Published in *Financial Analysts Journal*, vol. 71, no. 6 (November/December 2015)

Covered Calls Uncovered*

Roni Israelov **Lars N. Nielsen**

October 2015

Equity index covered calls have historically provided attractive risk-adjusted returns largely because they collect equity and volatility risk premia from their long equity and short volatility exposures. However, they also embed exposure to an uncompensated risk, a naïve equity market reversal strategy. This paper presents a novel performance attribution methodology, which deconstructs the strategy into these three identified exposures, in order to measure each's contribution to the covered call's return. The covered call's equity exposure is responsible for most of the strategy's risk and return. The strategy's short volatility exposure has had a realized Sharpe ratio close to 1.0, but its contribution to risk has been less than 10 percent. The equity reversal exposure is responsible for about one-quarter of the covered call's risk, but provides little reward. Finally, we propose a risk-managed covered call strategy that hedges the equity reversal exposure in an attempt to eliminate this uncompensated risk. Our proposed strategy improved the covered call's Sharpe ratio, and reduced its volatility and downside equity beta.

* Roni Israelov is Vice President at AQR Capital Management. Lars N. Nielsen is Principal at AQR Capital Management. We thank Jacob Boudoukh, Brian Hurst, Ronen Israel, Bradley Jones, Michael Katz, Ari Levine, John Liew, Andrew Sterge, Rodney Sullivan, and Daniel Villalon for helpful comments and suggestions, and Matthew Klein and Harsha Tummala for data and analysis.

Equity index covered calls are the most easily accessible source of the volatility risk premium to most investors.[1] The volatility risk premium, which is absent from most investors' portfolios, has had more than double the risk-adjusted returns (Sharpe ratio) of the equity risk premium, which is the dominant source of return for most investors. By providing the equity and volatility risk premia, equity index covered calls returns have been historically attractive, nearly matching the returns of their underlying index with significantly lower volatility.[2]

Options are a form of financial insurance and the volatility risk premium is compensation paid by option buyers to the option sellers who underwrite this insurance. Bakshi and Kapadia (2003) analyze delta-hedged option returns to show that equity index options include a volatility risk premium. Bollen and Whaley (2004) and Garleanu, Pedersen, and Poteshman (2005) show how option demand by natural buyers can lead to a risk premium. Litterman (2011) suggests that long-term investors, such as pensions and endowments, should be natural providers of financial insurance and sellers of options.

Yet, many investors remain skeptical of covered call strategies. Although deceptively simple — long equity and short a call option — covered calls are not well understood. Israelov and Nielsen (2014) identify and dispel eight commonly circulated myths on covered calls. These myths sound plausible; they would not have such longevity if that were not the case. But they can be problematic if they affect portfolio construction decisions. The securities overwritten and the strikes and maturities of the call options that are sold should be explicitly selected to achieve the portfolio's allocation to equity and volatility risk premia without taking unnecessary risk. Price targets, downside protection, and income generation are a diversion.

One source of confusion on covered calls may be due to the opacity of the strategy's risk exposures. Our paper's first contribution is a novel performance attribution methodology for portfolios holding options, such as the covered call strategy. We demonstrate how to decompose the portfolio return into three distinct risk exposures: passive equity, equity market timing, and short volatility.

Our performance attribution methodology provides investment managers with a tool to effectively and transparently communicate their strategy's performance to their investors and allows investors to properly place the covered call's risk exposures and returns in the context of their overall portfolios. Further, it provides a framework by which portfolio managers can evaluate the impact of strike, maturity, underlying security selection, risk management, and leverage on their strategy's risk and returns. Proper performance attribution facilitates improved portfolio construction.

For example, selling at-the-money options is expected to provide the highest exposure to short volatility. Covered calls strategies that sell low-strike options have less equity exposure than those that sell high-strike options. The risk-adjusted performance of short volatility may be higher for low-strike options because of the implied volatility smile in part due to demand for portfolio protection.

---

1 Bollerslev, Gibson, and Zhou (2006) define the volatility risk premium as the spread between an option's implied volatility and the underlying security's realized volatility. Although it is not an investment return *per se* when defined as such, the volatility risk premium is an intuitive measure of an option's richness. The volatility risk premium has also become industry jargon for the expected excess return earned when selling options. In our paper, we apply the terminology volatility risk premium to both contexts.

2 A number of papers, such as Whaley (2002), Feldman and Dhruv (2004), and Hill et al. (2006), have shown that S&P 500 covered calls have had average returns in line with the S&P 500 Index. Kapadia and Szado (2012) report a similar result for the Russell 2000.

By attributing the covered call's performance to its underlying exposures, a portfolio may be explicitly constructed to achieve specific objectives.

Although we use our performance attribution to better understand covered call strategies, it may be more broadly applied to any portfolio that includes options. The returns of these portfolios may be attributed to their passive and time-varying equity exposures and to their volatility exposure. For example, protected strategies that are long an index and long a protective put option typically have significantly lower returns than their underlying index. Our performance attribution would indicate the long volatility's contribution to the strategy's performance degradation and how much less equity risk premium has been earned due to the put option's average negative equity exposure. In a similar manner, Israelov and Klein (2015) apply our performance attribution to explain the risk and return characteristics of a more complex option portfolio: an equity index collar strategy that is long an index, short a call option, and long a protective put.

We demonstrate our proposed performance attribution by analyzing and comparing two covered call strategies. The first strategy mimics the CBOE S&P 500 BuyWrite Index (BXM), selling one-month at-the-money call options on option expiration dates. The second strategy mimics the CBOE S&P 500 2% OTM BuyWrite Index (BXY), selling one-month 2% out-of-the money call options on option expiration dates. Our performance attribution shows that passive equity is the dominant exposure for both covered call strategies. Short volatility contributes less than 10% of the risk, but with a Sharpe ratio near 1.0, adds approximately 2% annualized return to the covered call strategies.

Option-savvy market participants, such as market makers, are well aware that options include market timing, an active equity exposure. In fact, they often employ a delta-hedging program specifically designed to reduce the risk arising from this dynamic exposure. However, the covered call benchmark (CBOE BuyWrite Index) and most covered call funds do not hedge the time varying equity exposure arising from option convexity. Further, the risk and return contribution of an unhedged short option position's dynamic equity exposure is by-and-large not reported by those who manage to those who invest in covered call strategies and is unaddressed in the covered call literature.

We employ our performance attribution to document that market timing is responsible for about one-quarter of the at-the-money covered call's risk. The timing bet is smallest immediately after option expiration and largest just prior to option expiration. In fact, on the day before the call option expires, the equity timing position provides on average nearly the same risk as the passive equity exposure. We further show that covered call investors have not been compensated for bearing this risk. Because the embedded market timing is hedgeable by trading the underlying equity, covered call investors do not need to take that bet to earn the volatility risk premium. In other words, by shorting an option, covered calls include a market timing exposure that bets on equity reversals whose risk is material, uncompensated, and unnecessary for earning the volatility risk premium.

Having identified the covered call's active equity exposure as an uncompensated contributor to risk, our final contribution analyzes a risk-managed covered call strategy that hedges away the identified dynamic equity exposure. On each day, the covered call's active equity exposure may be measured by computing the delta of the strategy's call option. The strategy trades an offsetting amount of the S&P 500 so that the covered call's equity exposure remains constant. This risk management exercise mimics the delta-hedging approach taken by volatility desks. In so doing, the risk-managed covered call achieves higher risk-adjusted returns than does the traditional covered call because it continues to collect the same amount of equity and volatility risk premium, but is no longer exposed to equity market timing risk. The risk-managed strategy improved the covered call Sharpe ratio from 0.37 to 0.52 by reducing its annualized volatility from 11.4% to 9.2%.

The risk-managed covered call has an additional benefit beyond improving risk-adjusted returns. The strategy's goal, design, and execution are clear and they transparently map to its performance. The strategy seeks to collect equity and volatility risk premia and does so by being long equity and short volatility. We may explicitly construct a portfolio by choosing how much risk to allocate to the two desired exposures and subsequently measure their resulting contributions to the strategy's performance.

Covered Call Performance Attribution

A covered call is a combined long position in a security and a short position in a call option on that security. The combined position caps the investor's upside on the underlying security at the option's strike price in exchange for the option premium.

Exhibit 1 graphically constructs an at-the-money covered call payoff diagram when the call option premium is $25 and the current asset price is $100. We may take the long equity exposure and split it in half. The top left plot depicts a portfolio that owns $50 of equity and $50 of cash. The top right plot depicts a portfolio that is short an at-the-money call option, owns $50 of equity, and is short $50 cash to finance the equity position.

Exhibit 1 introduces the foundation for our performance attribution. By splitting the positions in such a manner, we immediately see two distinct components. The first component provides the long-term strategic long equity allocation. In our above example, we have a 50% passive equity allocation. The second component provides the long-term strategic short volatility allocation. However, the second component provides the covered call with a third exposure: time-varying equity exposure that is zero on average. Although the top right plot shows the payoff at expiration, the exposures profile has a similar shape on all the days leading up to the option's expiration. It has positive slope when the call option is out of the money, negative slope with the call option is in the money, and approximately no exposure to the stock when the call option is at the money.

We may rearrange the covered call definition to define the three economically distinct components:

Covered Call	**= Equity — Call**	
	= (1 — InitialCallDelta) * Equity	} Passive Equity
	- (Call — CallDelta * Equity)	} Short Volatility
	+ (InitialCallDelta — CallDelta) * Equity	} Dynamic Equity

The passive equity exposure provides the strategy with equity risk premium and represents a long-term strategic allocation to equity markets. The dynamic equity exposure is effectively a market timing strategy. It is close to zero on average and may be viewed as a tactical equity allocation around the long-term strategic passive exposure. Unless it correlates to (i.e. forecasts) future equity returns, it should not contribute to the strategy's average returns. Under efficient markets, the expected return of this market timing component is zero.

Short volatility provides the strategy with volatility risk premium. Arguably, it too may be split into passive (strategic) and active (tactical) components. Its exposure to realized volatility (gamma) fluctuates over time. Gamma is higher when the option is close to the money and close to its expiration. Short volatility's exposure to changes in implied volatility (vega) also fluctuates over time. Vega is higher when the option is close to the money and distant from its expiration. In fact, short volatility can be split across other related dimensions as well. The option's maturity represents a calendar bet and the option's strike price represents a skew bet. Decomposing across all of these dimensions may be tractable if there is a well-defined passive short volatility asset. Unfortunately, there is not and we do not attempt to define one in this paper. For this reason, and to maintain parsimony in our performance attribution, we do not further decompose short volatility across any of the above identified dimensions.

An alternative performance attribution could regress covered call returns on the S&P 500 Index return and an S&P 500 variance swap return. The regression framework is commonly used to estimate return exposures to known factors. Rolling estimation of factor coefficients provide information on exposure dynamics. We believe our attribution methodology is more appropriate for a covered call for the following reasons. First, we know the covered call's constituent assets, so we may use a model to estimate equity exposure point-in-time rather than statistically estimate an average exposure over a rolling period. Option convexity can lead to rapid changes in equity exposure and the regression will not be able to fully capture these changes and thus underestimate the equity exposure dynamics. Second, there is no well-defined pure passive short volatility return series. A variance swap is one method to obtain short volatility exposure. Delta-hedging a short option is another method. Shorting VIX futures are a third, etc. The delta-hedged option has exposure to a variance swap, but with basis risk. That basis risk would be an additional term that complicates the decomposition. Our performance attribution mechanically decomposes the covered call's return using a model into passive equity, the delta-hedged option variant of short volatility, and equity market timing.

In order to demonstrate our attribution methodology in practice, we decompose a simple overwriting strategy, which mimics the industry standard covered call benchmark — the CBOE BuyWrite Index — into these three components. This strategy owns the S&P 500 Index and sells an at-the-money call monthly index option on option expiration dates. Specifically, its excess return is computed as:

$$r_{total,t} = \frac{spx_t + div_t - call_t}{spx_{t-1} - call_{t-1}} - r_{cash,t} - 1$$

Mimicking the BXM, our overwriting strategy effectively induces a mild time-varying leverage effect, caused by the denominator being $spx_{t-1} - call_{t-1}$ instead of spx_{t-1}. On the close of any given day, the strategy's leverage can therefore be modeled as $\frac{spx_t}{spx_t - call_t} > 1$, which in our sample was 1.02 on average with a maximum value of 1.14 .

The three returns in the decomposition are computed as follows:

$$r_{pe,t} = \overline{\Delta}_p * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

$$r_{sv,t} = \frac{(call_{t-1} - call_t) + \Delta_{c,t-1} * (spx_t + div_t - spx_{t-1} * (1 + r_{cash,t})) + call_{t-1} * r_{cash,t}}{spx_{t-1} - call_{t-1}}$$

$$r_{ae,t} = (\Delta_{p,t-1} - \overline{\Delta}_p) * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

where r_t is the excess return for the respective component, $r_{cash,t}$ is U.S. 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price, $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics[3], $\Delta_{p,t}$ is the portfolio's properly levered delta exposure, calculated as:

$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

and $\overline{\Delta}_p$ is the full-sample average portfolio delta exposure over all dates on which the at-the-money call options were sold. On the call option's expiration date, the call option is settled at the S&P 500 Special Opening Quotation, the intraday return is calculated as the expected portfolio delta after the new option sale[4] multiplied by the S&P 500 return from settlement to close, and a new short call option position is established at the day's closing price. Our short volatility return calculation is similar to that of Bakshi and Kapadia (2003), except we compute daily returns rather than returns through option expiration.

Whereas the returns above are computed to reflect the specific definition of the CBOE BuyWrite indices, the same approach may be generalized to any portfolio of options. The passive equity return can be computed as the time-series average of the aggregated portfolio delta multiplied by the underlying equity index's return in excess of cash. The active equity return can be computed as the time-series demeaned aggregated portfolio delta multiplied by the underlying equity index's return in excess of cash. The volatility return can be computed as the return to a hypothetical daily delta-hedged portfolio holding the same options and quantities as the original portfolio and having the same NAV.

---

3 By using delta reported by OptionMetrics, we are using the Black-Scholes model to identify delta-hedged returns and equity timing exposure. Alternatively, a stochastic volatility model could be used to generate the option's delta. A different model for delta would necessarily shift return between passive equity, short volatility, and equity timing and provide an alternative performance attribution. According to Bakshi and Kapadia (2003), establishing that the volatility risk premium and the mean discrete delta-hedged gains share the same sign does not require correct specification of the volatility process. If an improved model of an option's delta is used, we expect that short volatility's risk contribution should be lower due to the increased option hedging efficacy. For parsimony, our performance attribution relies on Black-Scholes option deltas.

4 If we assume an implied volatility of 18%, then the Black-Scholes deltas of an at-the-money and 2% out-of-the-money call option with one month to expiration can be calculated as 0.5 and 0.3, respectively, after rounding. Based on these calculations, our expected portfolio deltas on rebalance were 0.5 and 0.7 for the two backtests.

Table 1 and **Table 2** report the full-sample summary statistics and the correlation matrix of the decomposition, respectively, and cumulative returns are plotted in **Exhibit 2**. The passive equity exposure realized 8.5% annualized volatility, while short volatility realized a modest 2% annualized volatility. The two components had a correlation of 0.26 due to the negative relationship between equity returns and changes in implied volatility. Equity timing was a significant source of risk, realizing more than half the volatility of the passive equity exposure and contributing almost four times the risk of short volatility.[5]

In our sample, the passive equity exposure had close to a 0.4 Sharpe ratio. Short volatility contributed about two-thirds of the return of long equity, but with a quarter of its risk, realizing a 1.0 Sharpe ratio. Shorting volatility has provided one-third of the covered call's average return even though it is only responsible for less than 10% of its risk. Figelman (2009) reports that over the period March 1994 through September 2005, equity and volatility risk premium each contributed 2.9% to the at-the-money covered call's annual expected return.[6] Our decomposition over the period March 1996 through December 2014 shows a moderately higher equity risk premium and lower volatility risk premium.

Although equity timing has also realized moderately positive returns over our sample, the 0.5% annualized return is not statistically significant given its 4.8% annualized volatility (0.4 t-statistic). More importantly, its alpha to S&P 500 is nearly zero (-0.0%) and it is unclear why this method of equity timing would be a compensated risk premium. The strategy's active exposure can be computed *ex ante* and hence the embedded equity timing exposure could be implemented by dynamically replicating the covered call's equity exposure if so desired, but such a timing strategy has zero expected returns if markets are efficient. Even under inefficient markets, it remains unclear why such a path-dependent and arbitrary[7] timing strategy would capture the market's inefficiency.

We repeat the exercise for a strategy mimicking the CBOE S&P 500 2% OTM BuyWrite Index. On rebalance dates, the average portfolio delta of this strategy is 0.70. **Table 3** and **Table 4** report full-sample summary statistics and the correlation matrix, while **Exhibit 3** plots the cumulative returns. Mechanically, the out-of-the-money covered call strategy has higher passive equity exposure and collects more equity risk premium than does its at-the-money counterpart. Out-of-the-money options have lower short volatility exposure than do at-the-money options. They have lower convexity as represented by gamma and they have lower exposure to changes in the options' implied volatilities as represented by vega. In this case, we do not see a significant impact to the risk or return of the short volatility exposure, indicating that the 2% OTM delta-hedged call option is not materially different than an at-the-money delta-hedged call option.

---

5 Risk contribution is defined as the covariance of the component with the BuyWrite Index divided by the variance of the BuyWrite Index.

6 Figelman (2009) decomposes covered call *expected* returns into three terms: (1) risk-free return plus (2) equity risk premium minus (3) call risk premium. Because a long call option has positive exposure to the stock, in their decomposition, the call risk premium includes equity risk premium. Our equity timing plays no role in their decomposition because its expected return is zero. We decompose the covered call's excess return into three economically distinct terms. As a result, the short volatility returns are equity neutral. Because we decompose actual realized covered call returns, we are able to analyze each component's contribution to the strategy's risk in addition to their contribution to the strategy's average return.

7 Covered calls can be written at different strikes and maturities and at any point in time, one implementation's active exposure might be positive while another's might be negative.

To check whether these results are robust over time, **Table 5** reports the ATM BuyWrite decomposition's summary statistics over three sub-periods of similar lengths: 1996 to 2001, 2002 to 2008, and 2009 to 2014. In all of these periods, the short volatility component realized a higher Sharpe ratio than the passive equity component, and was responsible for less than 10% of the covered call strategy's risk. Risk contributions were similar in the three sub-periods. Although not reported in this paper, a sub-period analysis of the OTM BuyWrite decomposition exhibited similar robustness.

These two examples demonstrate how our performance attribution allows us to determine portfolio construction's effect on risk exposures and realized returns. For instance, option strike selection influences exposure to passive equity, short volatility, and active equity. Other decisions, such as option maturity selection and amount of the portfolio that is overwritten, also impact these exposures. Further, delta-hedged option risk-adjusted performance may depend on the option's strike and maturity. Our proposed performance attribution methodology may help portfolio managers evaluate and improve the design of their covered call strategies.

Covered Calls Bet on Equity Reversals

The active equity exposure identified in our performance attribution is due to option convexity, its gamma. An at-the-money call option's delta is approximately 0.5. Hence, an at-the-money covered call, which is long the equity and short the call option, also has a 0.5 delta. However, this equity exposure changes as soon as the equity's price moves. Gamma measures the change in an option's delta with respect to a change in the underlying security's price.

Exhibit 4 compares the evolution of the CBOE BuyWrite's equity exposure with the S&P 500's return since the date of the last call option sale, across four recent expiration cycles. The equity exposure is slightly above 0.5 on option initiation dates, which is when the options have been sold. This is because the BuyWrite Index's methodology sells out-of-the-money call options that are nearest-to-the-money and then uses the call premium to lever the covered call position. As the index price increases, the call option's delta increases to reflect the higher probability that it will expire in the money. When the equity price falls, the call option's delta declines to reflect the higher probability that it will expire out of the money. As a result, the covered call's equity exposure is negatively related to the index price. A falling market leads to larger equity exposure and a rising market leads to smaller, but still positive equity exposure. As the call option nears its expiration, the strategy's delta has converged to either zero or one, depending on whether the index has appreciated or depreciated, respectively.

Exhibit 5 scatter plots the CBOE BuyWrite equity exposure against the S&P 500's return since the date of the last call option sale, over the full sample. As expected, the BuyWrite's equity exposure ranges from zero to one, is 0.5 on average, and is negatively related to the S&P 500's return since the prior call option sale. The BuyWrite Index has active equity exposure that resembles a reversal strategy and that active exposure can at times be as large as the strategy's passive equity allocation.

The size of the at-the-money covered call's active equity exposure varies over time in a predictable manner. **Exhibit 6** plots the distribution of the covered calls' equity exposure against the number of days since the call option was sold. Immediately after the call option is sold, the strategy's delta is tightly distributed around 0.5. As time passes, the covered call's delta disperses and by the time the option expires, the delta has settled on either zero or one. The active exposure is smallest immediately after the call option is sold, largest immediately prior to the option's expiration, and the average absolute active exposure is approximately 0.21. The time-varying pattern is further illustrated in **Exhibit 7**, which plots the distributions of the covered calls' equity exposure on dates that were either 0, 6, 12, or 18 business days after the last call option sale.

Risk-Managed Covered Calls

Our covered call performance attribution indicates that active equity exposure is a significant source of risk and our analysis of the relationship between the covered call's equity exposure and the S&P 500's index level shows why. Because the covered call's equity exposure is known *ex ante* and equity exposure is easily hedged with instruments such as futures or ETFs, we propose a risk-managed covered call strategy that hedges away the undesirable active equity exposure. After doing so, the resulting risk-managed covered call is effectively a long equity and short volatility portfolio[8], whose risk and return arise from these two exposures.

The proposed strategy is straightforward. We begin with an existing covered call allocation. Each day, we compute its equity exposure according to the Black-Scholes model. We hedge the active equity exposure using S&P 500 index futures. For instance, on September 30, 2014, the CBOE BuyWrite Index was short a 2020 strike call option expiring on October 17, 2014. The delta of that call option according to Black-Scholes is 0.15. Because the expected percent delta of the strategy's call options on rebalance dates was 0.5, we hedge our strategy with a short futures position sized at 35% of NAV. We repeat this exercise each day.

Table 6 reports performance statistics for the CBOE S&P 500 BuyWrite Index (BXM) and CBOE S&P 500 2% OTM BuyWrite Index (BXY) and for the two indices after we employ our risk management process.[9] Hedging the covered call strategy's active equity exposure successfully reduced the strategies' volatilities. Hedging reduced BXM's volatility from 11.4% to 9.2%, thereby increasing its Sharpe ratio from 0.37 to 0.52. Similarly, hedging reduced BXY's volatility from 13.3% to 12.4% and increased its Sharpe ratio from 0.41 to 0.46.

The BuyWrite indices have asymmetric betas in part because of their active equity reversal exposures. As the S&P 500 declines in value, their exposures to the index increases and vice versa. As a result, both BuyWrite indices have higher exposure to the S&P 500's losses than to its gains.

---

8 Bakshi and Kapadia (2005) document the existence of a volatility risk premium in their analysis of delta-hedged option returns. They show that the sign of the volatility risk premium provides the sign of the expected delta-hedged option return, even when volatility follows a stochastic process. Similarly, Figelman (2009) shows that the volatility risk premium is not explained by stock index's returns not following a normal distribution.

9 Comparing Table 1 and Table 3 with Table 6, the at-the-money backtest's return of 5.9% was roughly 1.0% higher than the actual BXM's return of 4.9%, and the 2% OTM backtest's return of 7.1% was roughly 0.8% higher than the BXY's return of 6.3%. These discrepancies are mostly an artifact of the BXM and BXY calculation methodologies on expiration dates. On these dates, the BXM and BXY are fully invested in the S&P 500 for the interval between the time that the old option expires and a "VWAP period" during which the new option is sold, roughly 2 hours later. Since intraday option prices are not available over the full period, our covered call backtests instead calculate the intraday return as the expected portfolio delta multiplied by the S&P 500 return from settlement to close, and a new short call option position is then established at the day's closing price. This discrepancy means that the BXM and BXY have relatively larger exposures to S&P 500 movements from the settlement until the VWAP period, an interval that has historically seen strongly negative returns on average. The CBOE paper "The BXM and Put Conundrum" also recognizes this effect, noting "The SOQ is often greater than the subsequent VWAP value of the S&P 500. As seen from Equation (1), the ratio of the SOQ to the VWAP drags down the rate of return of the BXM when the BXM call expires in the-money, which has occurred 70% of the time since 2004."

For example, the at-the-money BuyWrite Index has 0.85 downside beta and 0.46 upside beta. Our proposed risk management process brings these two exposures closer to parity, resulting in a 0.60 downside beta and 0.49 upside beta. The remaining asymmetry in beta is due to short volatility exposure.

The hedged covered call will necessarily have higher trading costs than the unhedged covered call. The examples we provide are intended to illustrate how the performance attribution can help to identify a risk that may be hedged and that hedging this risk successfully reduced the strategies' volatilities. Portfolio managers or investors who intend to hedge the covered call's equity timing risk can optimize their hedging activity to balance trading costs against equity timing risk if so desired. Once the final portfolio is constructed, our proposed attribution methodology can be used to identify and communicate the drivers of the strategy's performance.

Conclusion

Many investors seek to protect their portfolios by purchasing equity index options. As a result, options tend to include a risk premium as a form of compensation to option sellers. Covered calls, which are short options, collect this volatility risk premium in addition to the equity risk premium earned from their long equity exposure. Because of option convexity, covered calls also embed active equity exposure that behaves like a reversal strategy.

Unfortunately, covered calls are rarely considered in terms of their risk exposures. Our paper introduces a novel performance attribution methodology that decomposes the strategy's return into its passive and active equity and short volatility exposures. Not only does the performance attribution of our samples allow covered call investors to better understand the strategy's characteristics, but it also allows portfolio managers to assess the risk and return impact of portfolio construction decisions, such as the call option's strike and maturity, so that they may improve their strategy.

As an example, our paper proposes a risk-managed covered call to hedge away the uncompensated active equity exposure, which is a significant contributor to the covered call's risk. Our proposed strategy has similar expected returns to the original covered call, but with lower risk, lower downside beta, and a higher Sharpe ratio. And while the motivation for covered calls is often confusing and muddled by a number of myths, the motivation for the risk-managed covered call is clear: earn the equity and volatility risk premium by constructing a portfolio with long equity and short volatility exposure.

With these motives clearly established, creating custom portfolio solutions for those with increased flexibility can be a straightforward exercise. Those who seek to collect more volatility risk premium than is provided by a traditional covered call can sell more options to increase their short volatility exposure. Others who wish to supplement rather than replace their equity exposure with short volatility exposure can sell delta-neutral straddles rather than a delta-reducing call option. The (risk-managed) at-the-money covered call is but one choice along a continuum of possible allocations to long equity and short volatility for those who seek to earn the equity and volatility risk premia.

Related Studies

Bakshi, G. and N. Kapadia (2003), "Delta-Hedged Gains and the Negative Market Volatility Risk Premium," The Review of Financial Studies, 16(2), 527-566.

Bollen, N.P.B. and R. E. Whaley (2004), "Does Net Buying Pressure Affect the Shape of Implied Volatility Functions?" Journal of Finance, 59(2), 711-754.

Bollerslev, T. Gibson, M. and Hao Zhou (2006), "Dynamic Estimation of Volatility Risk Premia and Investor Risk Aversion from Option-Implied and Realized Volatilities," Working Paper, Federal Reserve Board.

Feldman, B. and R. Dhruv (2004), "Passive Options-Based Investment Strategies: The Case of the CBOE S&P 500 Buy Write Index," Institutional Investor Journal, Fall(1), 72-89.

Figelman, I. (2008), "Expected Return and Risk of Covered Call Strategies." Journal of Portfolio Management, Summer, 81-97.

Figelman, I. (2009), "Effect of Non-Normality Dynamics on the Expected Return of Options." Journal of Portfolio Management, Winter, 110-117

Garleanu, N., Pedersen, L.H., and A. M. Poteshman (2009), "Demand-Based Option Pricing," Review of Financial Studies 22(10), 4259-4299.

Hill, J.M., Gregory, K.B. and I. Tierens (2006), "Finding Alpha via Covered Index Writing," Financial Analysts Journal 62(5), 29-46.

Israelov, R. and M. Klein (2015), "Risk and Return of Equity Index Collar Strategies," AQR Working Paper.

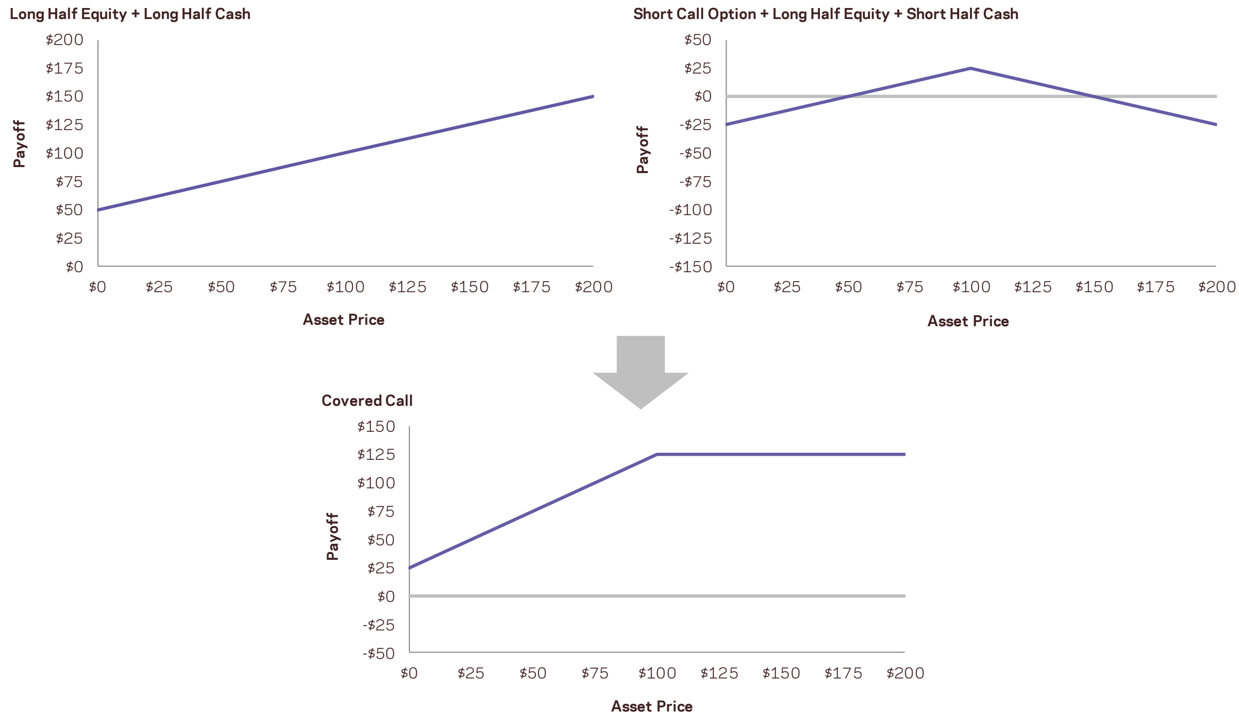
Israelov, R. and L.N. Nielsen (2014), "Covered Call Strategies: One Fact and Eight Myths," Financial Analysts Journal 70(6), 23-31.

Kapadia and Szado (2012), "The Risk and Return Characteristics of the Buy-Write Strategy on the Russell 2000 Index," The Journal of Alternative Investments 9(4), 39-56.

Litterman, R. (2011), "Who Should Hedge Tail Risk?" Financial Analysts Journal 67(3), 6-11.

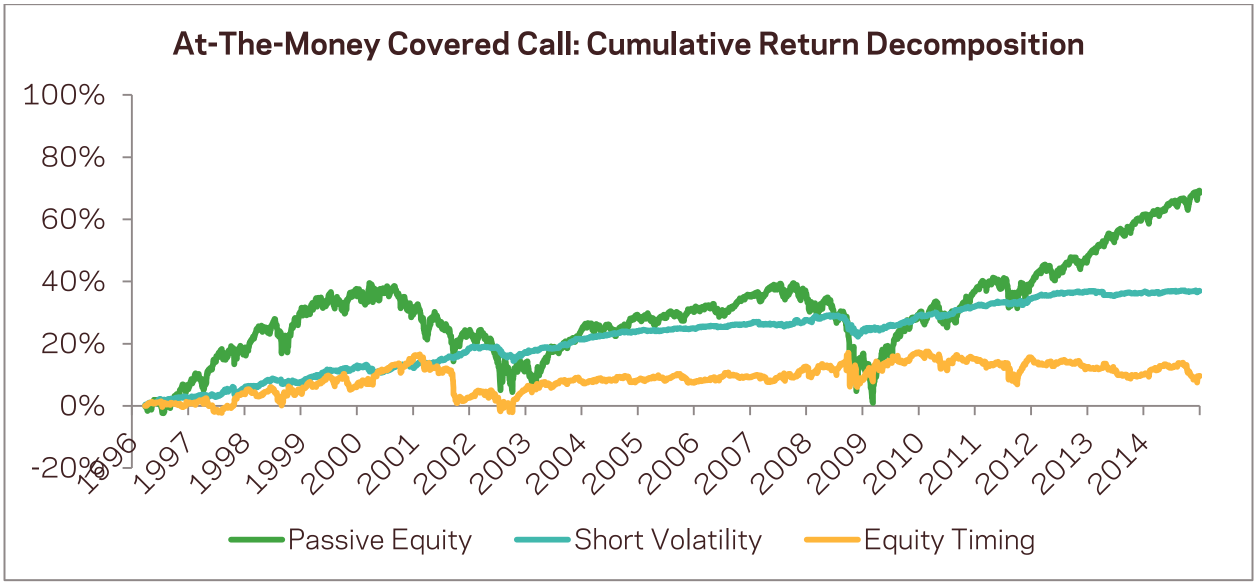
Whaley, R. E. (2002) "Return and Risk of CBOE Buy Write Monthly Index," The Journal of Derivatives, Winter, 35-42.

Exhibit 1 – Covered Call Payoff Diagram



The charts graphically construct an at-the-money covered call payoff diagram when the call option premium is $25 and the current asset price is $100. We may take the long equity exposure and split it in half. The top left plot depicts a portfolio that owns $50 of equity and $50 of cash. The top right plot depicts a portfolio that is short an at-the-money call option, owns $50 of equity, and is short $50 cash to finance the equity position.

Exhibit 2 – At-The-Money Overwriting Sample Cumulative Return Decomposition



The chart plots cumulative returns for the decomposition of an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM). The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. These returns are then decomposed into three components: passive S&P 500 equity exposure, dynamic S&P 500 equity timing exposure due to the call option's time varying delta, and short volatility exposure.

The three returns in the decomposition are computed as follows:

$$r_{pe,t} = \bar{\Delta}_p * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

$$r_{sv,t} = \frac{(call_{t-1} - call_t) + \Delta_{c,t-1} * \left(spx_t + div_t - spx_{t-1} * (1 + r_{cash,t})\right) + call_{t-1} * r_{cash,t}}{spx_{t-1} - call_{t-1}}$$

$$r_{ae,t} = \left(\Delta_{p,t-1} - \bar{\Delta}_p\right) * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

where r_t is the excess return for the respective component, $r_{cash,t}$ is US 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price, $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics, $\Delta_{p,t}$ is the portfolio's properly levered delta exposure, calculated as:

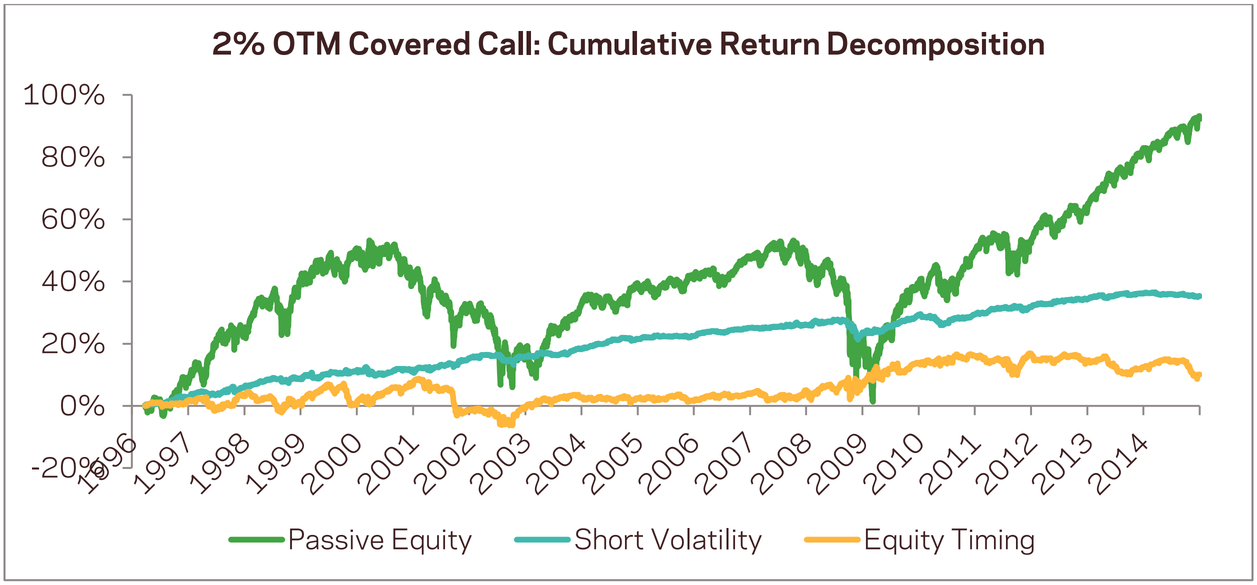
$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

and $\bar{\Delta}_p$ is the full-sample average portfolio delta exposure over all dates on which the at-the-money call options were sold.

The date range is March 25, 1996, until December 31, 2014.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Exhibit 3 – 2% Out-of-the-Money Overwriting Sample Cumulative Return Decomposition



The chart plots cumulative returns for the decomposition of a 2% out-of-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 2% OTM BuyWrite Index (BXY). The backtest is long the S&P 500 Index and short 2% out-of-the-money front-month S&P 500 call options, held to expiry. These returns are then decomposed into three components: passive S&P 500 equity exposure, dynamic S&P 500 equity timing exposure due to the call option's time varying delta, and short volatility exposure.

The three returns in the decomposition are computed as follows:

$$r_{pe,t} = \overline{\Delta}_p * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

$$r_{sv,t} = \frac{(call_{t-1} - call_t) + \Delta_{c,t-1} * (spx_t + div_t - spx_{t-1} * (1 + r_{cash,t})) + call_{t-1} * r_{cash,t}}{spx_{t-1} - call_{t-1}}$$

$$r_{ae,t} = (\Delta_{p,t-1} - \overline{\Delta}_p) * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

where r_t is the excess return for the respective component, $r_{cash,t}$ is US 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price, $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics, $\Delta_{p,t}$ is the portfolio's properly levered delta exposure, calculated as:

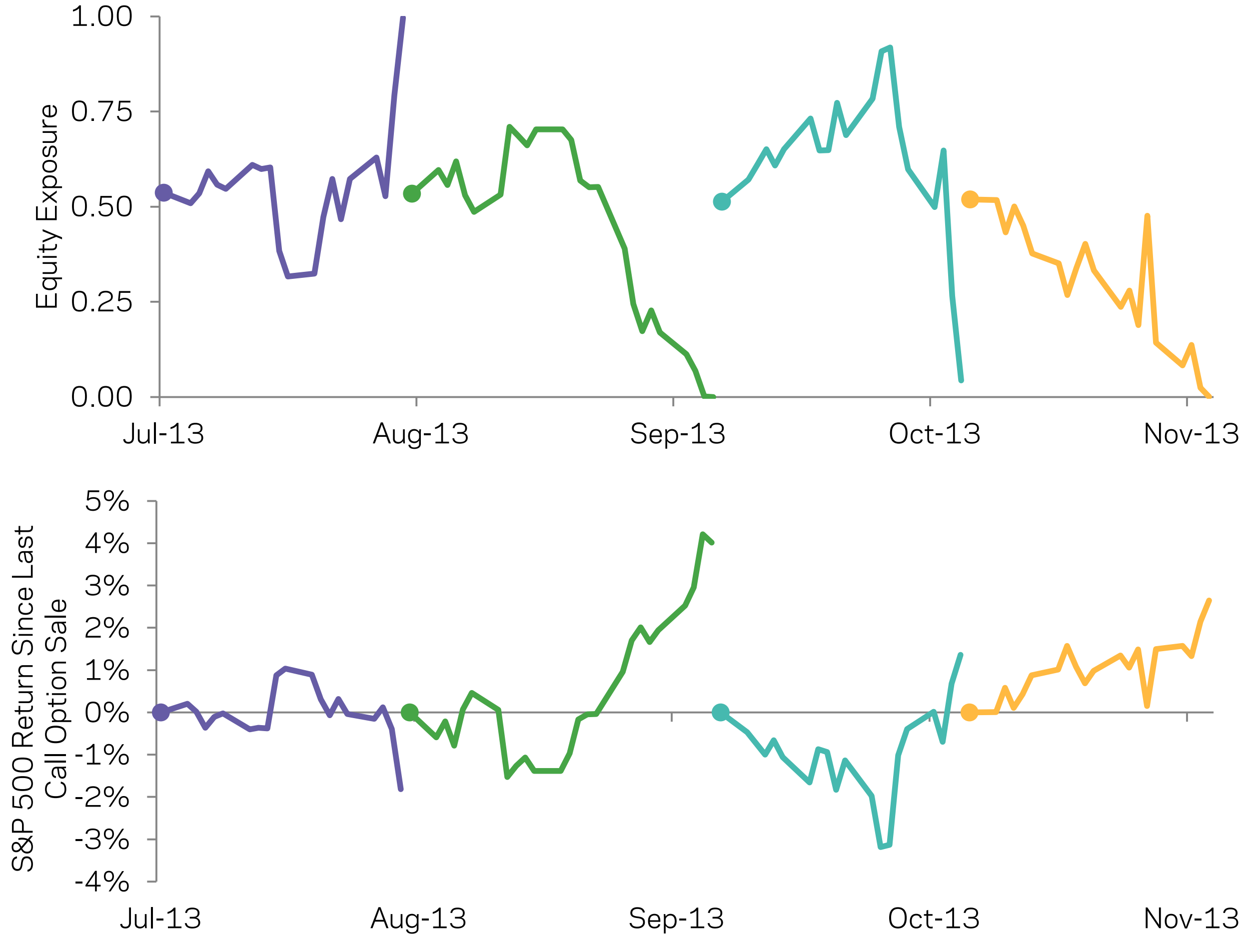
$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

and $\overline{\Delta}_p$ is the full-sample average portfolio delta exposure over all dates on which the out-of-the-money call options were sold.

The date range is March 25, 1996, until December 31, 2014.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Exhibit 4 – CBOE S&P 500 BuyWrite Index's Delta Sample vs. S&P 500 Index Return



The top chart shows the equity exposure from July 19, 2013, until November 14, 2013, for an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM). The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. The portfolio's equity exposure is calculated as:

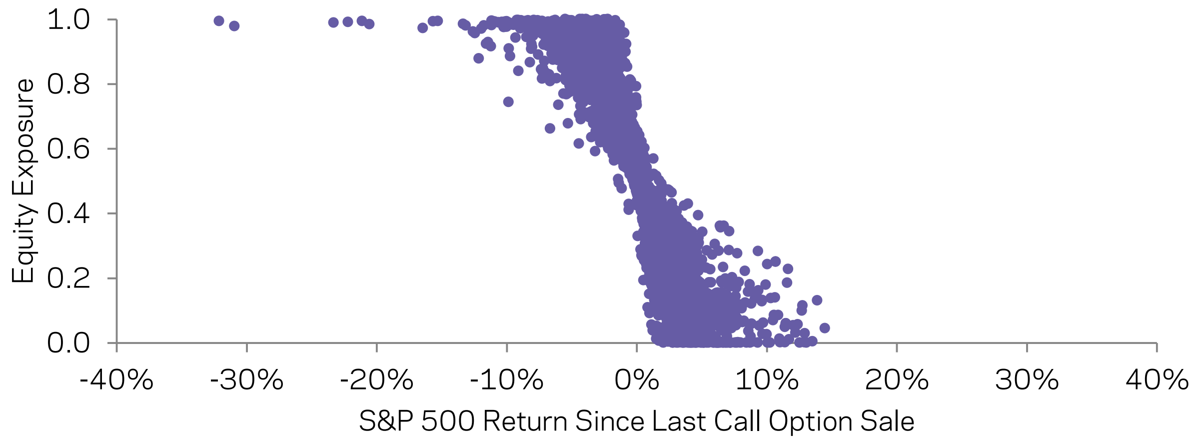
$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

where spx_t is the S&P 500 Index, $call_t$ is the call price, and $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics.

The bottom chart shows the percent change in the level of S&P 500 Index since the close of the last monthly option expiration date, from July 19, 2013, until November 14, 2013.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Exhibit 5 – CBOE BuyWrite Equity Exposure vs. S&P 500 Return



The chart shows the equity exposure for an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM), plotted against the percent change in the level of S&P 500 Index since the close of the last monthly option expiration date. The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. The portfolio's equity exposure is calculated as:

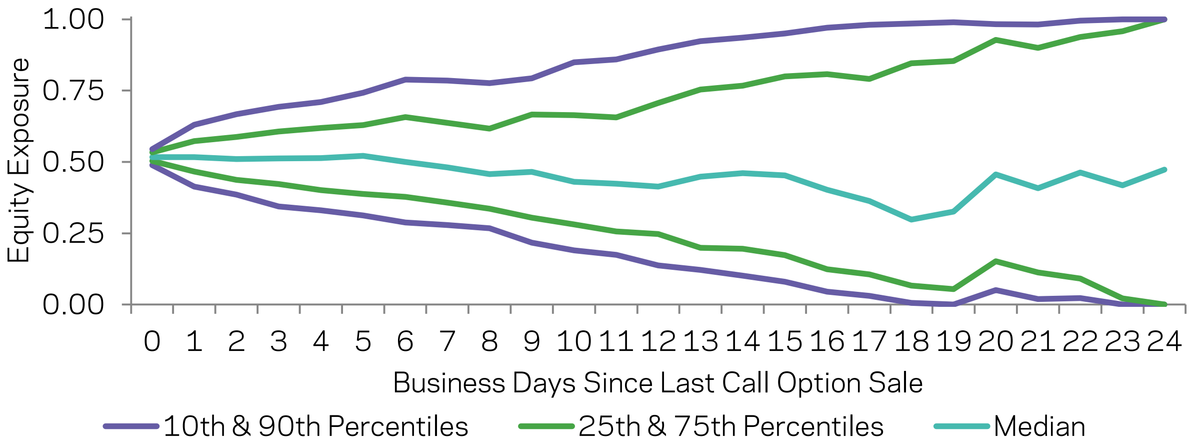
$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

where spx_t is the S&P 500 Index, $call_t$ is the call price, and $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics.

The date range is from March 25, 1996 to December 31, 2013.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Exhibit 6 – Range of CBOE S&P 500 BuyWrite Index's Deltas



The chart plots percentiles of the equity exposure for an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM), bucketed by the number of business days since the last call option sale (i.e. the last monthly option expiration date). The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. The portfolio's equity exposure is calculated as:

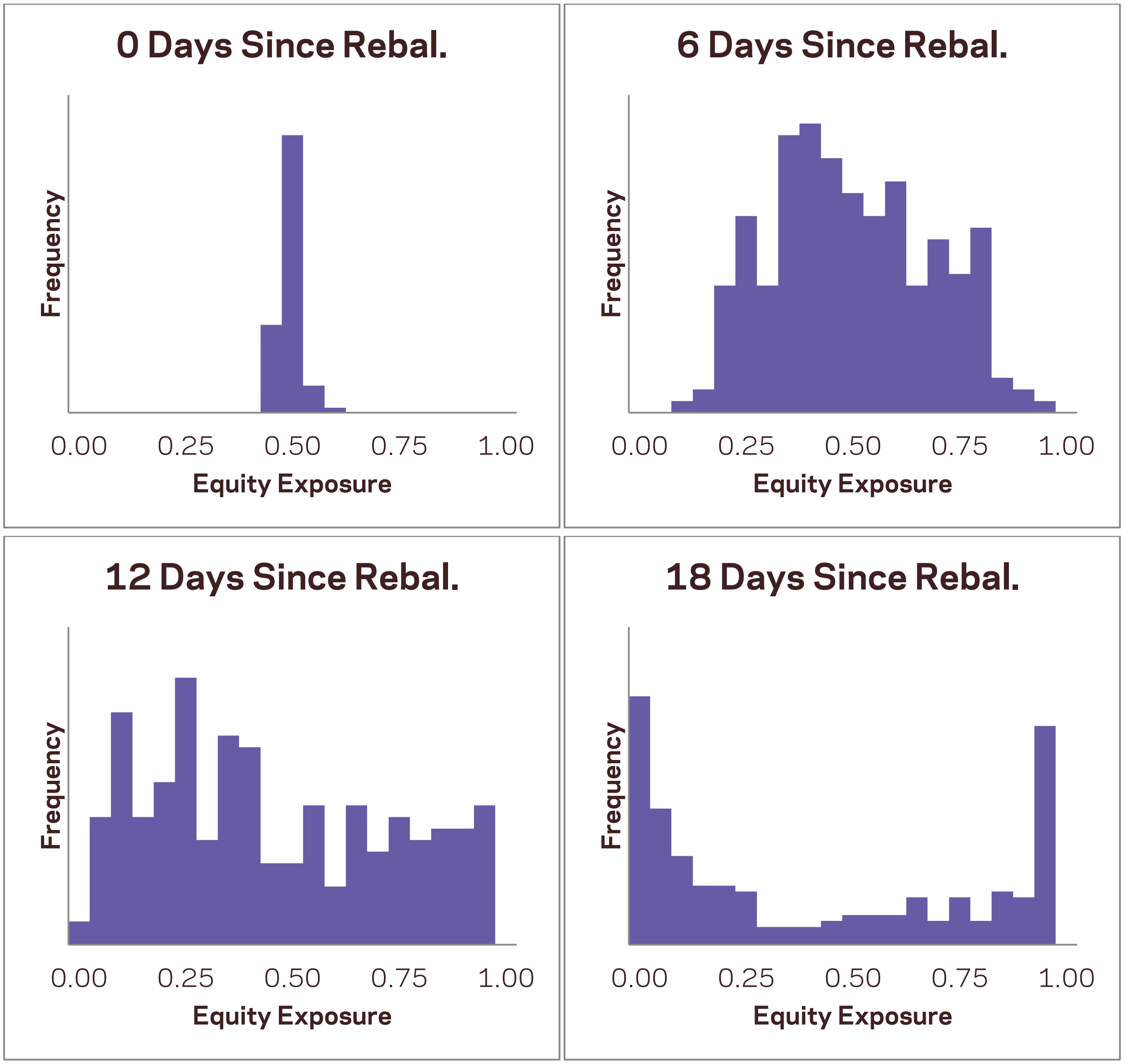
$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

where spx_t is the S&P 500 Index, $call_t$ is the call price, and $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics.

The date range is from March 25, 1996 to December 31, 2013.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Exhibit 7 – BXM Delta Distribution at Constant Number of Business Days since Last Rebalance



The charts show the distributions of the equity exposure for an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM), on dates that were either 0, 6,12, or 18 business days after the last call option sale (i.e. the last monthly option expiration date). Each chart buckets the equity exposure in intervals of 0.05. The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. The portfolio's equity exposure is calculated as:

$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

where spx_t is the S&P 500 Index, $call_t$ is the call price, and $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics.

The date range is from March 25, 1996, to December 31, 2014.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Table 1: At-The-Money Overwriting Sample Return Decomposition (Annualized)

1996-2014	At-The-Money Covered Call Strategy	Passive Equity	Short Volatility	Equity Timing
Excess Return (Simple)	5.9%	3.5%	1.9%	0.5%
Excess Return (Geom.)	5.3%	3.2%	1.9%	0.4%
Volatility	11.4%	8.5%	1.9%	4.8%
Sharpe Ratio (Simple)	0.52	0.41	0.98	0.10
Skew	-1.7	-0.8	-1.1	-1.4
Kurtosis	8.7	3.4	5.4	7.4
Risk Contribution	100%	67%	7%	26%
Alpha to S&P 500	1.7%	--	1.7%	-0.0%
Beta to S&P 500 Index	0.62	0.52	0.03	0.07
- Upside Beta	0.46	0.51	-0.02	-0.04
- Downside Beta	0.86	0.53	0.09	0.25

The table shows summary statistics for the decomposition of an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM), over the period March 25, 1996, until December 31, 2014. The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. Its excess return is computed as:

$$r_{total,t} = \frac{spx_t + div_t - call_t}{spx_{t-1} - call_{t-1}} - r_{cash,t} - 1$$

These returns are then decomposed into three components: passive S&P 500 equity exposure, dynamic S&P 500 equity timing exposure due to the call option's time varying delta, and short volatility exposure.

The three returns in the decomposition are computed as follows:

$$r_{pe,t} = \bar{\Delta}_p * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

$$r_{sv,t} = \frac{(call_{t-1} - call_t) + \Delta_{c,t-1} * \left(spx_t + div_t - spx_{t-1} * (1 + r_{cash,t})\right) + call_{t-1} * r_{cash,t}}{spx_{t-1} - call_{t-1}}$$

$$r_{ae,t} = \left(\Delta_{p,t-1} - \bar{\Delta}_p\right) * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

where r_t is the excess return for the respective component, $r_{cash,t}$ is US 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price, $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics, $\Delta_{p,t}$ is the portfolio's properly levered delta exposure, calculated as:

$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

and $\bar{\Delta}_p$ is the full-sample average portfolio delta exposure over all dates on which the at-the-money call options were sold.

Risk contribution is defined as the covariance of the component with the full strategy, divided by the variance of the full strategy. Volatility, skew, kurtosis, alpha, beta, upside beta and downside beta were all computed using 21-day overlapping returns.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Table 2: At-The-Money Overwriting Sample Correlation Matrix

	At-The-Money Covered Call Strategy	Passive Equity	Short Volatility	Equity Timing
At-The-Money Covered Call Strategy	1.00	0.89	0.44	0.62
Passive Equity	0.89	1.00	0.26	0.24
Short Volatility	0.44	0.26	1.00	0.16
Equity Timing	0.62	0.24	0.16	1.00

The table shows correlations for the decomposition of an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM), over the period March 25, 1996, until December 31, 2014. The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. Its excess return is computed as:

$$r_{total,t} = \frac{spx_t + div_t - call_t}{spx_{t-1} - call_{t-1}} - r_{cash,t} - 1$$

These returns are then decomposed into three components: passive S&P 500 equity exposure, dynamic S&P 500 equity timing exposure due to the call option's time varying delta, and short volatility exposure.

The three returns in the decomposition are computed as follows:

$$r_{pe,t} = \overline{\Delta}_p * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

$$r_{sv,t} = \frac{(call_{t-1} - call_t) + \Delta_{c,t-1} * (spx_t + div_t - spx_{t-1} * (1 + r_{cash,t})) + call_{t-1} * r_{cash,t}}{spx_{t-1} - call_{t-1}}$$

$$r_{ae,t} = (\Delta_{p,t-1} - \overline{\Delta}_p) * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

where r_t is the excess return for the respective component, $r_{cash,t}$ is US 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price, $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics, $\Delta_{p,t}$ is the portfolio's properly levered delta exposure, calculated as:

$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

and $\overline{\Delta}_p$ is the full-sample average portfolio delta exposure over all dates on which the at-the-money call options were sold.
The correlations are computed using 21-day overlapping returns.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Table 3: 2% Out-Of-The-Money Overwriting Sample Return Decomposition (Annualized)

1996-2014	2% OTM Covered Call Strategy	Passive Equity	Short Volatility	Equity Timing
Excess Return (Simple)	7.1%	4.7%	1.8%	0.5%
Excess Return (Geom.)	6.2%	4.0%	1.9%	0.4%
Volatility	13.3%	11.4%	1.9%	4.0%
Sharpe Ratio (Simple)	0.53	0.41	0.98	0.13
Skew	-1.2	-0.8	-0.9	-0.8
Kurtosis	5.4	3.3	4.0	4.1
Risk Contribution	100%	83%	5%	12%
Alpha to S&P 500	1.9%	--	1.6%	0.3%
Beta to S&P 500 Index	0.76	0.70	0.03	0.03
- Upside Beta	0.61	0.69	-0.01	-0.08
- Downside Beta	0.90	0.71	0.07	0.13

The table shows summary statistics for the decomposition of a 2% out-of-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 2% OTM BuyWrite Index (BXY), over the period March 25, 1996, until December 31, 2014. The backtest is long the S&P 500 Index and short 2% out-of-the-money front-month S&P 500 call options, held to expiry. Its excess return is computed as:

$$r_{total,t} = \frac{spx_t + div_t - call_t}{spx_{t-1} - call_{t-1}} - r_{cash,t} - 1$$

These returns are then decomposed into three components: passive S&P 500 equity exposure, dynamic S&P 500 equity timing exposure due to the call option's time varying delta, and short volatility exposure.

The three returns in the decomposition are computed as follows:

$$r_{pe,t} = \overline{\Delta}_p * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

$$r_{sv,t} = \frac{(call_{t-1} - call_t) + \Delta_{c,t-1} * \left(spx_t + div_t - spx_{t-1} * (1 + r_{cash,t})\right) + call_{t-1} * r_{cash,t}}{spx_{t-1} - call_{t-1}}$$

$$r_{ae,t} = \left(\Delta_{p,t-1} - \overline{\Delta}_p\right) * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

where r_t is the excess return for the respective component, $r_{cash,t}$ is US 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price, $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics, $\Delta_{p,t}$ is the portfolio's properly levered delta exposure, calculated as:

$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

and $\overline{\Delta}_p$ is the full-sample average portfolio delta exposure over all dates on which the out-of-the-money call options were sold.

Risk contribution is defined as the covariance of the component with the full strategy, divided by the variance of the full strategy. Volatility, skew, kurtosis, alpha, beta, upside beta and downside beta were all computed using 21-day overlapping returns.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Table 4: 2% Out-Of-The-Money Overwriting Sample Correlation Matrix

	2% OTM Covered Call Strategy	Passive Equity	Short Volatility	Equity Timing
2% OTM Covered Call Strategy	1.00	0.94	0.39	0.43
Passive Equity	0.94	1.00	0.27	0.13
Short Volatility	0.39	0.27	1.00	0.06
Equity Timing	0.43	0.13	0.06	1.00

The table shows correlations for the decomposition of a 2% out-of-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 2% OTM BuyWrite Index (BXY), over the period March 25, 1996, until December 31, 2014. The backtest is long the S&P 500 Index and short 2% out-of-the-money front-month S&P 500 call options, held to expiry. Its excess return is computed as:

$$r_{total,t} = \frac{spx_t + div_t - call_t}{spx_{t-1} - call_{t-1}} - r_{cash,t} - 1$$

These returns are then decomposed into three components: passive S&P 500 equity exposure, dynamic S&P 500 equity timing exposure due to the call option's time varying delta, and short volatility exposure.

The three returns in the decomposition are computed as follows:

$$r_{pe,t} = \overline{\Delta}_p * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

$$r_{sv,t} = \frac{(call_{t-1} - call_t) + \Delta_{c,t-1} * (spx_t + div_t - spx_{t-1} * (1 + r_{cash,t})) + call_{t-1} * r_{cash,t}}{spx_{t-1} - call_{t-1}}$$

$$r_{ae,t} = (\Delta_{p,t-1} - \overline{\Delta}_p) * \left(\frac{spx_t + div_t - spx_{t-1}}{spx_{t-1}} - r_{cash,t} \right)$$

where r_t is the excess return for the respective component, $r_{cash,t}$ is US 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price, $\Delta_{c,t}$ is the call option's percent delta as reported by OptionMetrics, $\Delta_{p,t}$ is the portfolio's properly levered delta exposure, calculated as:

$$\Delta_{p,t} = (1 - \Delta_{c,t}) * \left(\frac{spx_t}{spx_t - call_t} \right)$$

and $\overline{\Delta}_p$ is the full-sample average portfolio delta exposure over all dates on which the out-of-the-money call options were sold.

Correlations were computed using 21-day overlapping returns.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Table 5: At-The-Money Overwriting Sample
Return Decomposition across Sub-Periods (Annualized)

1996-2001	At-The-Money Covered Call Strategy	Passive Equity	Short Volatility	Equity Timing
Excess Return (Simple)	7.4%	3.9%	3.0%	0.5%
Volatility	10.9%	8.7%	2.1%	5.4%
Sharpe Ratio (Simple)	0.68	0.45	1.49	0.08
Risk Contribution	100%	68%	9%	23%

2002-2008	At-The-Money Covered Call Strategy	Passive Equity	Short Volatility	Equity Timing
Excess Return (Simple)	0.5%	-1.2%	0.8%	0.8%
Volatility	12.3%	8.6%	2.1%	4.5%
Sharpe Ratio (Simple)	0.04	-0.13	0.40	0.18
Risk Contribution	100%	65%	6%	28%

2009-2014	At-The-Money Covered Call Strategy	Passive Equity	Short Volatility	Equity Timing
Excess Return (Simple)	10.8%	8.6%	2.0%	0.2%
Volatility	10.7%	7.9%	1.4%	4.5%
Sharpe Ratio (Simple)	1.01	1.09	1.39	0.04
Risk Contribution	100%	69%	7%	24%

The tables shows summary statistics for the decomposition of an at-the-money covered call strategy mimicking the methodology of the CBOE S&P 500 BuyWrite Index (BXM), over 3 sub-periods. The backtest is long the S&P 500 Index and short at-the-money front-month S&P 500 call options, held to expiry. Its excess return is computed as:

$$r_{total,t} = \frac{spx_t + div_t - call_t}{spx_{t-1} - call_{t-1}} - r_{cash,t} - 1$$

where $r_{cash,t}$ is US 3-Month LIBOR, spx_t is the S&P 500 Index, div_t represents the dividends payable to the S&P 500 (expressed in S&P 500 Index points), $call_t$ is the call price.

These returns are then decomposed into three components: passive S&P 500 equity exposure, dynamic S&P 500 equity timing exposure due to the call option's time varying delta, and short volatility exposure.

Risk contribution is defined as the covariance of the component with the full strategy, divided by the variance of the full strategy. Volatility is computed using 21-day overlapping returns.

The 3 sub-periods are: March 25, 1996, until December 31, 2001, January 1, 2002, until December 31, 2008, and January 1, 2009, until December 31, 2014.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's

Table 6: Summary Statistics
Returns (Annualized)

1996-2014	S&P 500	BXM	Hedged BXM	BXY	Hedged BXY
Excess Return (Simple)	6.8%	4.9%	5.1%	6.3%	6.5%
Excess Return (Geom.)	5.2%	4.2%	4.8%	5.4%	5.8%
Volatility	16.4%	11.4%	9.2%	13.3%	12.4%
Sharpe Ratio (Geom.)	0.32	0.37	0.52	0.41	0.46
Skew	-0.7	-1.6	-1.1	-1.1	-0.9
Kurtosis	3.1	7.6	4.2	5.0	3.7
Beta to S&P 500 Index	1.00	0.62	0.54	0.76	0.75
- Upside Beta	1.00	0.46	0.49	0.61	0.71
- Downside Beta	1.00	0.85	0.60	0.89	0.78

The table shows summary statistics for various hedged and unhedged covered call series, as well as the S&P 500. The "BXM" column refers to the actual returns of the CBOE S&P 500 BuyWrite Index, which models a portfolio that is long the S&P 500 Index and short at-the-money front month S&P 500 call options, held to expiry. The "BXY" column refers to the actual returns of the CBOE S&P 500 2% OTM BuyWrite Index (BXY), which models a portfolio that is long the S&P 500 Index and short 2% out-of-the-money front month S&P 500 call options, held to expiry.

To compute the "Hedged" series for BXM and BXY, we first simulate covered call backtests mimicking the methodologies of the indices. Each day, we compute the equity exposure of the call option according to the Black-Scholes model. We then hedge the "active equity exposure" using S&P 500 index futures, where the "active equity exposure" is defined as the difference between the call's delta and the expected delta of the selected call options on options rebalance dates (defined as 0.5 for the at-the-money backtest and 0.3 for the 2% out-of-the-money backtest). The "Hedged BXM" column refers to the sum of the actual BXM returns and the time series of index future hedge returns for our simulated BXM backtest. The "Hedged BXY" column refers to the sum of the actual BXY returns and the time series of index future hedge returns for our simulated BXY backtest.

Returns are excess of US 3-Month LIBOR. Volatility, skew, kurtosis, beta, upside beta, and downside beta are computed using 21-day overlapping returns.

The date range is March 25, 1996, until December 31, 2014.

Source: AQR, Option Metrics, Chicago Board Options Exchange, Standard and Poor's