underperform in years with moderate positive NDX and endowment returns; and they tended to significantly outperform in moderate down years for the NDX and small endowment.

Exhibit 30: Small Endowment, 2% and 5% OTM Buy-Write Overlays
Raw Return by Year Ranked on Equity Return and Endowment Return



Source: Optionmetrics, Bloomberg

Exhibit 31: Small Endowment, 1 Mo. 2% and 5% OTM Buy-Write Overlays Raw Return by Year Ranked on Equity Return and Endowment Return

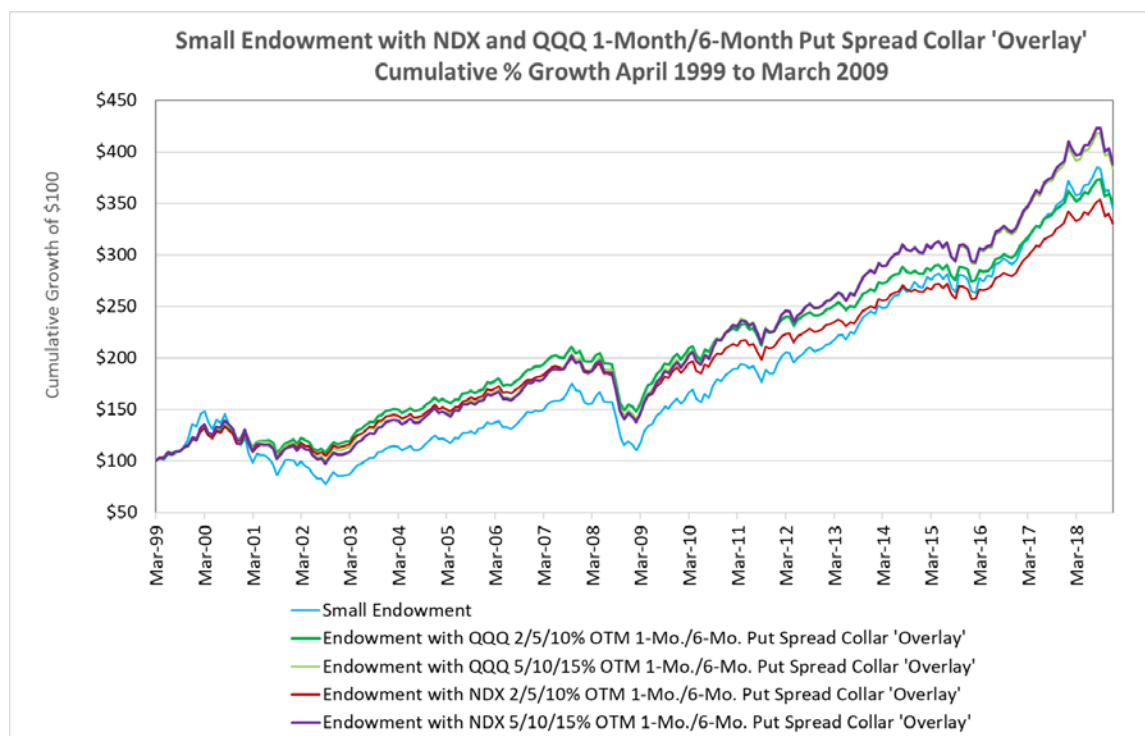
Year Sorted on Equity Return	2008	2002	2000	2001	2018	2005	2011	2006	2016	2015	2004	2012	2007	2014	2010	2017	2013	2003	2009
Small Endowment	-29%	-15%	-15%	-12%	-3%	6%	1%	11%	6%	3%	11%	13%	14%	10%	14%	20%	17%	31%	35%
Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	-27%	-3%	-1%	-4%	-1%	6%	1%	12%	7%	3%	10%	8%	10%	6%	11%	18%	12%	31%	34%
Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	-28%	-6%	-3%	-7%	-1%	4%	1%	11%	7%	2%	10%	11%	13%	6%	15%	21%	15%	31%	36%
Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	-27%	-4%	-1%	-5%	-1%	7%	1%	10%	7%	2%	10%	9%	11%	6%	11%	18%	12%	30%	34%
Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'	-28%	-7%	-3%	-7%	-1%	6%	2%	12%	7%	2%	11%	12%	12%	7%	16%	21%	15%	32%	36%
NDX TR	-42%	-38%	-37%	-33%	0%	2%	4%	7%	7%	10%	11%	18%	19%	19%	20%	33%	37%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	2%	3%	7%	7%	9%	11%	18%	19%	19%	20%	33%	37%	50%	55%

Year Sorted on Endowment Return	2008	2002	2000	2001	2018	2011	2015	2005	2016	2014	2004	2006	2012	2007	2010	2013	2017	2003	2009
Small Endowment	-29%	-15%	-15%	-12%	-3%	1%	3%	6%	6%	10%	11%	11%	13%	14%	14%	17%	20%	31%	35%
Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	-27%	-3%	-1%	-4%	-1%	1%	3%	6%	7%	6%	10%	12%	8%	10%	11%	12%	18%	31%	34%
Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	-28%	-6%	-3%	-7%	-1%	1%	2%	4%	7%	6%	10%	11%	11%	13%	15%	15%	21%	31%	36%
Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	-27%	-4%	-1%	-5%	-1%	1%	2%	7%	7%	6%	10%	10%	9%	11%	11%	12%	18%	30%	34%
Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'	-28%	-7%	-3%	-7%	-1%	2%	2%	6%	7%	7%	11%	12%	12%	12%	16%	15%	21%	32%	36%
NDX TR	-42%	-38%	-37%	-33%	0%	4%	10%	2%	7%	19%	11%	7%	18%	19%	20%	37%	33%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	3%	9%	2%	7%	19%	11%	7%	18%	19%	20%	37%	33%	50%	55%

Source: Optionmetrics, Bloomberg

This section considers the addition of put spread collar overlays to the small endowment portfolio. In the overall period, the put spread collar overlays provided mixed results from a raw return perspective. The 2%/5%/10% OTM NDX put spread collar slightly reduced returns while the corresponding QQQ put spread collar resulted in unchanged endowment returns. In contrast, both 5%/10%/15% OTM put spread collar overlays provided an increase in returns of about 50 bps. All of the put spread collar overlays reduced standard deviation (on average, they reduced standard deviation by 3%). From a risk-adjusted return perspective, the put spread collars all improved performance. On average, they increased the information ratio by 0.17 and alpha by 1.3%.

Exhibit 32: Small Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Cumulative Returns Full Period — April 1999 to December 2018



Source: Optionmetrics, Bloomberg

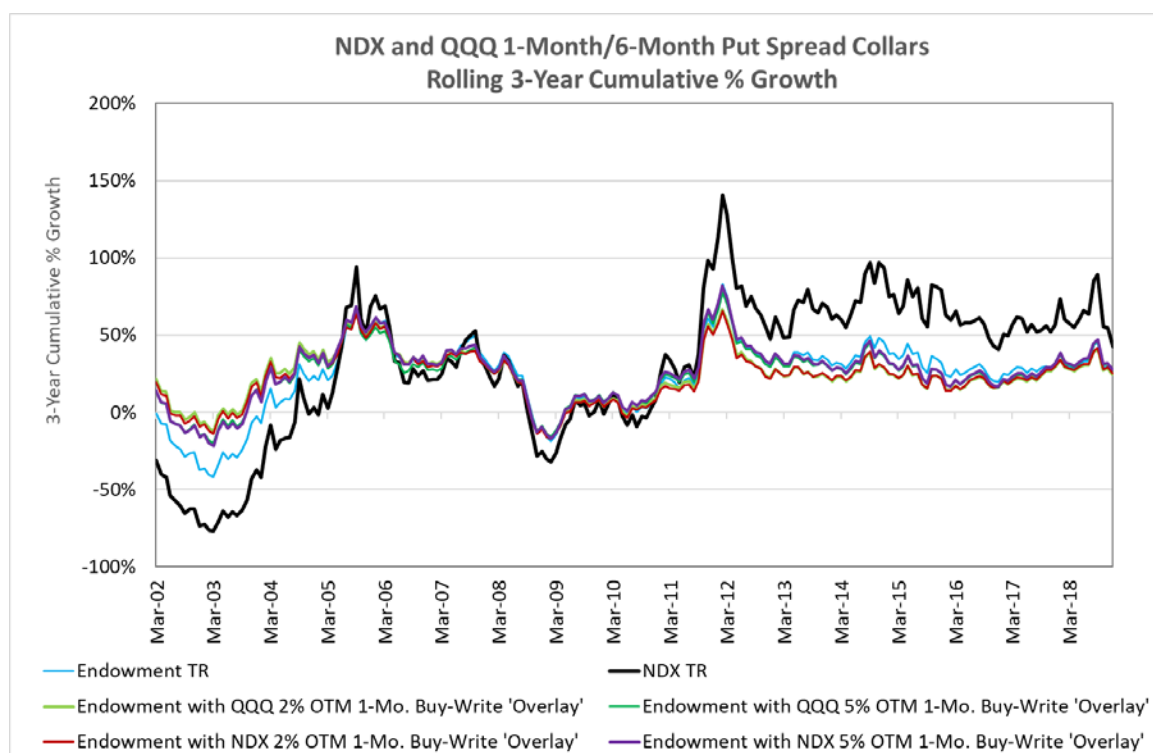
Exhibit 33: Small Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Summary Statistics Full Period — April 1999 to December 2018

April 1999 to December 2018	Small Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	6.5%	6.5%	7.0%	6.2%	7.1%
Annualized Standard Deviation	13.3%	9.5%	10.7%	9.8%	11.0%
Information Ratio	0.49	0.69	0.66	0.64	0.65
Maximum Drawdown	-48%	-30%	-31%	-31%	-32%
Skewness	-0.46	-0.81	-0.66	-0.80	-0.68
Kurtosis	1.37	2.18	1.28	2.37	1.52
Correlation w NDX	0.97	0.89	0.92	0.90	0.92
Beta wrt NDX	0.53	0.35	0.41	0.36	0.42
Alpha wrt NDX	2.2%	3.6%	3.6%	3.2%	3.6%
% Up Days	60%	64%	62%	65%	63%
% Down Days	40%	36%	38%	35%	37%
Alpha P-Value	0.001	0.000	0.000	0.001	0.000

Source: Optionmetrics, Bloomberg

Exhibit 34 illustrates the rolling three-year cumulative returns of the endowment portfolio with and without the put spread collar overlays. As with the buy-write overlays, the put spread collars reduced volatility, although the impact was larger in the early years when equity allocations were higher.

**Exhibit 34: Small Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Rolling 3-Year Returns Full Period
— April 1999 to December 2018**

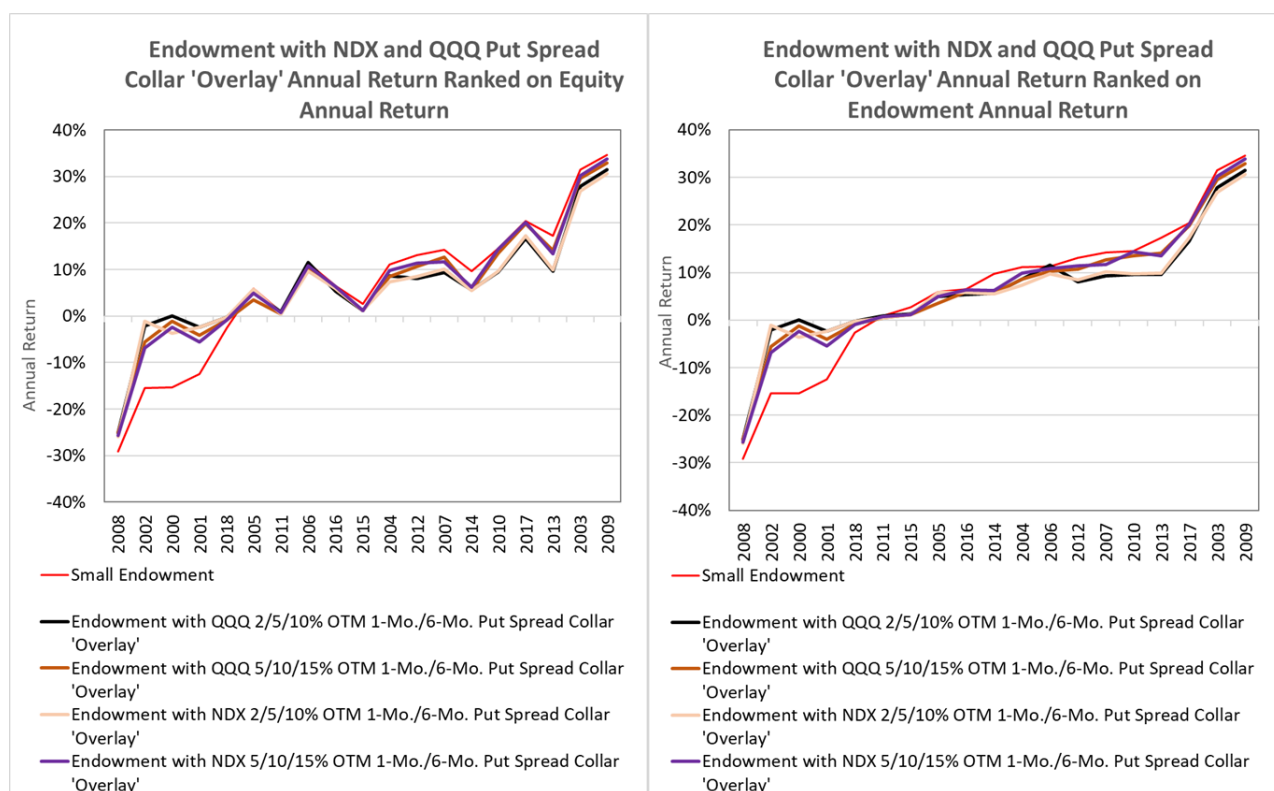


Source: Optionmetrics, Bloomberg

The following section considers the put spread collar overlay impact on a year-by-year basis. The left panel of Exhibit 35 and the top panel of Exhibit 36 provide the small endowment and put spread collar overlay annual returns sorted on NDX returns while the right panel of Exhibit 35 and the lower panel of Exhibit 36 sort on the annual small

endowment returns. Similar to the buy-write overlays, the put spread collars overlays generally had little impact on returns in years with extreme NDX and endowment gains and losses; tended to somewhat underperform in years with moderate positive NDX and endowment returns; and significantly outperformed in moderate down years for the NDX and small endowment. The impacts of the 2%/5%/10% OTM put spread collar overlays were more extreme than for the further OTM 5%/10%/15% OTM put spread collars. The further OTM put spread collar overlays provided significant loss mitigation in years of moderate (3% to 15%) small endowment losses, while reducing gains by a small amount in years with positive NDX and small endowment returns.

Exhibit 35: Small Endowment, 1Mo/6-Mo. 2/5/10% and 5/10/15% OTM Put Spread Collar Overlays Raw Return by Year Ranked on Equity Return and Endowment Return



Source: Optionmetrics, Bloomberg

Exhibit 36: Small Endowment, 1Mo/6-Mo. 2/5/10% and 5/10/15% OTM Put Spread Collar Overlays Raw Return by Year Ranked on Equity Return and Endowment Return

Year Sorted on Equity Return	2008	2002	2000	2001	2018	2005	2011	2006	2016	2015	2004	2012	2007	2014	2010	2017	2013	2003	2009
Small Endowment	-29%	-15%	-15%	-12%	-3%	6%	1%	11%	6%	3%	11%	13%	14%	10%	14%	20%	17%	31%	35%
Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-25%	-2%	0%	-2%	0%	5%	1%	12%	5%	1%	9%	8%	9%	6%	10%	17%	10%	28%	32%
Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-25%	-6%	-1%	-4%	-1%	3%	0%	10%	6%	1%	9%	11%	13%	6%	14%	20%	14%	30%	33%
Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-26%	-1%	-4%	-2%	0%	6%	0%	10%	6%	1%	7%	8%	10%	5%	10%	17%	10%	27%	31%
Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-26%	-7%	-2%	-6%	-1%	5%	1%	11%	6%	1%	10%	11%	12%	6%	14%	20%	13%	30%	34%
NDX TR	-42%	-38%	-37%	-33%	0%	2%	4%	7%	7%	10%	11%	18%	19%	19%	20%	33%	37%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	2%	3%	7%	7%	9%	11%	18%	19%	19%	20%	33%	37%	50%	55%

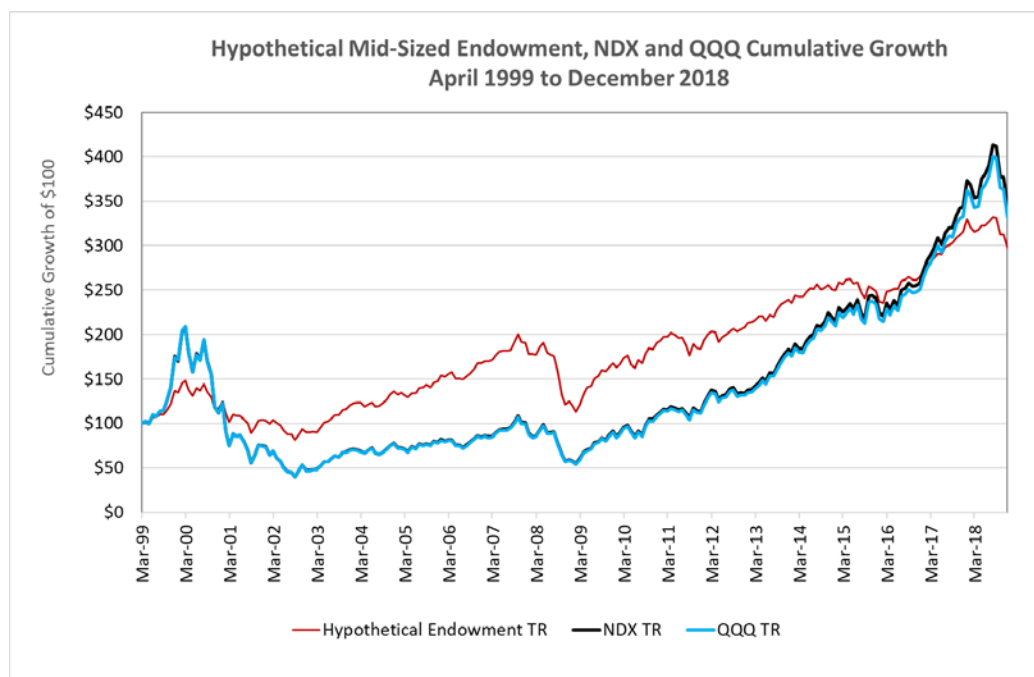
Year Sorted on Endowment Return	2008	2002	2000	2001	2018	2011	2015	2005	2016	2014	2004	2006	2012	2007	2010	2013	2017	2003	2009
Small Endowment	-29%	-15%	-15%	-12%	-3%	1%	3%	6%	6%	10%	11%	11%	13%	14%	14%	17%	20%	31%	35%
Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-25%	-2%	0%	-2%	0%	1%	1%	5%	5%	6%	9%	12%	8%	9%	10%	10%	17%	28%	32%
Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-25%	-6%	-1%	-4%	-1%	0%	1%	3%	6%	6%	9%	10%	11%	13%	14%	14%	20%	30%	33%
Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-26%	-1%	-4%	-2%	0%	0%	1%	6%	6%	5%	7%	10%	8%	10%	10%	10%	17%	27%	31%
Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-26%	-7%	-2%	-6%	-1%	1%	1%	5%	6%	6%	10%	11%	11%	12%	14%	13%	20%	30%	34%
NDX TR	-42%	-38%	-37%	-33%	0%	4%	10%	2%	7%	19%	11%	7%	18%	19%	20%	37%	33%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	3%	9%	2%	7%	19%	11%	7%	18%	19%	20%	37%	33%	50%	55%

Source: Optionmetrics, Bloomberg

Mid-Sized Endowment (\$100 to \$500 Million in Assets)

Exhibit 37 provides a graphical representation of the full-period performance of the mid-sized endowment, NDX, QQQ and the buy-write overlays. It is evident in Exhibit 37 that the mid-sized endowment outperformed the NDX and QQQ over much of the period despite its lower full-period return.

Exhibit 37: Hypothetical Mid-Sized Endowment, QQQ and NDX Cumulative Growth Full Period — April 1999 to December 2018

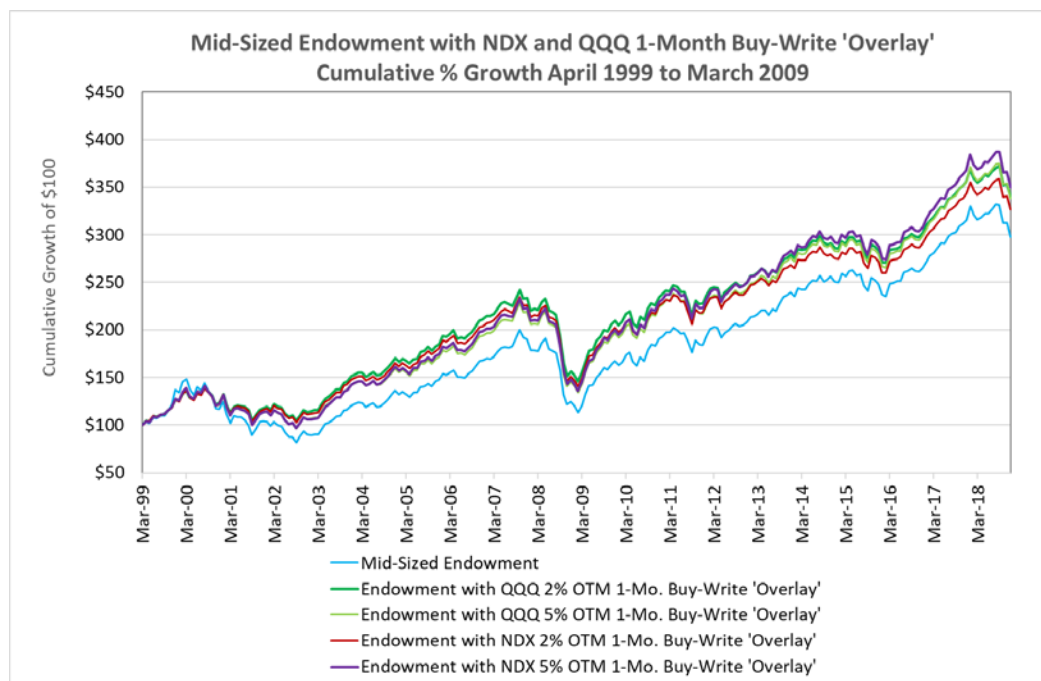


Source: Optionmetrics, Bloomberg

Exhibits 38 and 39 illustrate the theoretical performance of the hypothetical mid-sized endowment portfolio with and without the buy-write overlays for the full period from April 1999 to December 2018. The buy-write overlays all provided small increases in the annualized returns and reductions in standard deviations. On average, the buy-write overlays increased annualized returns by 70 bps, with the NDX 5% OTM buy-write providing the largest increase of 90 bps. The average decrease in standard deviation for the buy-writes was 1.6%. From a risk-adjusted return perspective, the average increase in the information ratio was 0.12 (up by about 1/4) while the average increase in alpha was

1.3% per year. Once again, the NDX and QQQ implementations performed very similarly.

Exhibit 38: Mid-Sized Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Cumulative Returns Full Period — April 1999 to December 2018



Source: Optionmetrics, Bloomberg

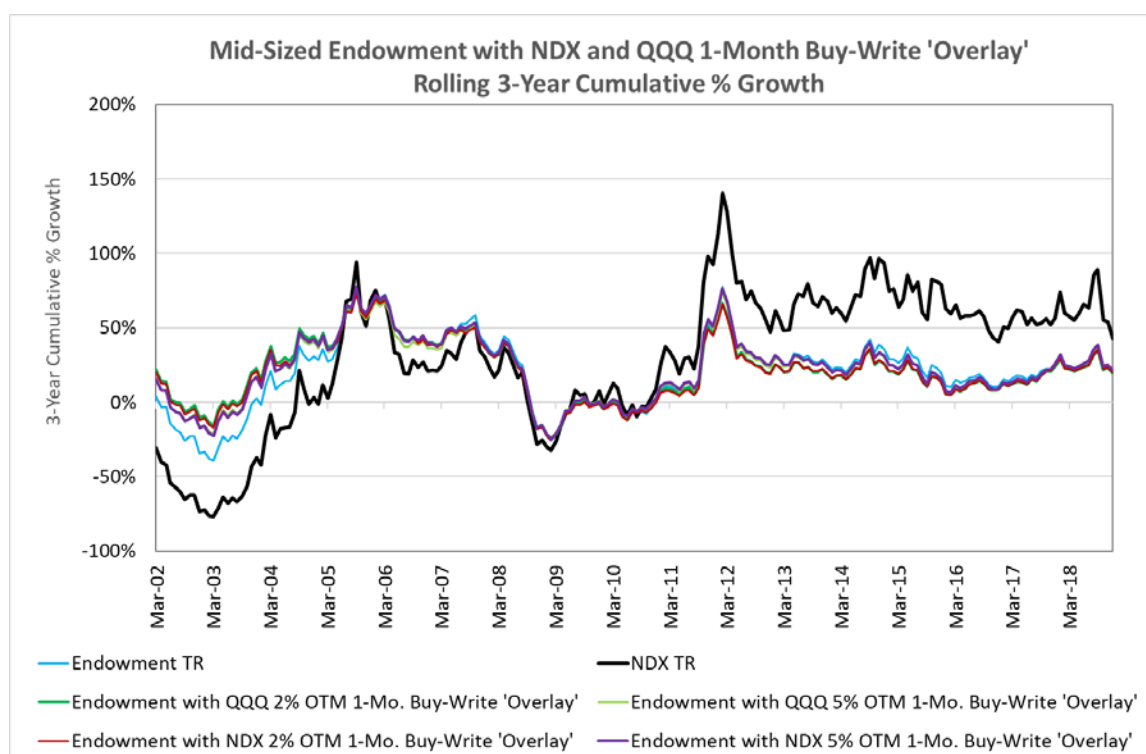
Exhibit 39: Mid-Sized Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Full Period — April 1999 to December 2018

April 1999 to December 2018	Mid-Sized Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	5.7%	6.4%	6.4%	6.2%	6.5%
Annualized Standard Deviation	13.3%	11.3%	12.0%	11.4%	12.1%
Information Ratio	0.43	0.56	0.53	0.54	0.54
Maximum Drawdown	-45%	-40%	-41%	-40%	-41%
Skewness	-0.58	-0.92	-0.81	-0.94	-0.82
Kurtosis	1.78	2.61	2.03	2.76	2.12
Correlation w NDX	0.94	0.88	0.90	0.88	0.90
Beta wrt NDX	0.52	0.41	0.44	0.41	0.45
Alpha wrt NDX	1.7%	3.1%	2.8%	2.9%	2.9%
% Up Days	60%	65%	62%	65%	63%
% Down Days	40%	35%	38%	35%	37%
Alpha P-Value	0.109	0.014	0.020	0.022	0.014

Source: Optionmetrics, Bloomberg

Exhibit 40 illustrates the three-year rolling cumulative returns of the NDX total return index, the mid-sized endowment portfolio and the mid-sized endowment with the buy-write overlays. The exhibit clearly illustrates the reduced volatility of the buy-write overlay portfolios, although the impact was greater at the start of the period when the equity allocation was larger.

Exhibit 40: Mid-Sized Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Rolling 3-Year Returns Full Period — April 1999 to December 2018

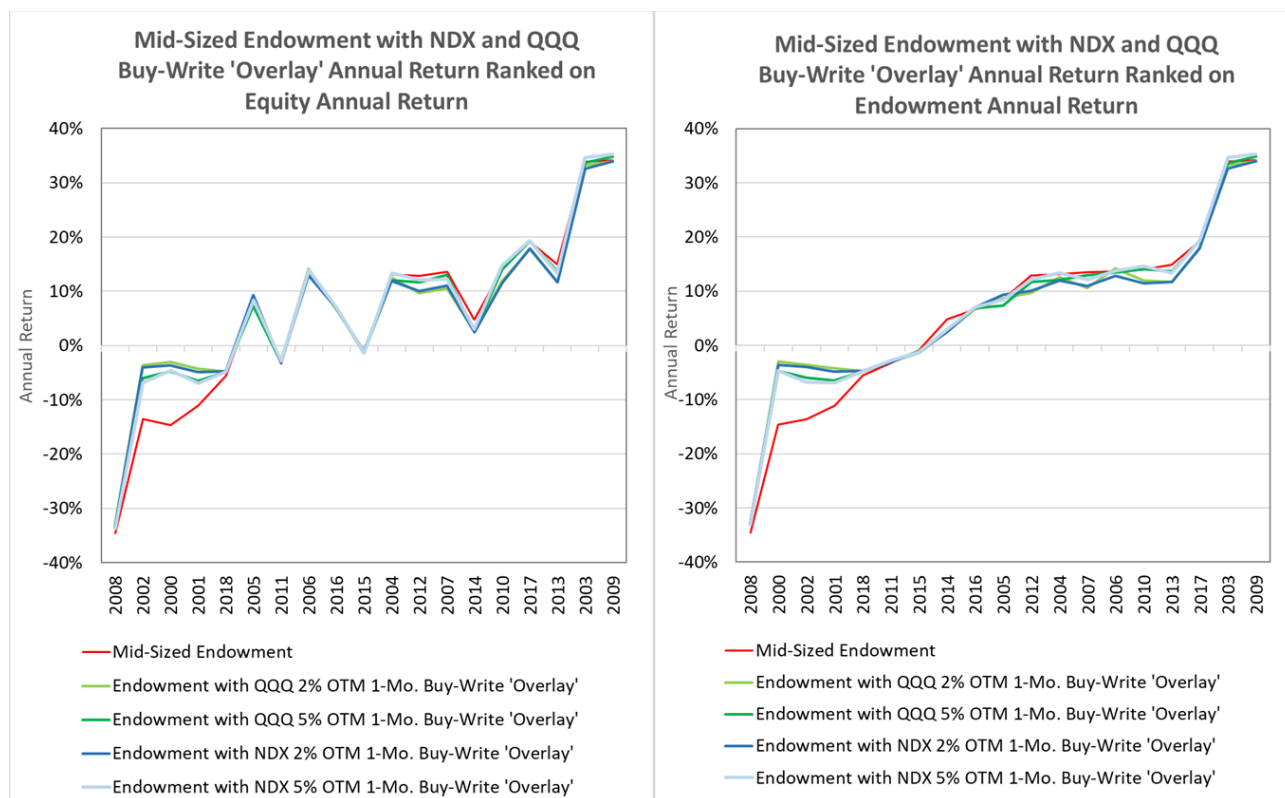


Source: Optionmetrics, Bloomberg

The following section considers the buy-write overlay performance on a year-by-year basis. Exhibits 41 and 42 illustrate annual returns of the mid-sized endowment with and without the buy-write overlays with the years sorted by the annual NDX index total

return and by the annual mid-sized endowment total return. The left panel of Exhibit 41 and the top panel of Exhibit 42 provide the mid-sized endowment and buy-write overlay annual returns sorted on NDX returns while the right panel of Exhibit 41 and the lower panel of Exhibit 42 sort on the annual mid-sized endowment returns. The buy-write overlays provided very similar returns to the mid-sized endowment in years with extremely high or extremely low NDX and endowment returns; and they somewhat underperformed in years with moderate positive NDX and endowment returns. In years of moderate NDX and mid-sized endowment losses, the buy-write overlays provided meaningful return improvements.

**Exhibit 41: Mid-Sized Endowment, 2% and 5% OTM Buy-Write Overlays
Raw Return by Year Ranked on Equity Return and Endowment Return**



Source: Optionmetrics, Bloomberg

Exhibit 42: Mid-Sized Endowment, 1 Mo. 2% and 5% OTM Buy-Write Overlays Raw Return by Year Ranked on Equity Return and Endowment Return

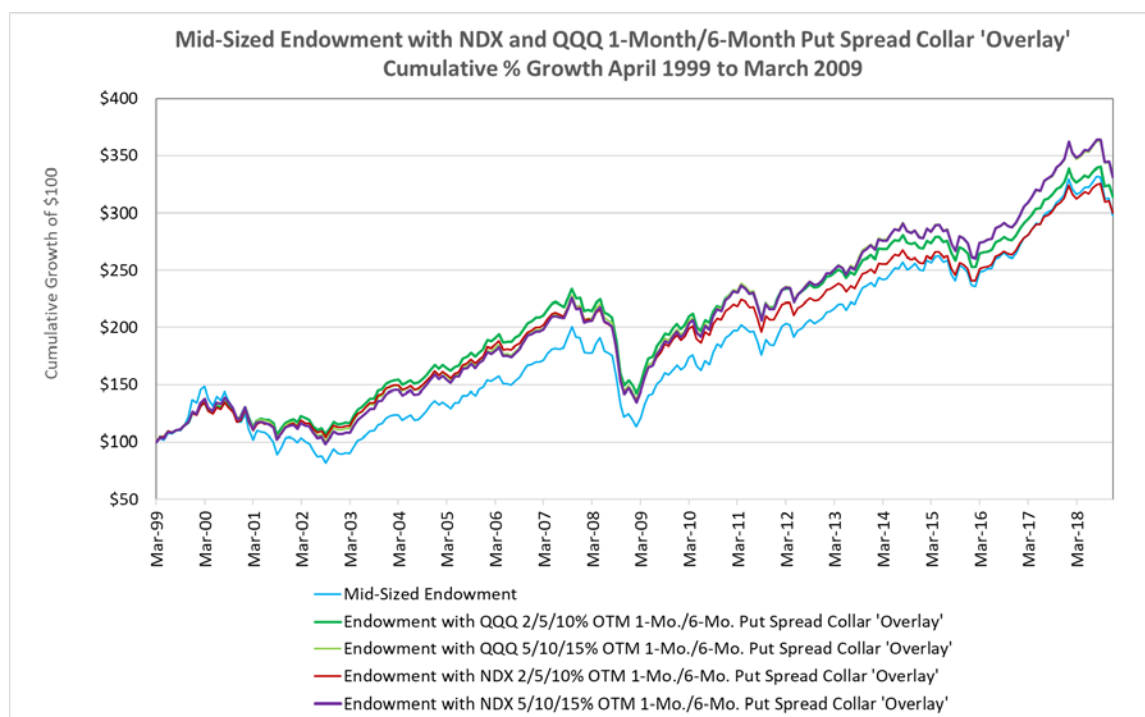
Year Sorted on Equity Return	2008	2002	2000	2001	2018	2005	2011	2006	2016	2015	2004	2012	2007	2014	2010	2017	2013	2003	2009
Mid-Sized Endowment	-35%	-14%	-15%	-11%	-6%	9%	-3%	14%	7%	-1%	13%	13%	14%	5%	14%	19%	15%	34%	34%
Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	-33%	-4%	-3%	-4%	-5%	9%	-3%	14%	7%	-1%	13%	10%	11%	3%	12%	18%	12%	33%	34%
Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	-34%	-6%	-5%	-6%	-5%	7%	-3%	13%	7%	-1%	12%	12%	13%	3%	14%	19%	14%	34%	35%
Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	-33%	-4%	-4%	-5%	-5%	9%	-3%	13%	7%	-1%	12%	10%	11%	2%	12%	18%	12%	33%	34%
Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'	-34%	-7%	-5%	-7%	-5%	8%	-3%	14%	7%	-1%	13%	12%	12%	3%	15%	19%	13%	35%	35%
NDX TR	-42%	-38%	-37%	-33%	0%	2%	4%	7%	7%	10%	11%	18%	19%	19%	20%	33%	37%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	2%	3%	7%	7%	9%	11%	18%	19%	19%	20%	33%	37%	50%	55%

Year Sorted on Endowment Return	2008	2000	2002	2001	2018	2011	2015	2014	2016	2005	2012	2004	2007	2006	2010	2013	2017	2003	2009
Mid-Sized Endowment	-35%	-15%	-14%	-11%	-6%	-3%	-1%	5%	7%	9%	13%	13%	14%	14%	14%	15%	19%	34%	34%
Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	-33%	-3%	-4%	-4%	-5%	-3%	-1%	3%	7%	9%	10%	13%	11%	14%	12%	12%	18%	33%	34%
Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	-33%	-5%	-6%	-6%	-5%	-3%	-1%	3%	7%	7%	12%	12%	13%	13%	14%	14%	19%	34%	35%
Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	-33%	-4%	-4%	-5%	-5%	-3%	-1%	2%	7%	9%	10%	12%	11%	13%	12%	12%	18%	33%	34%
Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'	-33%	-5%	-7%	-7%	-5%	-3%	-1%	3%	7%	8%	12%	13%	12%	14%	15%	13%	19%	35%	35%
NDX TR	-33%	-37%	-38%	-33%	0%	4%	10%	19%	7%	2%	18%	11%	19%	7%	20%	37%	33%	49%	55%
QQQ TR	-33%	-36%	-37%	-33%	0%	3%	9%	19%	7%	2%	18%	11%	19%	7%	20%	37%	33%	50%	55%

Source: Optionmetrics, Bloomberg

This section considers the addition of put spread collar overlays to the mid-sized endowment portfolio. In the overall period, the put spread collar overlays provided raw return improvements ranging from 0 to 60 bps, with an average return increase of 40 bps. On average, the put spread collar overlays reduced standard deviation by 2.2%. The put spread collars all improved risk-adjusted returns, increasing the information ratio by 0.12 and alpha by 1.1%, on average.

Exhibit 43: Mid-Sized Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Cumulative Returns Full Period — April 1999 to December 2018



Source: Optionmetrics, Bloomberg

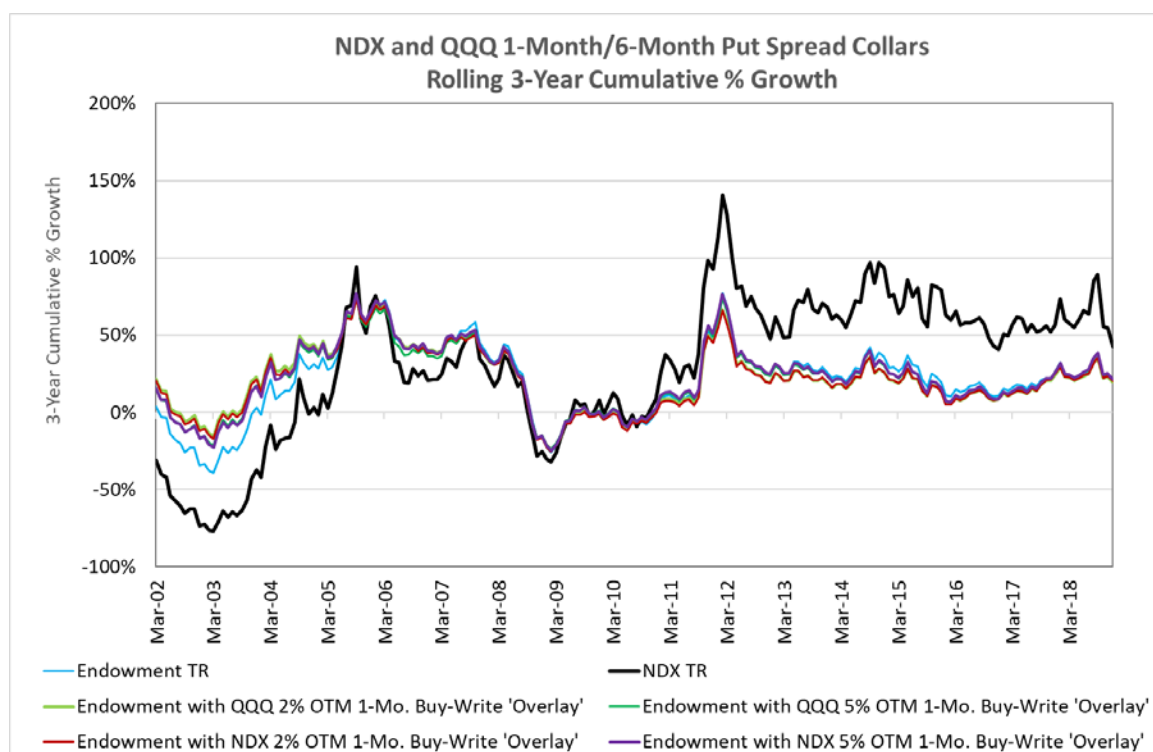
Exhibit 44: Mid-Sized Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Summary Statistics Full Period — April 1999 to December 2018

April 1999 to December 2018	Mid-Sized Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	5.7%	6.0%	6.2%	5.7%	6.3%
Annualized Standard Deviation	13.3%	10.6%	11.4%	10.8%	11.6%
Information Ratio	0.43	0.56	0.55	0.53	0.54
Maximum Drawdown	-45%	-39%	-40%	-39%	-40%
Skewness	-0.58	-0.92	-0.80	-0.91	-0.81
Kurtosis	1.78	2.86	2.10	2.86	2.16
Correlation w NDX	0.94	0.86	0.89	0.87	0.89
Beta wrt NDX	0.52	0.37	0.42	0.39	0.43
Alpha wrt NDX	1.7%	2.9%	2.9%	2.6%	2.8%
% Up Days	60%	65%	62%	64%	63%
% Down Days	40%	35%	38%	36%	37%
Alpha P-Value	0.109	0.019	0.017	0.033	0.019

Source: Optionmetrics, Bloomberg

Exhibit 45 illustrates the rolling three-year cumulative returns of the endowment portfolio with and without the put spread collar overlays. The put spread collars reduced volatility, particularly in the early years when equity allocations was higher.

Exhibit 45: Mid-Sized Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Rolling 3-Year Returns Full Period
— April 1999 to December 2018

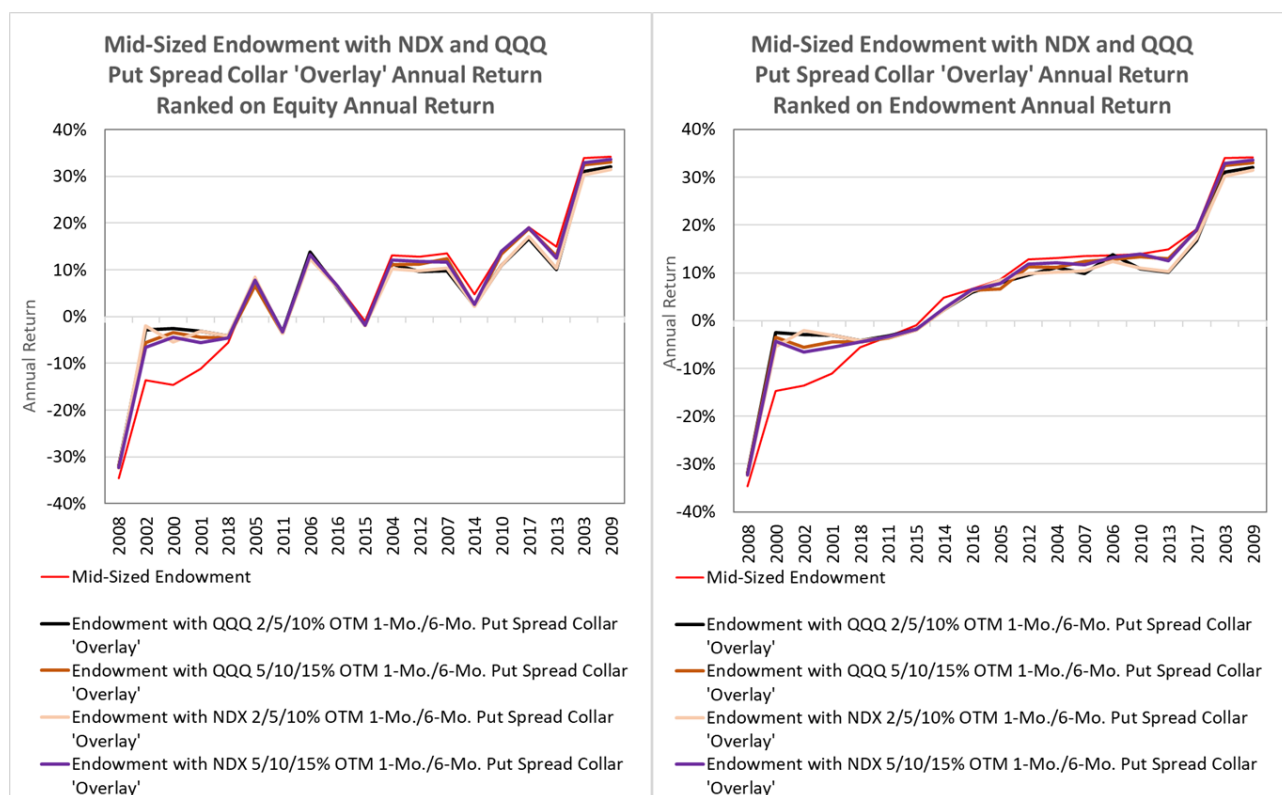


Source: Optionmetrics, Bloomberg

The following section considers the year-by-year impact of the put spread collar overlays on the mid-sized endowment. The left panel of Exhibit 46 and the top panel of Exhibit 47 provide the mid-sized endowment and put spread collar overlay annual returns sorted on NDX returns while the right panel of Exhibit 46 and the lower panel of Exhibit 47 sort on the annual mid-sized endowment returns. The put spread collars overlays provided small

return improvements in the most extreme down year (2008) for the NDX and endowment and small return reductions in the most extreme up years (2003 and 2009) for the NDX and endowment. In years of moderate losses, the put spread collars provided large improvements in returns. The put spread collars reduced returns in moderately positive return years for the NDX and mid-sized endowment. The 5%/10%/15% OTM put spread collar overlays provided significant loss mitigation in years of moderate (3% to 15%) losses, while reducing gains by a small amount in years with positive NDX and mid-sized endowment returns.

Exhibit 46: Mid-Sized Endowment, 1Mo/6-Mo. 2/5/10% and 5/10/15% OTM Put Spread Collar Overlays Raw Return by Year Ranked on Equity Return and Endowment Return



Source: Optionmetrics, Bloomberg

Exhibit 47: Mid-Sized Endowment, 1Mo/6-Mo. 2/5/10% and 5/10/15% OTM Put Spread Collar Overlays Raw Return by Year Ranked on Equity Return and Endowment Return

Year Sorted on Equity Return	2008	2002	2000	2001	2018	2005	2011	2006	2016	2015	2004	2012	2007	2014	2010	2017	2013	2003	2009
Mid-Sized Endowment	-35%	-14%	-15%	-11%	-6%	9%	-3%	14%	7%	-1%	13%	13%	14%	5%	14%	19%	15%	34%	34%
Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-3%	-3%	-3%	-4%	8%	-3%	14%	6%	-2%	11%	10%	10%	2%	11%	17%	10%	31%	32%
Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-6%	-3%	-4%	-4%	7%	-4%	13%	6%	-2%	11%	11%	12%	2%	13%	19%	13%	32%	33%
Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-2%	-5%	-3%	-4%	8%	-3%	12%	6%	-2%	10%	10%	10%	2%	11%	17%	10%	30%	32%
Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-7%	-4%	-6%	-5%	8%	-3%	13%	7%	-2%	12%	12%	12%	3%	14%	19%	13%	33%	34%
NDX TR	-42%	-38%	-37%	-33%	0%	2%	4%	7%	7%	10%	11%	18%	19%	19%	20%	33%	37%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	2%	3%	7%	7%	9%	11%	18%	19%	19%	20%	33%	37%	50%	55%

Year Sorted on Endowment Return	2008	2000	2002	2001	2018	2011	2015	2014	2016	2005	2012	2004	2007	2006	2010	2013	2017	2003	2009
Mid-Sized Endowment	-35%	-15%	-14%	-11%	-6%	-3%	-1%	5%	7%	9%	13%	13%	14%	14%	14%	15%	19%	34%	34%
Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-3%	-3%	-3%	-4%	-3%	-2%	2%	6%	8%	10%	11%	10%	14%	11%	10%	17%	31%	32%
Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-3%	-6%	-4%	-4%	-4%	-2%	2%	6%	7%	11%	11%	12%	13%	13%	13%	19%	32%	33%
Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-5%	-2%	-3%	-4%	-3%	-2%	2%	6%	8%	10%	10%	10%	12%	11%	10%	17%	30%	32%
Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-32%	-4%	-7%	-6%	-5%	-3%	-2%	3%	7%	8%	12%	12%	12%	13%	14%	13%	19%	33%	34%
NDX TR	-42%	-37%	-38%	-33%	0%	4%	10%	19%	7%	2%	18%	11%	19%	7%	20%	37%	33%	49%	55%
QQQ TR	-42%	-36%	-37%	-33%	0%	3%	9%	19%	7%	2%	18%	11%	19%	7%	20%	37%	33%	50%	55%

Source: Optionmetrics, Bloomberg

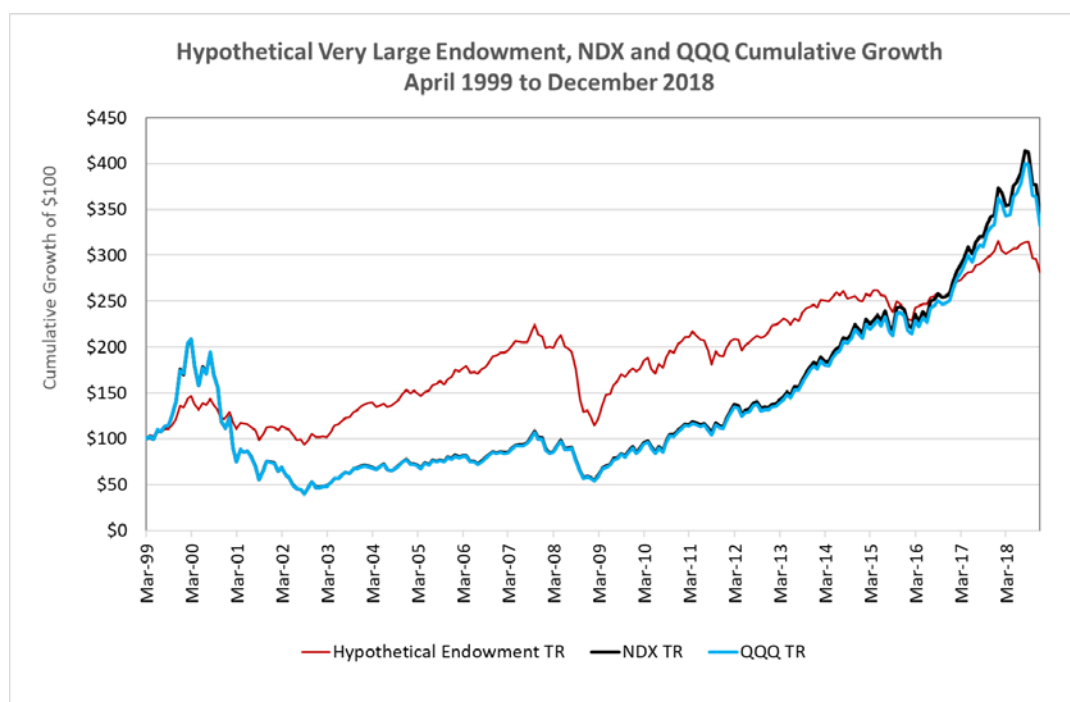
In general, the impacts of the buy-write and put spread collar overlays were greater when applied to the small endowment than for the mid-sized endowment. This is consistent with the fact that the small endowment had a larger equity allocation than the mid-sized endowment throughout the period of study. It is also consistent with the fact that the mid-sized endowment appears to have been a more diversified portfolio with greater allocations to alternative investments. Thus, the small endowment may have benefited more from risk mitigation due to its lower diversification-based risk management. The following section extends the analysis to the hypothetical very large endowment. It is

worth noting that the very large endowment had the lowest equity allocation of the three hypothetical endowments.

Very Large Endowment (\$100 to \$500 Million in Assets)

Exhibit 48 provides a graphical representation of the full-period performance of the very large endowment, NDX, QQQ and the buy-write overlays. It is evident in Exhibit 48 that as with the mid-sized endowment, the very large endowment outperformed the NDX and QQQ over much of the period while exhibiting a lower full-period return.

Exhibit 48: Hypothetical Very Large Endowment, QQQ and NDX Cumulative Growth Full Period — April 1999 to December 2018

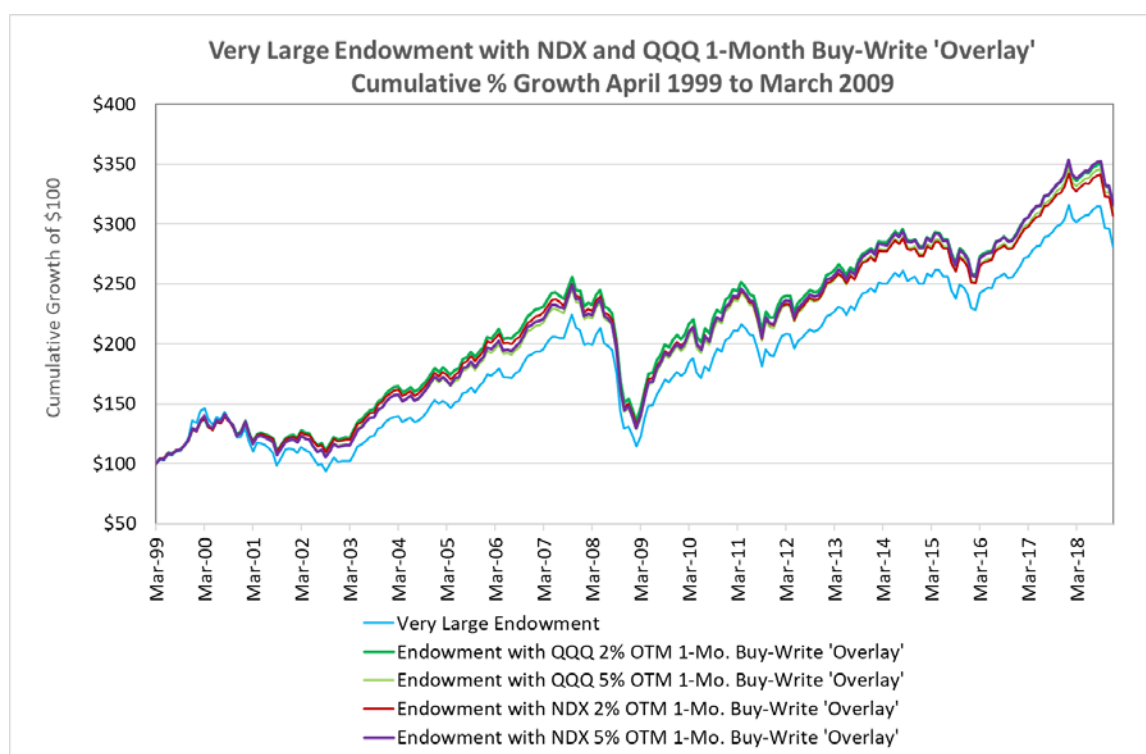


Source: Optionmetrics, Bloomberg

Exhibits 49 and 50 illustrate the performance of the hypothetical very large endowment portfolio with and without the buy-write overlays for the full period from April 1999 to December 2018. As with the small and mid-sized endowments, for the very large

endowments the buy-write overlays all provided small increases in annualized returns and reductions in standard deviations. On average, the buy-write overlays increased annualized returns by 60 bps. The average decrease in standard deviation for the buy-writes was 1.0%. The buy-writes also increased risk-adjusted returns. The average increase in the information ratio was 0.08, while the average increase in alpha was 1.0% per year. Once again, the NDX and QQQ implementations performed very similarly.

Exhibit 49: Very Large Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Cumulative Returns Full Period — April 1999 to December 2018



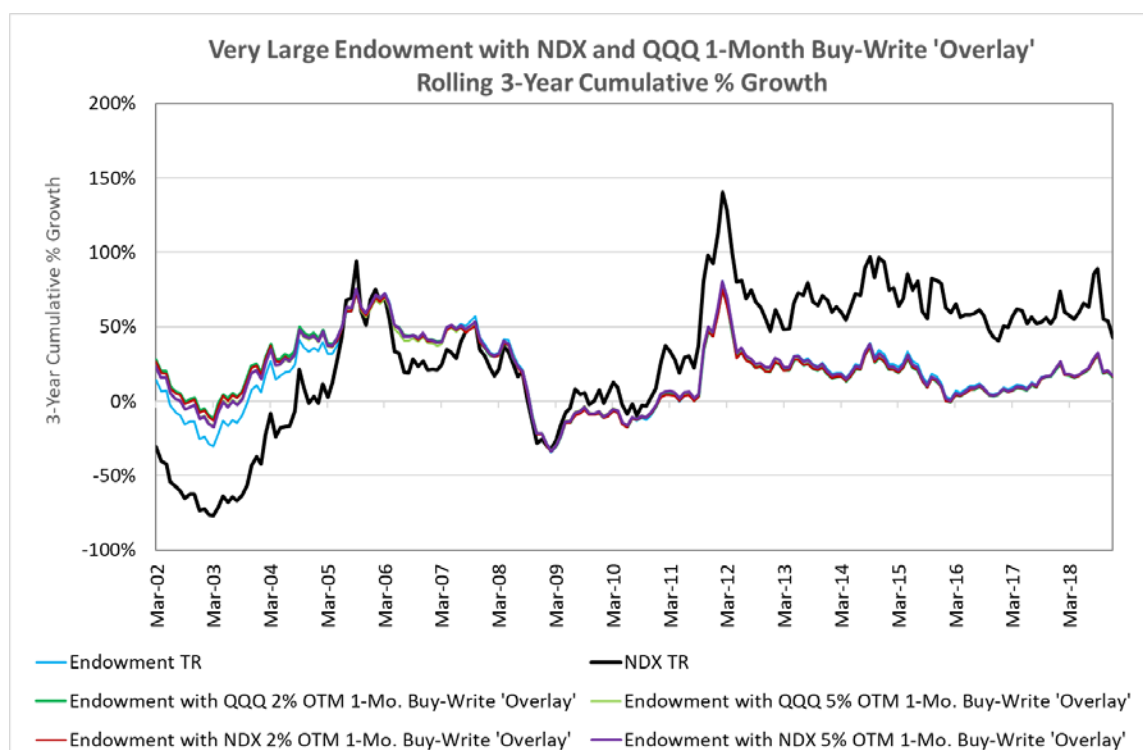
Source: Optionmetrics, Bloomberg

Exhibit 50: Very Large Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Full Period — April 1999 to December 2018

April 1999 to December 2018	Very Large Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	5.4%	6.0%	5.9%	5.9%	6.0%
Annualized Standard Deviation	13.1%	11.8%	12.3%	11.9%	12.3%
Information Ratio	0.41	0.51	0.48	0.49	0.49
Maximum Drawdown	-49%	-47%	-48%	-47%	-48%
Skewness	-0.66	-0.91	-0.84	-0.92	-0.84
Kurtosis	2.64	3.49	3.05	3.60	3.10
Correlation w NDX	0.88	0.83	0.84	0.83	0.85
Beta wrt NDX	0.48	0.40	0.43	0.40	0.43
Alpha wrt NDX	1.7%	2.8%	2.6%	2.7%	2.6%
% Up Days	61%	62%	62%	62%	62%
% Down Days	39%	38%	38%	38%	38%
Alpha P-Value	0.223	0.064	0.086	0.079	0.078

Source: Optionmetrics, Bloomberg

Exhibit 51: Very Large Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Rolling 3-Year Returns Full Period — April 1999 to December 2018



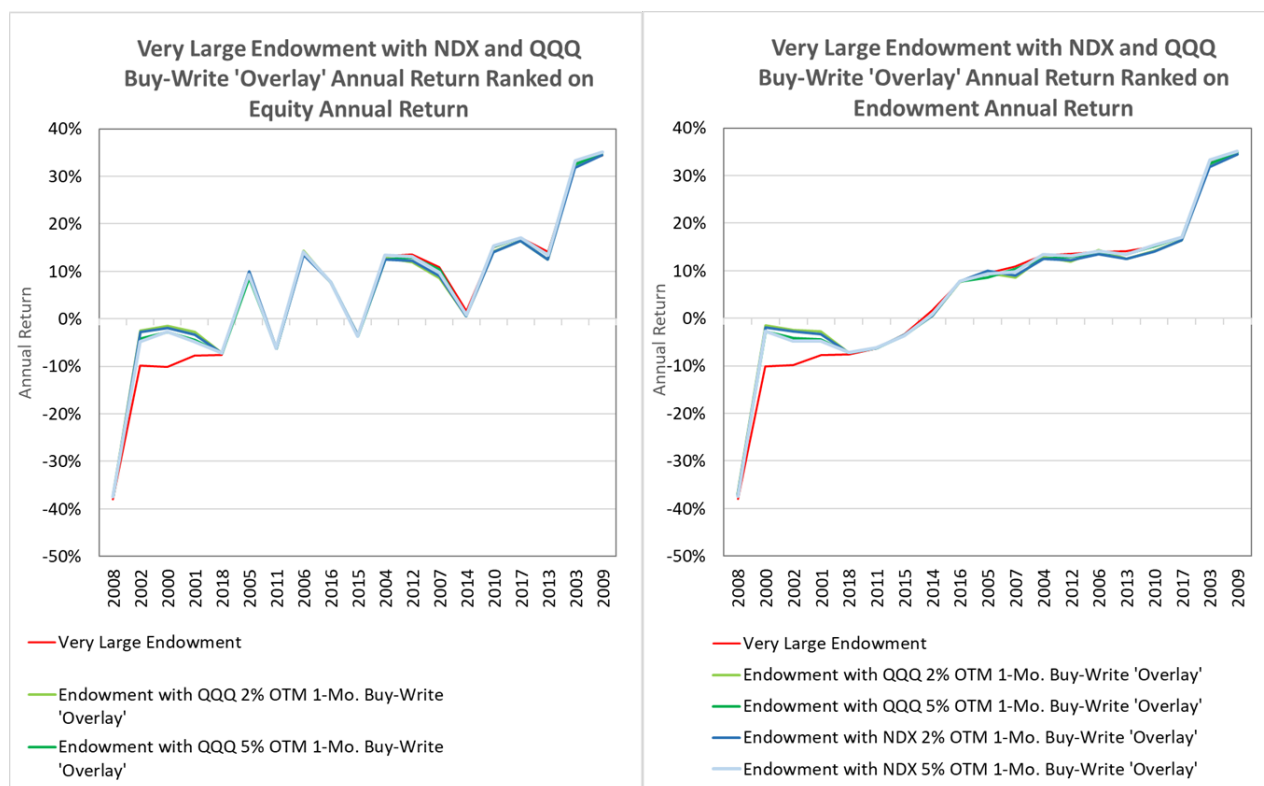
Source: Optionmetrics, Bloomberg

Exhibit 51 illustrates the three-year rolling cumulative return of the NDX total return index, the very large endowment portfolio and the very large endowment with the buy-

write overlays. The exhibit clearly illustrates the reduced volatility of the buy-write overlay portfolios. However, the difference essentially disappeared at the end of the period when the equity allocation diminished.

The following section considers the theoretical buy-write overlay performance on a year-by-year basis. Exhibits 52 and 53 illustrate annual returns of the very large endowment with and without the buy-write overlays with the years sorted by the annual NDX index total return and by the annual very large endowment total return.

Exhibit 52: Very Large Endowment, 2% and 5% OTM Buy-Write Overlays Raw Return by Year Ranked on Equity Return and Endowment Return



Source: Optionmetrics, Bloomberg

The left panel of Exhibit 52 and the top panel of Exhibit 53 provide the very large endowment and buy-write overlay annual returns sorted on NDX returns while the right panel of Exhibit 52 and the lower panel of Exhibit 53 sort on the annual very large endowment returns. The buy-write overlays provided very similar returns to the very large endowment in most years. However, in the years 2000 to 2002, in which the very large endowment lost 8% to 10% per year and the NDX index lost 33% to 37% per year, the buy-write overlays provided meaningful improvements in returns of 3% to 9% per year.

Exhibit 53: Very Large Endowment, 1 Mo. 2% and 5% OTM Buy-Write Overlays Raw Return by Year Ranked on Equity Return and Endowment Return

Year Sorted on Equity Return	2008	2002	2000	2001	2018	2005	2011	2006	2016	2015	2004	2012	2007	2014	2010	2017	2013	2003	2009
Very Large Endowment	-38%	-10%	-10%	-8%	-8%	9%	-6%	14%	8%	-3%	13%	14%	11%	2%	15%	17%	14%	33%	34%
Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-2%	-1%	-3%	-7%	10%	-6%	14%	8%	-3%	13%	12%	9%	1%	14%	16%	13%	32%	34%
Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-4%	-3%	-4%	-7%	9%	-6%	14%	8%	-4%	13%	13%	10%	1%	15%	17%	13%	33%	35%
Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-3%	-2%	-3%	-7%	10%	-6%	13%	8%	-4%	12%	12%	9%	1%	14%	16%	13%	32%	34%
Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-5%	-3%	-5%	-7%	9%	-6%	14%	8%	-4%	13%	13%	10%	1%	15%	17%	13%	33%	35%
NDX TR	-42%	-38%	-37%	-33%	0%	2%	4%	7%	7%	10%	11%	18%	19%	19%	20%	33%	37%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	2%	3%	7%	7%	9%	11%	18%	19%	19%	20%	33%	37%	50%	55%

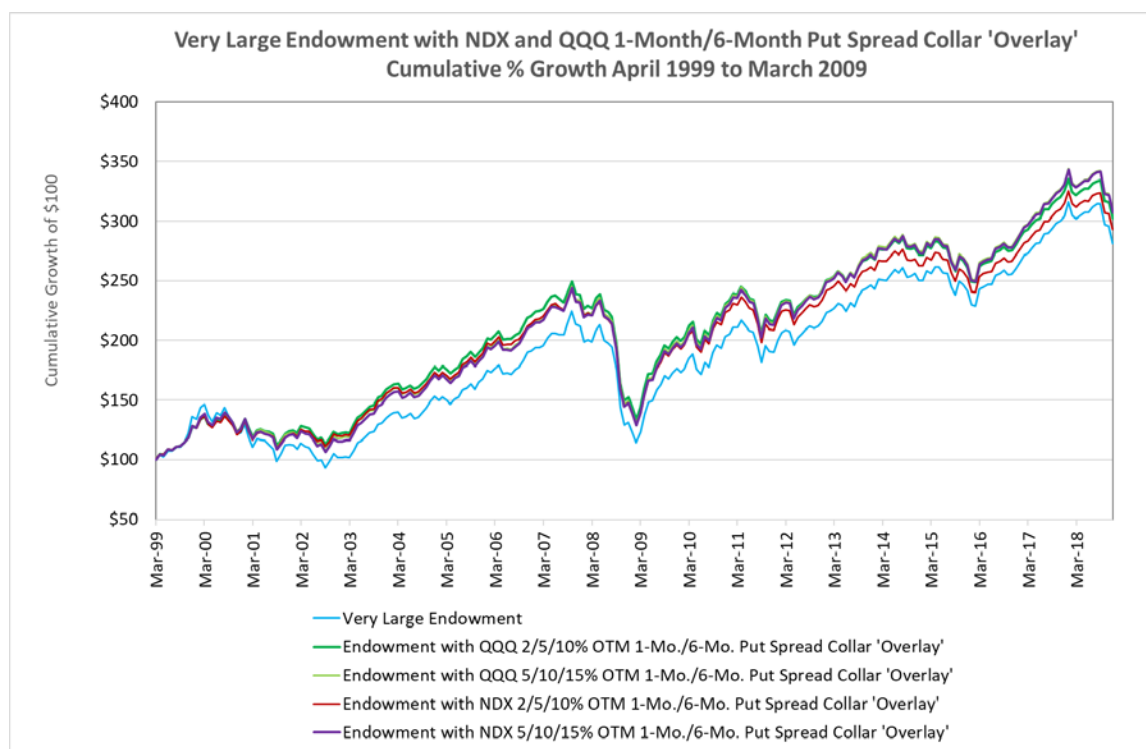
Year Sorted on Endowment Return	2008	2000	2002	2001	2018	2011	2015	2014	2016	2005	2007	2004	2012	2006	2013	2010	2017	2003	2009
Very Large Endowment	-38%	-10%	-10%	-8%	-8%	-6%	-3%	2%	8%	9%	11%	13%	14%	14%	14%	15%	17%	33%	34%
Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-1%	-2%	-3%	-7%	-6%	-3%	1%	8%	10%	9%	13%	12%	14%	13%	14%	16%	32%	34%
Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-3%	-4%	-4%	-7%	-6%	-4%	1%	8%	9%	10%	13%	13%	14%	13%	15%	17%	33%	35%
Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-2%	-3%	-3%	-7%	-6%	-4%	1%	8%	10%	9%	12%	12%	13%	13%	14%	16%	32%	34%
Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'	-37%	-3%	-5%	-5%	-7%	-6%	-4%	1%	8%	9%	10%	13%	13%	14%	13%	15%	17%	33%	35%
NDX TR	-42%	-37%	-38%	-33%	0%	4%	10%	19%	7%	2%	19%	11%	18%	7%	37%	20%	33%	49%	55%
QQQ TR	-42%	-36%	-37%	-33%	0%	3%	9%	19%	7%	2%	19%	11%	18%	7%	37%	20%	33%	50%	55%

Source: Optionmetrics, Bloomberg

We now consider the addition of put spread collar overlays to the very large endowment portfolio. In the overall period, the put spread collar overlays provided small raw return improvements, averaging 40 bps. On average, the put spread collar overlays reduced

standard deviation by 1.4%. The put spread collars improved risk-adjusted returns, increasing the information ratio by 0.08 and alpha by 0.9%, on average.

Exhibit 54: Very Large Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Cumulative Returns Full Period — April 1999 to December 2018



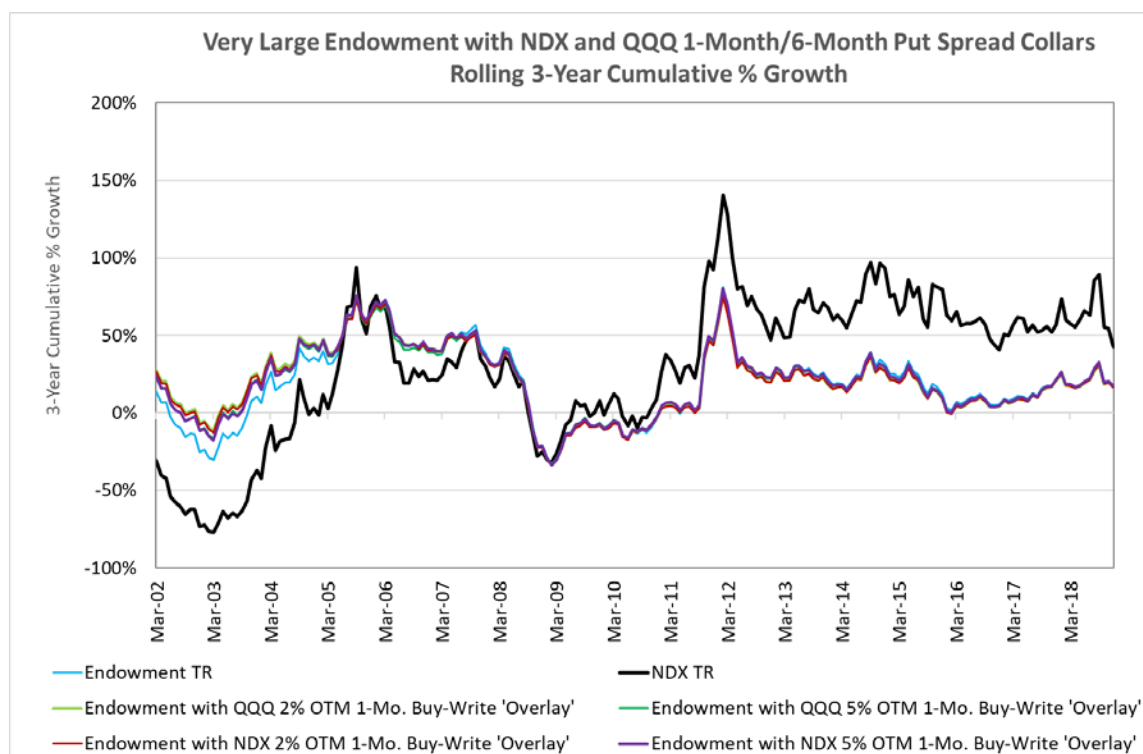
Source: Optionmetrics, Bloomberg

Exhibit 55: Very Large Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Summary Statistics Full Period — April 1999 to December 2018

April 1999 to December 2018	Very Large Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	5.4%	5.8%	5.9%	5.6%	5.8%
Annualized Standard Deviation	13.1%	11.4%	11.9%	11.5%	12.0%
Information Ratio	0.41	0.51	0.49	0.49	0.49
Maximum Drawdown	-49%	-46%	-47%	-47%	-47%
Skewness	-0.66	-0.90	-0.83	-0.89	-0.83
Kurtosis	2.64	3.74	3.18	3.67	3.17
Correlation w NDX	0.88	0.81	0.83	0.82	0.84
Beta wrt NDX	0.48	0.38	0.41	0.39	0.41
Alpha wrt NDX	1.7%	2.8%	2.7%	2.5%	2.6%
% Up Days	61%	62%	62%	62%	62%
% Down Days	39%	38%	38%	38%	38%
Alpha P-Value	0.223	0.070	0.077	0.093	0.084

Source: Optionmetrics, Bloomberg

Exhibit 56: Very Large Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Rolling 3-Year Returns Full Period — April 1999 to December 2018

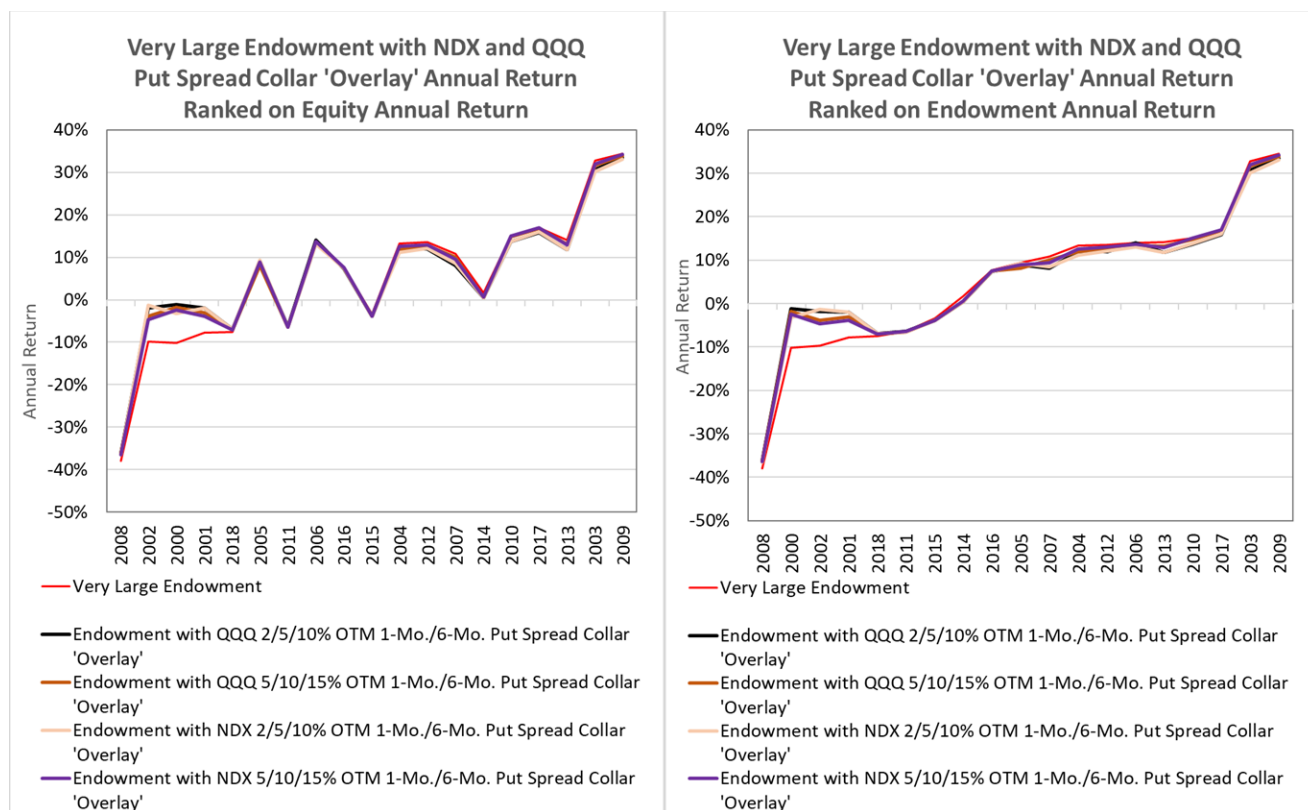


Source: Optionmetrics, Bloomberg

Exhibit 56 illustrates the rolling three-year cumulative returns of the very large endowment portfolio with and without the put spread collar overlays. The put spread collars reduced volatility, although this was only evident in the early years when equity allocations were higher.

The following section considers the year-by-year impact of the put spread collar overlays on the very large endowment.

Exhibit 57: Very Large Endowment, 1Mo/6-Mo. 2/5/10% and 5/10/15% OTM Put Spread Collar Overlays Raw Return by Year Ranked on Equity Return and Endowment Return



Source: Optionmetrics, Bloomberg

The left panel of Exhibit 57 and the top panel of Exhibit 58 provide the very large endowment and put spread collar overlay annual returns sorted on NDX returns while the right panel of Exhibit 57 and the lower panel of Exhibit 58 sort on the annual very large endowment returns. As with the buy-write overlays, the performance of the put spread collar overlays was very similar to that of the very large endowment in all years except 2000 to 2002, in which the endowment and the NDX index both experienced large losses. In those years, the put spread collar overlays provided 4% to 9% higher returns than the endowment.

Exhibit 58: Very Large Endowment, 1Mo/6-Mo. 2/5/10% and 5/10/15% OTM Put Spread Collar Overlays Raw Return by Year Ranked on Equity Return and Endowment Return

Year Sorted on Equity Return	2008	2002	2000	2001	2018	2005	2011	2006	2016	2015	2004	2012	2007	2014	2010	2017	2013	2003	2009
Very Large Endowment	-38%	-10%	-10%	-8%	-8%	9%	-6%	14%	8%	-3%	13%	14%	11%	2%	15%	17%	14%	33%	34%
Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-36%	-2%	-1%	-2%	-7%	9%	-6%	14%	7%	-4%	12%	12%	8%	0%	14%	16%	12%	31%	33%
Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-36%	-4%	-2%	-3%	-7%	8%	-6%	13%	7%	-4%	12%	13%	10%	0%	15%	17%	13%	32%	34%
Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-37%	-1%	-3%	-2%	-7%	9%	-6%	13%	7%	-4%	11%	12%	9%	0%	14%	16%	12%	30%	33%
Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-36%	-5%	-2%	-4%	-7%	9%	-6%	14%	8%	-4%	13%	13%	9%	1%	15%	17%	13%	32%	34%
NDX TR	-42%	-38%	-37%	-33%	0%	2%	4%	7%	7%	10%	11%	18%	19%	19%	20%	33%	37%	49%	55%
QQQ TR	-42%	-37%	-36%	-33%	0%	2%	3%	7%	7%	9%	11%	18%	19%	19%	20%	33%	37%	50%	55%
Year Sorted on Endowment Return	2008	2000	2002	2001	2018	2011	2015	2014	2016	2005	2007	2004	2012	2006	2013	2010	2017	2003	2009
Very Large Endowment	-38%	-10%	-10%	-8%	-8%	-6%	-3%	2%	8%	9%	11%	13%	14%	14%	14%	15%	17%	33%	34%
Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-36%	-1%	-2%	-2%	-7%	-6%	-4%	0%	7%	9%	8%	12%	12%	14%	12%	14%	16%	31%	33%
Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-36%	-2%	-4%	-3%	-7%	-6%	-4%	0%	7%	8%	10%	12%	13%	13%	13%	15%	17%	32%	34%
Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-37%	-3%	-1%	-2%	-7%	-6%	-4%	0%	7%	9%	9%	11%	12%	13%	12%	14%	16%	30%	33%
Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	-36%	-2%	-5%	-4%	-7%	-6%	-4%	1%	8%	9%	9%	13%	13%	14%	13%	15%	17%	32%	34%
NDX TR	-42%	-37%	-38%	-33%	0%	4%	10%	19%	7%	2%	19%	11%	18%	7%	37%	20%	33%	49%	55%
QQQ TR	-42%	-36%	-37%	-33%	0%	3%	9%	19%	7%	2%	19%	11%	18%	7%	37%	20%	33%	50%	55%

Source: Optionmetrics, Bloomberg

In general, the impacts of the buy-write and put spread collar overlays were greatest for the small endowment and least for the very large endowment. This is consistent with the fact that the small endowment had the highest equity allocation, while the very large endowment had the smallest equity allocation throughout the period of study. It is also consistent with the fact that the degree of diversification (and use of alternative investments) increased with endowment size, suggesting that the small endowment may have had the most potential to benefit from the risk mitigation provided by the options overlays.

The appendix provides an analysis of endowment-based option overlay performance in the best and worst three-year periods for the NDX index.

Conclusions

Over the almost 20-year period covered in the study, the buy-write and put spread collar strategies provided meaningful risk reduction and return enhancement benefits to standalone equity positions. The performance of the NDX and QQQ strategies were very similar to one another with no clear outperformer, suggesting that the choice between the two for any investor may be largely driven by the differing option specifications and their fit with the investor's particular needs or circumstances.

While the improvements provided by theoretical buy-write and put spread collar overlays to small, mid-sized and very large hypothetical endowment portfolios were smaller than the impacts when applied to an equity portfolio, they were meaningful and positive. In almost all cases, raw returns increased, standard deviations and maximum drawdowns

deceased and risk-adjusted returns improved. On a year-by-year basis, it appears that the largest impact of the option overlays occurred in years in which the equity market (NDX index) and the endowments experienced moderate to high losses. This is particularly the case for the very large endowment where the overlays had very little impact in up years and in the worst year (2008) for the very large endowment and the NDX index, although they significantly reduced losses in 2000 through 2002.

Ultimately, the results of the study suggest that buy-write and put spread collar strategies may be able to provide meaningful benefits to small, mid-sized and very large endowments at the margin when applied passively. Further benefits may be possible when applied in an active manner since skilled portfolio managers may be able to add alpha in the equity portion of the portfolio as well as in the option overlay.

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Appendix: Endowment Performance with and without Buy-Write and Put Spread Collar Overlays Best and Worst 3-Year Period for Equity

The following exhibits illustrate the performance of the small, mid-size and very large endowments with and without option overlays over the best and worst three-year periods for the NDX index over the period of study.

In Exhibit 59, it is clear that, in the best three-year period for the NDX index over the period of study, the buy-write overlay reduced the raw return of the small endowment portfolio while simultaneously reducing standard deviation. The results for risk-adjusted returns were mixed. The 2% OTM buy-write overlays slightly decreased alphas while the 5% OTM buy-write overlays increased alphas. In the worst three-year period for the equity market over the period of study the buy-write overlays increased returns and reduced risk, although alphas were reduced by the 2% OTM buy-write overlays. As illustrated in Exhibit 60, the put spread collar overlays for the small endowment provided similar results to the buy-write overlays.

Exhibit 59: Small Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Best and Worst 3-Year Period for Equity

April 2009 to March 2012	Small Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	20.5%	16.7%	19.4%	16.3%	20.1%
Annualized Standard Deviation	12.0%	10.3%	11.1%	10.2%	11.2%
Information Ratio	1.71	1.62	1.75	1.59	1.80
Maximum Drawdown	-9%	-9%	-10%	-9%	-9%
Skewness	0.06	-0.15	-0.20	-0.18	-0.18
Kurtosis	-0.43	-0.35	-0.49	-0.27	-0.51
Correlation w NDX	0.97	0.93	0.96	0.93	0.96
Beta wrt NDX	0.62	0.52	0.57	0.51	0.58
Alpha wrt NDX	1.0%	0.8%	1.7%	0.7%	2.1%
% Up Days	69%	69%	67%	69%	67%
% Down Days	31%	31%	33%	31%	33%
Alpha P-Value	0.569	0.740	0.429	0.782	0.301

April 2006 to March 2009	Small Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	-5.1%	-4.4%	-4.1%	-4.7%	-4.4%
Annualized Standard Deviation	14.7%	12.9%	14.0%	13.0%	14.0%
Information Ratio	-0.35	-0.34	-0.29	-0.36	-0.32
Maximum Drawdown	-37%	-31%	-33%	-32%	-34%
Skewness	-1.09	-1.32	-1.12	-1.33	-1.12
Kurtosis	1.33	2.02	1.38	2.36	1.56
Correlation w NDX	0.98	0.95	0.97	0.95	0.96
Beta wrt NDX	0.65	0.55	0.61	0.56	0.61
Alpha wrt NDX	0.8%	0.6%	1.4%	0.3%	1.1%
% Up Days	56%	61%	58%	61%	56%
% Down Days	44%	39%	42%	39%	44%
Alpha P-Value	0.677	0.818	0.501	0.910	0.613

Source: Optionmetrics, Bloomberg

Exhibit 60: Small Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Summary Statistics Best and Worst 3-Year Period for Equity

April 2009 to March 2012	Small Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	20.5%	15.5%	18.1%	15.0%	18.9%
Annualized Standard Deviation	12.0%	9.7%	10.6%	9.5%	10.7%
Information Ratio	1.71	1.60	1.72	1.58	1.77
Maximum Drawdown	-9%	-9%	-10%	-9%	-9%
Skewness	0.06	-0.16	-0.26	-0.19	-0.21
Kurtosis	-0.43	-0.26	-0.51	-0.28	-0.50
Correlation w NDX	0.97	0.92	0.95	0.92	0.95
Beta wrt NDX	0.62	0.48	0.54	0.47	0.55
Alpha wrt NDX	1.0%	0.9%	1.4%	0.7%	1.9%
% Up Days	69%	69%	67%	69%	67%
% Down Days	31%	31%	33%	31%	33%
Alpha P-Value	0.569	0.729	0.510	0.781	0.371

April 2006 to March 2009	Small Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	-5.1%	-4.4%	-3.7%	-4.9%	-4.1%
Annualized Standard Deviation	14.7%	11.9%	13.2%	11.9%	13.2%
Information Ratio	-0.35	-0.37	-0.28	-0.41	-0.31
Maximum Drawdown	-37%	-30%	-31%	-31%	-32%
Skewness	-1.09	-1.41	-1.21	-1.39	-1.18
Kurtosis	1.33	2.53	1.73	2.66	1.70
Correlation w NDX	0.98	0.93	0.96	0.94	0.96
Beta wrt NDX	0.65	0.50	0.57	0.50	0.57
Alpha wrt NDX	0.8%	0.1%	1.4%	-0.4%	1.1%
% Up Days	56%	58%	56%	58%	56%
% Down Days	44%	42%	44%	42%	44%
Alpha P-Value	0.677	0.969	0.521	0.872	0.631

Source: Optionmetrics, Bloomberg

As illustrated in Exhibits 61 through 68, the results for the mid-sized and very large endowments in the best and worst three-year periods for the NDX index were generally similar to those of the small endowment.

Exhibit 61: Mid-Sized Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Best and Worst 3-Year Period for Equity

April 2009 to March 2012	Mid-Sized Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	18.9%	16.5%	18.2%	16.2%	18.7%
Annualized Standard Deviation	12.9%	11.8%	12.3%	11.7%	12.4%
Information Ratio	1.47	1.39	1.48	1.38	1.51
Maximum Drawdown	-13%	-13%	-13%	-13%	-13%
Skewness	-0.02	-0.16	-0.19	-0.17	-0.17
Kurtosis	-0.29	-0.20	-0.30	-0.17	-0.32
Correlation w NDX	0.94	0.91	0.93	0.91	0.93
Beta wrt NDX	0.65	0.58	0.61	0.57	0.62
Alpha wrt NDX	-0.9%	-1.1%	-0.5%	-1.1%	-0.2%
% Up Days	67%	67%	64%	67%	64%
% Down Days	33%	33%	36%	33%	36%
Alpha P-Value	0.757	0.738	0.873	0.724	0.945

April 2006 to March 2009	Mid-Sized Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	-8.0%	-7.6%	-7.3%	-7.8%	-7.5%
Annualized Standard Deviation	16.2%	14.9%	15.7%	15.0%	15.7%
Information Ratio	-0.49	-0.51	-0.47	-0.52	-0.48
Maximum Drawdown	-43%	-40%	-41%	-40%	-41%
Skewness	-1.33	-1.51	-1.36	-1.53	-1.38
Kurtosis	2.38	2.91	2.37	3.19	2.57
Correlation w NDX	0.95	0.93	0.94	0.92	0.94
Beta wrt NDX	0.69	0.62	0.67	0.63	0.66
Alpha wrt NDX	-1.7%	-1.9%	-1.2%	-2.1%	-1.5%
% Up Days	53%	58%	56%	58%	56%
% Down Days	47%	42%	44%	42%	44%
Alpha P-Value	0.585	0.567	0.694	0.531	0.641

Source: Optionmetrics, Bloomberg

Exhibit 62: Mid-Sized Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Summary Statistics Best and Worst 3-Year Period for Equity

April 2009 to March 2012	Mid-Sized Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	18.9%	15.7%	17.4%	15.4%	17.9%
Annualized Standard Deviation	12.9%	11.4%	12.0%	11.3%	12.1%
Information Ratio	1.47	1.38	1.45	1.36	1.48
Maximum Drawdown	-13%	-13%	-13%	-13%	-13%
Skewness	-0.02	-0.16	-0.22	-0.17	-0.19
Kurtosis	-0.29	-0.14	-0.30	-0.15	-0.29
Correlation w NDX	0.94	0.90	0.92	0.90	0.92
Beta wrt NDX	0.65	0.56	0.60	0.55	0.60
Alpha wrt NDX	-0.9%	-1.0%	-0.7%	-1.2%	-0.4%
% Up Days	67%	67%	64%	67%	64%
% Down Days	33%	33%	36%	33%	36%
Alpha P-Value	0.757	0.749	0.821	0.715	0.899

April 2006 to March 2009	Mid-Sized Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	-8.0%	-7.5%	-7.1%	-7.9%	-7.3%
Annualized Standard Deviation	16.2%	14.2%	15.1%	14.2%	15.2%
Information Ratio	-0.49	-0.53	-0.47	-0.55	-0.48
Maximum Drawdown	-43%	-39%	-40%	-39%	-40%
Skewness	-1.33	-1.55	-1.41	-1.56	-1.41
Kurtosis	2.38	3.20	2.61	3.37	2.66
Correlation w NDX	0.95	0.92	0.94	0.92	0.93
Beta wrt NDX	0.69	0.59	0.64	0.59	0.64
Alpha wrt NDX	-1.7%	-2.3%	-1.3%	-2.6%	-1.5%
% Up Days	53%	58%	58%	58%	58%
% Down Days	47%	42%	42%	42%	42%
Alpha P-Value	0.585	0.505	0.690	0.440	0.635

Source: Optionmetrics, Bloomberg

Endowment Risk Management and Return Enhancement with Listed Index and ETF Options

E. Szado, April 2019.

Please see last page for important disclosures.

Exhibit 63: Very Large Endowment and 1-Mo. Buy-Writes 2% and 5% OTM Summary Statistics Best and Worst 3-Year Period for Equity

April 2009 to March 2012	Very Large Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	19.3%	18.1%	18.9%	18.0%	19.1%
Annualized Standard Deviation	14.6%	14.1%	14.3%	14.0%	14.3%
Information Ratio	1.32	1.29	1.32	1.28	1.34
Maximum Drawdown	-16%	-16%	-17%	-16%	-16%
Skewness	0.06	-0.01	-0.02	-0.02	-0.02
Kurtosis	0.17	0.14	0.11	0.15	0.10
Correlation w NDX	0.90	0.89	0.90	0.89	0.90
Beta wrt NDX	0.71	0.67	0.69	0.67	0.69
Alpha wrt NDX	-2.0%	-2.1%	-1.9%	-2.2%	-1.7%
% Up Days	61%	61%	61%	61%	61%
% Down Days	39%	39%	39%	39%	39%
Alpha P-Value	0.620	0.610	0.655	0.605	0.677

April 2006 to March 2009	Very Large Endowment	Endowment with QQQ 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with QQQ 5% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 2% OTM 1-Mo. Buy-Write 'Overlay'	Endowment with NDX 5% OTM 1-Mo. Buy-Write 'Overlay'
Annualized Return	-11.4%	-11.2%	-11.0%	-11.4%	-11.1%
Annualized Standard Deviation	17.4%	16.5%	17.0%	16.6%	17.0%
Information Ratio	-0.65	-0.68	-0.65	-0.69	-0.66
Maximum Drawdown	-49%	-47%	-48%	-47%	-48%
Skewness	-1.41	-1.51	-1.43	-1.54	-1.44
Kurtosis	2.85	3.18	2.82	3.38	2.98
Correlation w NDX	0.92	0.90	0.91	0.90	0.91
Beta wrt NDX	0.72	0.67	0.70	0.67	0.70
Alpha wrt NDX	-5.0%	-5.3%	-4.7%	-5.5%	-4.9%
% Up Days	53%	56%	56%	56%	56%
% Down Days	47%	44%	44%	44%	44%
Alpha P-Value	0.238	0.226	0.261	0.216	0.247

Source: Optionmetrics, Bloomberg

Exhibit 64: Very Large Endowment and 1-Mo./6-Mo. Put Spread Collars 2/5/10% and 5/10/15% OTM Summary Statistics Best and Worst 3-Year Period for Equity

April 2009 to March 2012	Very Large Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	19.3%	17.7%	18.5%	17.5%	18.8%
Annualized Standard Deviation	14.6%	13.9%	14.2%	13.8%	14.2%
Information Ratio	1.32	1.28	1.31	1.27	1.32
Maximum Drawdown	-16%	-16%	-16%	-16%	-16%
Skewness	0.06	-0.01	-0.03	-0.02	-0.02
Kurtosis	0.17	0.18	0.10	0.17	0.11
Correlation w NDX	0.90	0.89	0.89	0.89	0.89
Beta wrt NDX	0.71	0.66	0.68	0.66	0.68
Alpha wrt NDX	-2.0%	-2.1%	-2.0%	-2.2%	-1.8%
% Up Days	61%	61%	61%	61%	61%
% Down Days	39%	39%	39%	39%	39%
Alpha P-Value	0.620	0.612	0.637	0.599	0.661

April 2006 to March 2009	Very Large Endowment	Endowment with QQQ 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with QQQ 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 2/5/10% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'	Endowment with NDX 5/10/15% OTM 1-Mo./6-Mo. Put Spread Collar 'Overlay'
Annualized Return	-11.4%	-11.1%	-10.8%	-11.4%	-11.0%
Annualized Standard Deviation	17.4%	16.1%	16.6%	16.1%	16.7%
Information Ratio	-0.65	-0.69	-0.65	-0.71	-0.66
Maximum Drawdown	-49%	-46%	-47%	-47%	-47%
Skewness	-1.41	-1.53	-1.44	-1.54	-1.45
Kurtosis	2.85	3.31	2.93	3.44	3.01
Correlation w NDX	0.92	0.89	0.91	0.89	0.90
Beta wrt NDX	0.72	0.65	0.68	0.65	0.68
Alpha wrt NDX	-5.0%	-5.5%	-4.7%	-5.8%	-4.9%
% Up Days	53%	58%	56%	56%	56%
% Down Days	47%	42%	44%	44%	44%
Alpha P-Value	0.238	0.210	0.261	0.192	0.248

Source: Optionmetrics, Bloomberg

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E. Szado, April 2019.

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