# Option-Writing Strategies in a Low-Volatility Framework

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O ver the last decade, the invest-
ment community has witnessed
a rapid rise in the number of
assets invested in low-volatility
strategies.[1] The low-volatility anomaly refers
to the empirical observation that portfolios
comprising low-beta stocks tend to substan-
tially outperform their higher-beta counter-
parts. This is a paradoxical outcome from the
perspective of the capital asset pricing model
(CAPM). Given the increasing popularity
of low-volatility strategies, the anomaly is of
more than theoretical interest; it offers poten-
tially intriguing investment opportunities.

Several behavioral finance hypotheses
have been proposed to explain the low-
volatility anomaly. One of the most widely
cited explanations—investors' preference for
lotterylike gambles—contends that individ-
uals prefer to speculate in stocks with high
volatility, especially those with high positive
skewness. Another explanation argues that
borrowing-constrained investors may use
high-beta stocks to increase portfolio risk
and expected return. Both behaviors create
excess demand for high-beta stocks, which
drives their prices up and their returns down
relative to low-beta stocks.

Although studies of the low-volatility
anomaly have focused almost exclusively on
equities, industry practitioners have extended
their low-volatility offerings to include cov-
ered call option strategies. Call options provide

highly leveraged exposure to the upside of the
underlying stocks with very modest commit-
ment of capital. They not only have a lottery-
like positive skew but can also be employed
by leverage-constrained investors as a tool
for increasing risk-adjusted portfolio returns.
These characteristics suggest that call options
may be systematically overpriced.[2]

Covered call writing, in which inves-
tors sell call options against their stock hold-
ings as a means of enhancing portfolio return
and reducing risk,[3] is a common investment
strategy that has been employed since the
establishment of the Chicago Board Options
Exchange (CBOE) in 1973. It is often referred
to as a buy–write strategy because investors
seek to outperform their benchmark indexes
by *writing* index call options against equity
shares that they have *bought* long. The CBOE
introduced the Buy–Write Monthly Index
(BXM) in 2002 as a benchmark for evalu-
ating buy–write investment strategies.[4]

Buy–write strategies tend to exhibit
risk–return profiles that are similar to those
of low-volatility equity portfolios. To date,
however, studies on low-volatility investing
have not included buy–write strategies. The
objective of our research is to determine
whether buy–write strategies have risk char-
acteristics that are sufficiently different from
stock-only low-volatility strategies to pro-
vide diversification benefits to low-volatility
investors.

This article seeks to contribute in three primary areas. First, we compare different buy–write strategies based on writing call options with varying maturities and rebalancing frequencies. We find that selling three-month-to-maturity index call options is significantly more effective at capturing the buy–write outperformance than other maturities. Identifying the sources of the performance differential advances our understanding of buy–write strategies. Second, we compare the risk and return profiles of buy–write strategies with those of conventional low-volatility equity strategies. In particular, we explore whether they share common factor exposures and whether buy–write strategies offer new and attractive sources of premiums. We find that buy–write strategies, unlike low-volatility equity strategies, do not load on the value, small-cap, and betting against beta (BAB) factors; however, they do exhibit a market beta that is significantly below one. This suggests that the volatility reduction for both categories of low-volatility strategies is driven by the reduction in market beta whereas their performances are attributable to different factors, and thus they serve to diversify each other. Finally, by using buy–write strategies, we provide empirical support for the preference-for-lottery and leverage-constraint hypotheses. This is particularly interesting because, while the buy–write outperformance is uncorrelated with low-volatility equity outperformance, the underlying investor behaviors may be the same.

## LITERATURE REVIEW

### Covered Call Strategy

Practitioners and academics have discussed the covered call strategy since the debut of the CBOE. Merton et al. [1978] used simulated call option prices to construct hypothetical buy–write portfolios over the period 1963–1975 to demonstrate that option writing reduces both risk and return. However, the usefulness of the study has been questioned: Some argue that the results are biased given the divergence of simulated option prices from actual prices; others have stated that the study period chosen covers a long bull market, which might not be representative of the average experience. Grube et al. [1979] questioned the impact of the transaction cost on the result, and Trennepohl and Dukes [1981] found that covered call writing lowered a portfolio's standard deviation and improved returns over the

period 1974–1977 and various subsamples. Trennepohl and Dukes [1981] also observed a reduction in positive skewness of the covered call portfolio, suggesting that the skewness of the distribution might play an appreciably more important part in option pricing than is reflected in standard models.

In the first part of our empirical study, we compare buy–write strategies using index call options with different times to maturity and rebalancing frequencies. The selection of the period 1996–2012 covers numerous bull and bear markets, including spectacular bubbles and crises. This longer sample should provide a more representative and comprehensive dataset for empirical analysis and interpretation. We also use bid–ask transaction costs in estimating the potential economic benefits of the buy–write strategies.

### Low-Volatility Anomaly

The recent literature has argued that the low-volatility premium is related to the investor's preference for positive skewness in asset returns. Building on the cumulative prospect theory set forth by Kahneman and Tversky [1979], Barberis [2013] posits that a positively skewed security—a security whose return distribution has a right tail that is longer than its left tail—will be overpriced relative to the valuation it would command from a representative investor in the classic asset pricing literature. Investors who use the stock market for gambling or who are leverage-constrained can prefer positively skewed assets.[5] According to the preference-for-gambling hypothesis, speculative investors can use highly positively skewed stocks and call options, which naturally have high positive skew, as lottery tickets. Leverage-constrained investors can increase portfolio risk and expected return by overallocating to high-beta stocks (which have natural positive skew) and call options (which have embedded economic leverage). Barberis [2013] finds that out-of-the-money options, which have positively skewed returns, tend to be overvalued and thus deliver low returns relative to the standard option pricing model expectations. Conrad et al. [2013] also find that stocks with negative ex ante skewness yield higher returns.

If Barberis [2013] is right, the preference for positively skewed assets drives the performance advantage of low-volatility equity strategies—which underweight high-beta stocks—and of buy–write strategies, which

sell call options. Indeed, on the surface, the two strategies share similar long-horizon risk and return characteristics. Are they, therefore, similar to each other from a factor exposure perspective? This is a key question we address in the second part of our empirical analysis.

Chow et al. [2014] studied low-volatility portfolios constructed on the basis of minimum variance, low volatility, and low beta. They argued that all low-volatility equity portfolios have similar factor characteristics: They overweight the value, BAB,[6] and duration[7] factors to generate excess returns. This implies that investors would not be able to create meaningful diversification by combining different low-volatility equity portfolios. Additionally, as pointed out by Chow et al. [2014] and Kuo and Li [2013], most low-volatility methodologies have several undesirable attributes in common: high turnover in illiquid names and concentrated country/industry allocations.

In the context of Chow et al. [2014], it is interesting to ask whether buy–write strategies provide new sources of premiums and risk exposure. We explore this possibility in this article. However, in the final section of our empirical analysis, we also examine whether the active country/industry exposures of buy–write strategies create undesirable concentrations and result in unacceptable tracking error.

### Data and Methodology

While there is a large variety of buy–write strategies, we examine only one simple version and its natural variants. Specifically, we invest 100% long into the S&P 500 Cash Index[8] and then sell S&P 500 Index call options. This is similar to the CBOE's BXM index construction. Variants considered include different option maturities and rebalancing cycles.

**Data.** This study uses CBOE's OptionMetrics Database. The dataset consists of closing bids and offers of all options and indexes quoted across all exchanges for the period from January 1996 to December 2012.[9] The length of the sample period allows assessment of buy–write performance in different market conditions. The options are European style, thus eliminating the complexity of analyzing optimal early exercise. The OptionMetrics data also provide us with computed delta, theta, gamma, vega, and implied volatility statistics, which we apply in the option attribution analysis. The returns on the S&P 500 are total returns. For purposes of comparison, we obtained the equity time series of other prevalent low-volatility strategies from Chow et al. [2014]. We obtained Carhart four-factor time series returns data from the Kenneth French Data Library,[10] and for the additional factors of BAB and duration, we looked again to Chow et al. [2014].[11]

**Construction methodology.** The benchmark BXM is formed by writing a one-month at-the-money (ATM) call against a long position in the S&P 500. The portfolio was fully covered. The call was held to expiration, at which time a new one-month call was written. In this article, we extended the BXM strategy by writing longer-dated, three-month call options with rebalancing frequencies of one month and three months to form two additional variants. Specifically, the three-month monthly rebalanced buy–write portfolio sells a three-month call option on the S&P 500 at time 0; the call option was then bought back one month later, and a new three-month call option was simultaneously sold. The holding period for the three-month-to-maturity call option was one month each time. For the portfolio rebalanced quarterly, the three-month call was held until its expiration, at which point a new three-month call option was written. We chose the three-month option rather than longer-dated options for practical reasons: Only three-month- and one-month-to-maturity options are issued every month.

For our study, we were interested in the effect of varying option maturities and rebalancing frequencies on the performance of the buy–write strategy. Additionally, for robustness, we considered five different strikes of the call options, from 5% in-the-money to 5% out-of-the money with a 2.5% increment. We also compared the buy–write strategies with the S&P 500 Total Return Index to illustrate the impact of the covered call strategy on portfolio risk and return.

To calculate one-month holding-period returns for our buy–write strategy, we first computed the daily returns as follows:

$$R_{s,t+1} = (d_{t+1} + I_{t+1} - I_t) / I_t$$

$$R_{C,t+1} = (d_{t+1} + I_{t+1} + C_t - I_t - C_{t+1}) / (I_t - C_t)$$

where

$R_{s,t+1}$ = daily return of the S&P 500 from day $t$ to day $t + 1$;

$d_{t+1}$ = cash dividend paid on day $t + 1$;
$I_t$ = spot price of the S&P 500 at the close of the day $t$;
$R_{C,t+1}$ = daily return of the covered call portfolio from day $t$ to day $t + 1$;
$C_t$ = the reported call price at the close of day $t$.

Notice that when adjusting for the implied transaction cost induced by the option bid–ask spread, the call price is assumed to be sold to open at the prevailing bid price before the market close. Similarly, the call will be bought to close the position at the prevailing ask price at the end of the rebalancing day. Other than when the call options are traded, daily returns are based on the midpoint of the last pair of bid–ask quotes of every trading day. If, for specific analytical purposes, the bid–ask spread is not taken into account, then the midpoint price is applied when the option is sold to open or bought to close. The monthly returns are then computed as:

$$R_{monthly} = \prod_{t=1}^{\substack{\# \, of \, days \\ in \, month}} (1 + R_{daily,t}) - 1$$

In a later section of this article, we also examine other option-based strategies, in which a straddle is sold in conjunction with a long S&P 500 position. The return calculation formulas already provided extend easily to these strategies.

## PERFORMANCE AND DISCUSSION

In this section, we report the returns of the three ATM[12] buy–write strategies and the buy-and-hold S&P 500 portfolio for the period from February 1996 to December 2012, inclusive. We are primarily interested in understanding the factors that contribute to the observed performance differences. Unless otherwise stated, the reported returns are geometric and annualized.

Exhibit 1 provides a graphical presentation of the cumulative return for the three buy–write portfolios and the S&P 500. All portfolios are normalized to a level of $1 as of January 31, 1996, the start of the measurement period. It is evident from the graph that, ignoring transaction costs, the cumulative growth of the three-month-to-maturity monthly rebalanced (3mo-1mo) buy–write

strategy significantly outperforms the benchmark with far less volatility. The one-month monthly rebalanced (1mo-1mo) strategy outperforms the S&P 500 as well but underperforms the 3mo-1mo portfolio. The outperformance of the 3mo-1mo buy–write is driven in large part by the significantly smaller drawdown experienced during the tech bubble collapse and the global financial crisis (GFC). On the other hand, the three-month-to-maturity quarterly rebalanced (3mo-3mo) strategy merely keeps pace with the S&P 500 benchmark return; nonetheless, it does provide volatility reduction, similar to the other buy–write strategies.

Exhibit 2 reports more detailed risk and return statistics for the three buy–write strategies. Note that all three strategies produce a higher Sharpe ratio than the S&P 500 benchmark, which is also true of adjusting for the bid–ask spread. All buy–write strategies are also less volatile and have a lower drawdown versus the S&P 500, similar to low-equity volatility portfolios. Also as in low-volatility equity portfolios, the higher Sharpe ratio is not solely the result of lower return volatility. The monthly rebalanced buy–write portfolios provide superior long-term returns as well.

As suggested by the conditional returns reported in Exhibit 2, buy–write portfolios sacrifice upside participation in raging bull-market months. In exchange, they gain substantial downside protection in bear-market months. Empirically, there are more significant market meltdowns than "melt-ups," which make this trade-off potentially desirable. We observe in Exhibit 1 that performance during bear markets makes a significant difference to compounded growth. This is further supported by the observation that the maximum drawdowns of the buy–write portfolios were far less than that of the underlying index during the dot-com bust and the GFC (Exhibit 2). The improvement to compound return driven by a reduction in the left tail is similarly observed for low-volatility equity strategies.

When investors sell a call option against the S&P 500, they are betting that the index will undergo a sufficiently mild increase in value over the holding period; specifically, the price increase should not cause the call option to increase in value. In the language of option pricing, the S&P 500 call option's time value (theta) declines over time, but its expiration payoff increases with the S&P 500 level, which has a positive average drift. The two offsetting effects combine to determine the profit from selling the call option. Because the S&P

# EXHIBIT 1

**Growth of $1 Excluding Transaction Costs, February 1996–December 2012**
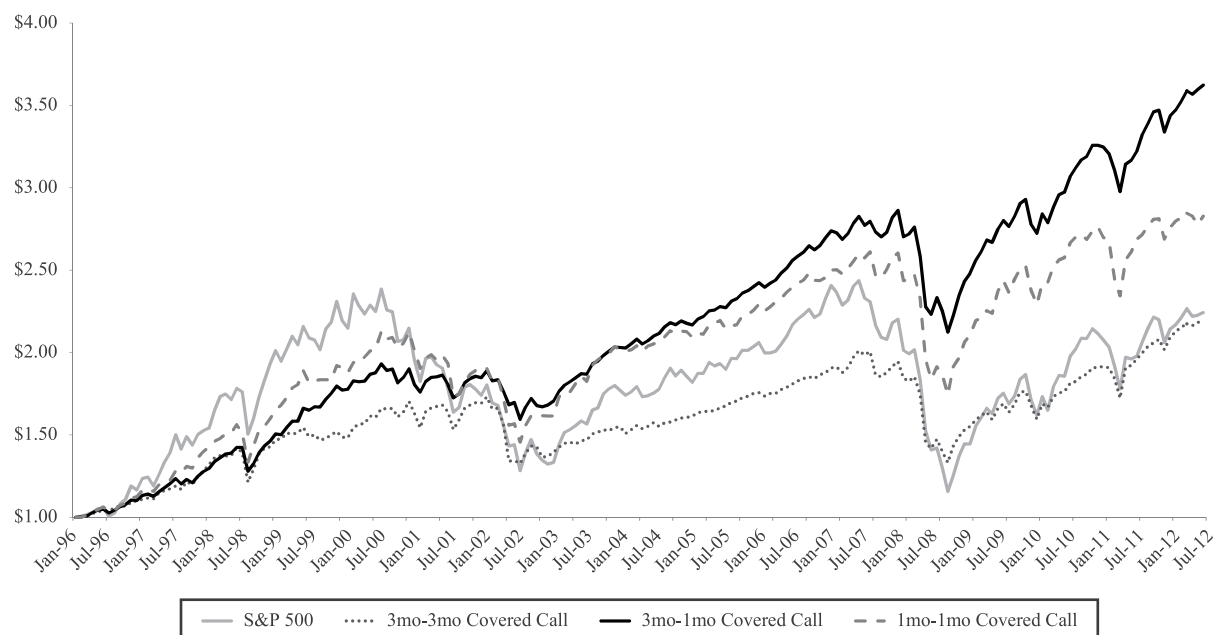


*Source: OptionMetrics.*

# EXHIBIT 2

**Risk and Return Characteristics, February 1996–December 2012**

| Statistics | S&P 500 Benchmark | 3-Month Quarterly Rebalancing ATM Covered Call (3mo-3mo) | 3-Month Monthly Rebalancing ATM Covered Call (3mo-1mo) | 1-Month Monthly Rebalancing ATM Covered Call (1mo-1mo) |
|---|---|---|---|---|
| **Exclude Bid–Ask Spread** | | | | |
| Annualized Geometric Return | 4.89% | 4.78% | 7.91% | 6.34% |
| Annualized Arithmetic Return | 6.08% | 5.29% | 8.02% | 6.84% |
| Standard Deviation | 16.03% | 10.89% | 8.72% | 11.54% |
| Sharpe Ratio | 0.13 | 0.18 | 0.57 | 0.30 |
| Maximum Drawdown | −52.56% | −33.79% | −25.84% | −33.19% |
| Maximum Drawdown Period | Oct 07 to Feb 09 | Oct 07 to Feb 09 | May 08 to Feb 09 | Dec 07 to Feb 09 |
| No. Months of Sample Period | 203 | 203 | 203 | 203 |
| No. Months Outperformed S&P 500 | N/A | 106 | 114 | 107 |
| | | | | |
| **Include Bid–Ask Spread** | | | | |
| Annualized Geometric Return | | 4.35% | 6.27% | 5.36% |
| Annualized Arithmetic Return | | 4.88% | 6.48% | 5.92% |
| | | | | |
| **Conditional Return** | | | | |
| 2% S&P 500[a] | 5.07% | 2.48% | 2.54% | 2.93% |
| −2% S&P 500[b] | −5.56% | −3.03% | −2.72% | −3.33% |

[a]*In 72 of 203 months, S&P 500 had a monthly return greater than 2%; conditional returns show the average of the 72 monthly returns of the four portfolios.*

[b]*In 51 of 203 months, S&P 500 had a monthly return worse than −2%; conditional returns show the average of the 51 monthly returns of the four portfolios.*

*Source: OptionMetrics.*

500 call option is a high-beta security, it is expected to produce high returns under standard asset pricing assumptions. In the classical setting, selling a covered call on the S&P 500 portfolio is equivalent to hedging away the market beta exposure (albeit in a nonlinear, asymmetric manner); in theory, this should reduce both portfolio volatility and expected return. However, empirically, we observed an increase in return in conjunction with volatility reduction for the 3mo-1mo and 1mo-1mo buy–write strategies, suggesting S&P 500 call options may be overvalued relative to the prediction of the standard models. A possible explanation may be that the buy–write strategy is negatively skewed—that is, it sells off positively skewed lottery securities to market speculators—and captures a very substantial premium associated with this undesirable third-moment characteristic. This hypothesis is consistent with observations gleaned from Barberis [2013] and Conrad et al. [2013].

Ultimately, whether selling covered calls makes for a good risk-adjusted investment depends on the improvement in the portfolio mean return given the reduction in positive skew relative to the S&P 500. It is important to understand that the buy–write strategy always has a better return in down markets. Exhibit 3 demonstrates the empirical return distribution of the 3mo-1mo buy–write strategy compared with the S&P 500. The attributes of interest in the return distribution relative to the S&P 500 investment are the absence of a significant portion of the positive tail and the resulting shift in the distribution mean.

Rebalancing longer-dated options on a monthly schedule is the optimal choice for several reasons. The three-month-to-maturity call option is particularly efficient because of both its liquidity and its availability at the monthly frequency; other long-dated options are not created monthly. Selling one-month-to-maturity call options on a monthly basis generates substantially less premium income than selling three-month-to-maturity call options monthly. Similarly, selling three-month-to-maturity call options quarterly also collects significantly less total premiums than doing so monthly. These claims hold true even after adjusting for the lower liquidity of the three-month call options and the cost of higher-frequency turnover. The lower drawdown of the 3mo-1mo portfolio versus the other buy–write portfolios is also consistent with its outperformance. We will explore in greater detail the potential explanations for the outperformance of the 3mo-1mo buy–write over the

## Exhibit 3
**Monthly Lognormal Return Distributions, February 1996–December 2012**
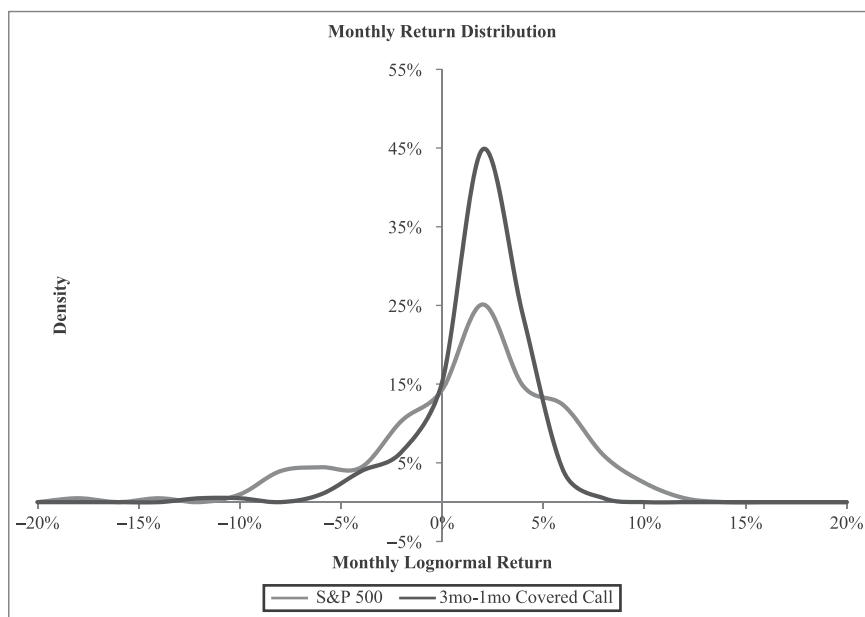


*Source: OptionMetrics.*

3mo–3mo and 1mo–1mo buy–write later in this article, but for the time being, we note that traditional mean-variance analysis is insufficient.

We then adopted the 3mo–1mo as our buy–write flavor du jour for the convenience of exposition. We also varied the 3mo–1mo strategy by writing options with different strike prices, thus providing additional robustness checks as well as generating more nuanced comparative statics. We compared these 3mo–1mo buy–write variants to three representative low-volatility strategies based on minimum-variance, low-volatility, and low-beta constructions.[13] Exhibit 4 displays the summary risk and return statistics of the five monthly rebalanced buy–write portfolios and the three leading low-volatility strategies over the period from February 1996 to December 2012. We also plotted the strategies' cumulative returns to provide visual information on the time series and the subsamples of performance in Exhibit 5.

Generally, buy–write strategies are able to produce lower volatilities, smaller negative monthly returns, and lower drawdowns than low-volatility equity portfolios. The annualized volatilities for the buy–write strategies average 9%, compared with 12% for the average low-volatility equity portfolio and 16% for the S&P 500. The largest drawdown for the buy–write strategies is −25% on average, compared with the maximum drawdowns of −52% for the S&P 500 and −36% on average for the low-volatility

equity strategies. The worst monthly return for the buy–write portfolios averaged approximately −12%, better than the worst monthly returns of −16.94% for the S&P 500 and −13% for the average low-volatility equity strategy. This came at the expense of higher negative skew, which is not driven by a more severe negative tail but rather by the lack of a meaningful positive tail. In other words, buy–write strategies do not provide participation in major bull markets, a fact that is also made evident by the substantially lower maximum monthly returns versus the low-volatility equity strategies. By comparison, low-volatility equity strategies have statistically and economically modest excess skewness versus the S&P 500.

Last but not least, as Exhibit 5 highlights, such comparative results will be heavily dependent on the ending point of the analysis. Key endpoints of analysis include mid-2000 (strong equity bull market), late 2001 to late 2002 (equity market crash), late 2007 (end of pre-GFC bull market), early 2009 (end of GFC equity market crash), and December 2012 (mid-bull market point). These endpoints show that low-volatility strategies typically outperform the buy–write strategies through an equity bull market, only to give these relative gains back during the subsequent bear market periods. A key exception to this trend is the bull market of the late 1990s, when the low-volatility equity strategies as a group dramatically underperformed and subsequently

# E X H I B I T  4
**Monthly Risk and Return Statistics, February 1996–December 2012**

| 1/31/1996–12/31/2012 | Return | | Standard Deviation | Sharpe Ratio | Skewness | Maximum Monthly Return | Minimum Monthly Return | Maximum Drawdown |
|---|---|---|---|---|---|---|---|---|
| | Arithmetic | Geometric | | | | | | |
| **Benchmark** | | | | | | | | |
| S&P 500 Buy-and-Hold | 6.08% | 4.89% | 16.03% | 0.13 | −0.76 | 10.77% | −16.94% | −52.56% |
| | | | | | | | | |
| **Three-month Monthly Rebalancing Covered Call Strategy** | | | | | | | | |
| 5% ITM | 6.85% | 6.87% | 6.14% | 0.65 | −0.91 | 4.48% | −9.70% | −17.81% |
| 2.5% ITM | 7.58% | 7.56% | 7.32% | 0.64 | −0.99 | 4.89% | −10.78% | −21.55% |
| ATM | 8.02% | 7.91% | 8.72% | 0.57 | −1.05 | 5.57% | −11.87% | −25.84% |
| 2.5% OTM | 8.26% | 8.00% | 10.30% | 0.49 | −0.93 | 6.18% | −12.91% | −29.97% |
| 5% OTM | 8.09% | 7.64% | 11.82% | 0.40 | −0.80 | 6.90% | −13.70% | −34.24% |
| | | | | | | | | |
| **Prevailing Low Volatility Strategy** | | | | | | | | |
| Minimum Variance (PCA) | 8.96% | 8.67% | 11.061% | 0.53 | −0.47 | 7.89% | −13.33% | −32.83% |
| Low Volatility (1/Vol) | 9.70% | 9.34% | 12.070% | 0.53 | −0.79 | 11.33% | −12.80% | −39.37% |
| Low Beta (1/β) | 10.30% | 9.99% | 12.186% | 0.58 | −0.80 | 11.06% | −14.42% | −35.81% |

*ITM = in the money; OTM = out of the money; PCA = principle component analysis.*

*Sources: Chow et al. [2014] and OptionMetrics.*

**Cumulative Performance of Low-Volatility U.S. Strategies vs. S&P 500, February 1996–December 2012**
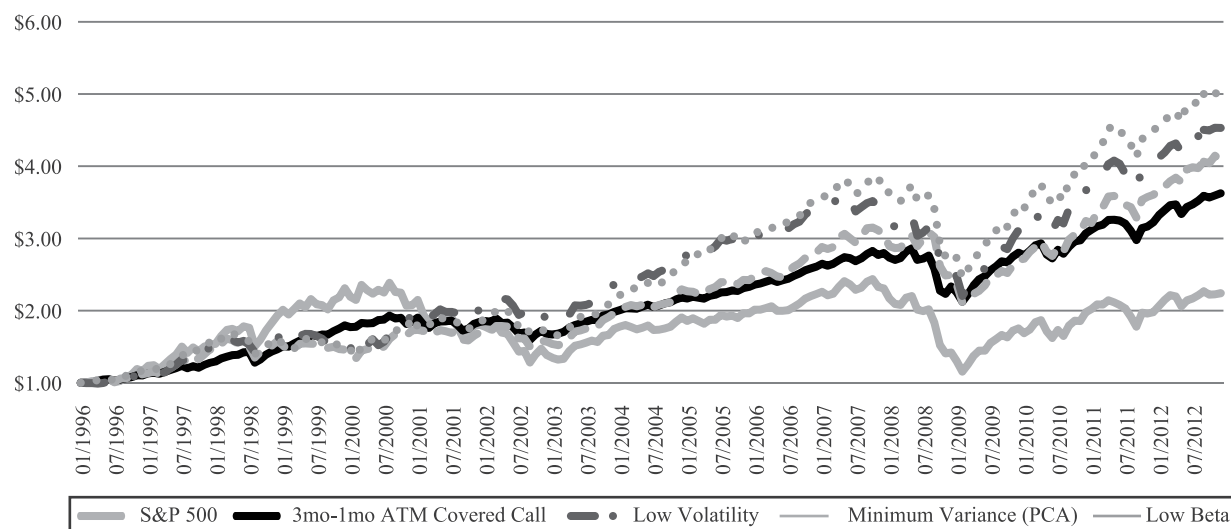


*Sources: Chow et al. [2014] and OptionMetrics.*

recovered (particularly versus the 3mo–1mo buy–write) during the subsequent bear market.

### Factor Analysis

An augmented Fama–French–Carhart four-factor model (FFC-4) is useful for analyzing the comparative performance of the buy–write and low-volatility strategies in greater depth. Chow et al. [2014] found that, in addition to the standard FFC-4 factors, low-volatility strategies have exposure to BAB and duration. Exhibit 6 shows the factor regression results based on the corresponding six-factor model.

The market betas of the buy–write and low-volatility equity portfolios alike are substantially below unity; indeed, the 3mo-1mo buy–write has a market beta of 0.51, meaningfully below that of the low-volatility equity strategies. However, it is important to note that the beta for a buy–write strategy varies over time in a mechanical way: When the market rallies, the buy–write portfolio beta continues to decline toward zero. This negative convexity is known as *negative gamma* in option pricing. The gamma effect cannot be measured by the linear factor models that are popular in standard asset pricing, but insofar as this undesirable negative gamma produces a premium, it partially explains the economically large and statistically significant factor-

adjusted alpha reported in Exhibit 6. The premium from selling positive skew also contributes to the factor-adjusted alpha.

When BAB is specified as a factor, the low-volatility equity strategies do not exhibit statistically significant factor-adjusted alpha. Frazzini and Pedersen [2014] proposed BAB to potentially capture the combined effect of the preference for lottery and leverage aversion or constraints on the cross-section of equities. However, the buy–write strategies do not load on BAB, indicating that the two (behavioral) effects do not express themselves in the equity market and the options market in a correlated way. Nor does the buy–write strategy load on the value factor, which is the primary contributor to the return outperformance of low-volatility equity strategies. The existence of factor-adjusted alpha and the differences in factor loading suggest that the buy–write strategy can be blended with a low-volatility equity strategy to create meaningful diversification.

### Sector Concentration

A common complaint about simple low-volatility equity strategies is their substantial concentrations in the utility and financial sectors. This allocation exposes the portfolio to industry shocks, which are not known to provide a risk premium over the long horizon. In Exhibit 7,

# Exhibit 6
**Factor Exposures Based on 6-Factor Carhart 4 + BAB + DUR Model, February 1996–December 2012**

| 2/1996–12/2012 | Annual Alpha | Market (S&P 500-RF) | Size (SMB) | Value (HML) | Momentum (MOM) | Betting Against Beta (BAB) | Duration (DUR) | R² |
|---|---|---|---|---|---|---|---|---|
| 3mo-1mo ATM Covered Call | 3.42%** | 0.51** | 0.06 | 0.00 | −0.01 | 0.01 | 0.00 | 0.90 |
| 1mo-1mo ATM Covered Call | 1.52% | 0.63** | 0.07* | 0.02 | −0.01 | 0.05 | −0.01 | 0.78 |
| 3mo-3mo ATM Covered Call | −0.34% | 0.58** | 0.10** | 0.06 | 0.00 | 0.02 | 0.06 | 0.71 |
| Minimum Variance | 1.48% | 0.61** | 0.18** | 0.07* | −0.02 | 0.28** | 0.04 | 0.80 |
| Low Volatility | 1.74% | 0.65** | 0.10** | 0.16* | −0.05* | 0.34** | 0.03 | 0.86 |
| Low Beta | 1.84% | 0.64** | 0.21** | 0.13** | −0.02 | 0.37** | 0.03 | 0.81 |

*Significant at the 10 percent level; **Significant at the 1 percent level.*
*Sources: Chow et al. [2014] and OptionMetrics, and Kenneth French Data Library.*

# Exhibit 7
**RMSE of Rolling 36-Month Industry Betas Based on S&P 500 Benchmark, January 1999–December 2012**

| 2/1996–12/2012 | Non-Dur | Dur | Manu | Energy | Chem | Tech | Telecom | Utils | Retail | Health | Finance | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3mo-1mo Covered Call | 0.107 | 0.047 | 0.169 | 0.065 | 0.096 | 0.121 | 0.097 | 0.069 | 0.084 | 0.074 | 0.117 | 0.168* |
| Minimum Variance | 0.221 | 0.067 | 0.194* | 0.104* | 0.181 | 0.216 | 0.131 | 0.241 | 0.084 | 0.161* | 0.167 | 0.155 |
| Low Volatility | 0.251* | 0.057 | 0.101 | 0.104 | 0.110 | 0.211 | 0.129 | 0.297* | 0.093* | 0.135 | 0.113 | 0.123 |
| Low Beta | 0.241 | 0.070 | 0.130 | 0.097 | 0.211* | 0.220* | 0.176* | 0.295 | 0.092 | 0.133 | 0.215* | 0.157 |

*Represents the portfolio with RMSE that is most statistically different from zero in each specific industry.*
*Sources: Chow et al. [2014] and OptionMetrics, and Kenneth French Data Library.*

we computed the active industry risk compared with the S&P 500 using rolling 36-month regression with the 12 industry portfolios as independent variables.[14] We report the root-mean-square error (RMSE) between the time series of measured industry betas of the selected strategy portfolio and that of the S&P 500.

As expected, the low-volatility strategies exhibit significantly larger variances in industry exposure than the S&P 500. This is especially true for the utility, financial, nondurable, and energy sectors, which are often overweights, and for technology, which is usually a significant underweight for low-volatility equity strategies. These active sector risks were not present in the buy–write strategy.

### Option Attribution Analysis

Although the factor analysis shows that the buy–write portfolio has different risk factor exposures than the low-volatility equity strategies, the linear regression fails to capture higher moment features, such as the negative skewness of the buy–write strategy. To further investigate the unexplained alphas in the factor regression, we use the Greeks to decompose the profit and loss (P/L) of

the option into the P/L due to market movement (delta and gamma), implied volatility (vega), and time decay (theta). To be specific, the daily P/L of the option in the three-month monthly rebalancing portfolio can be approximated using the following formula:

$$\text{Option P/L on day } t+1$$
$$= C_{t+1} - C_t \approx \Delta * (I_{t+1} - I_t) + \nu * (\sigma_{t+1} - \sigma_t)$$
$$+ \Theta * (\tau_{t+1} - \tau_t) + 0.5 * \Gamma * (I_{t+1} - I_t)^2$$

where

$\Delta$, $\nu$, $\Theta$, $\Gamma$ represent Delta, Vega, Theta, and Gamma, respectively;
$I_t$ = the underlying S&P 500 price on day $t$;
$\sigma_t$ = the implied volatility of the option on day $t$;
$\tau_t$ = time to maturity on day $t$.

Notice that the interest rate effect (called rho in the options literature) is not included here for the sake of simplicity, but the omission has little effect on the analysis. This attribution based only on four Greeks accounts for 98% of the total option P/L. The daily portfolio

return attributable to delta ($R_{\Delta,t+1}$), vega ($R_{\sigma,t+1}$), theta ($R_{\Theta,t+1}$), gamma ($R_{\Gamma,t+1}$), and the S&P 500 ($R_{I,t+1}$) are computed as follows:

$$R_{\Delta,t+1} = \frac{-\Delta * (I_{t+1} - I_t)}{I_t - C_t}$$

$$R_{\sigma,t+1} = \frac{-\nu * (\sigma_{t+1} - \sigma_t)}{I_t - C_t}$$

$$R_{\Theta,t+1} = \frac{-\Theta * (\tau_{t+1} - \tau_t)}{I_t - C_t}$$

$$R_{\Gamma,t+1} = \frac{-0.5 * \Gamma * (P_{t+1} - P_t)^2}{I_t - C_t}$$

$$R_{I,t+1} = \frac{d_{t+1} + I_{t+1} - I_t}{I_t - C_t}$$

The return due to delta and gamma map intuitively to market beta. This is evident from the equation, which clearly demonstrates the nonlinearity of the option's beta exposure. The return driven by theta, or the time decay, is related to the decay in the value of the positive skew (lottery ticket). Intuitively, buying a three-month at-the-money call option is equivalent to buying a lottery ticket for a premium (equal to time value) to bet on a market rally over the next three months. All else being equal, as we draw nearer to option maturity, the value of the lottery ticket declines because the likelihood of a large positive shock before expiration declines.

Although the writers of an ATM covered call option accept the liability for a large payout if the call option goes deep in the money, their unit position on the underlying price hedges away the upside market (delta) "risk." However, the option writers are inevitably exposed to a gamma loss: Although delta is a measure of option price sensitivity with respect to a small change in the underlying, delta itself also dynamically changes with the underlying price. Gamma captures the curvature that delta cannot fully describe, especially when there is a large movement in the underlying price. As option writers always short gamma, they will suffer large losses given any large market movement. In other words, the covered call portfolio unavoidably takes on a gamma loss of uncertain magnitude in exchange for a certain time premium. This combination of time premium (large probability but small gain) and gamma loss (small probability but large single loss) can be intuitively regarded

as selling lottery tickets, a business strategy with limited upside premium but unlimited downside risk.

Given this interpretation of the Greeks, we further divide the return of the covered call portfolio into four risk categories: market risk represented by the S&P 500 and delta return; lottery risk represented by theta and gamma return; ex ante volatility risk represented by vega return; and other option risks. Exhibit 8 summarizes the monthly returns of the components in the ATM covered call portfolio. The monthly returns are generated geometrically from the daily returns.

Over the sample period, writing a call option earns an attractive monthly return of 0.86% from the time premium (theta) while suffering from significant negative returns of −0.13% from sensitivity to the price change in the underlying (delta) and −0.62% from the rate of change in sensitivity (gamma). In addition, the highly negative skewness (−2.99) and positive kurtosis (11.95) indicate that the major risk of writing an option—namely, tail risk—is embedded in the gamma factor. Although it is a highly unlikely event, a major gamma loss usually happens at the worst time: when the market plummets. On average, however, the written call option generated a positive return of 0.16% that enhanced the performance of the overall portfolio.

Intuitively, the covered call portfolio can be regarded as taking on exposure to market, lottery, and volatility risk, each of which has a unique risk–return profile. Exhibit 8 shows that the lottery factor has a significantly positive monthly return, contributing about 40% of the total covered call portfolio return. The lower standard deviation of the market factor supports our earlier suggestion that the reduction in volatility mainly comes from the decreased market beta. However, there is reason to believe the lottery factor also makes a difference in this situation, given that its volatility is as low as 0.49%.

However, this low-volatility characteristic of the lottery factor in covered call writing seems anomalous, as financial theory consistently contends that investors cannot simultaneously reduce risk and increase returns in an efficient market. It is evident that the return of the lottery factor is significantly negatively skewed because of the gamma loss, which is a proxy for the risk of large market movements—both upside and, especially, downside. Conrad et al. [2013] argue that both ex ante positive kurtosis and negative skewness yield subsequently higher returns; from this perspective, the lottery premium may be owing to the investor's taking

**Greeks' Decomposition of Monthly Returns, February 1996–December 2012**

| 1/31/1996–12/31/2012 | Mean | Median | Standard Deviation | Skewness | Excess Kurtosis |
|---|---|---|---|---|---|
| **By Portfolio** | | | | | |
| S&P 500 Benchmark | 0.51% | 0.94% | 4.63% | −0.61 | 0.81 |
| ATM Covered Call | 0.67% | 1.21% | 2.52% | −1.56 | 4.39 |
| | | | | | |
| **By Factor** | | | | | |
| S&P 500 | 0.51% | 0.95% | 4.85% | −0.57 | 0.78 |
| Delta | −0.13% | −0.12% | 2.81% | 0.21 | 0.08 |
| Vega | −0.01% | 0.02% | 0.40% | −0.50 | 4.44 |
| Theta | 0.86% | 0.81% | 0.28% | 0.98 | 1.54 |
| Gamma | −0.62% | −0.48% | 0.55% | −2.99 | 11.95 |
| Residual | 0.03% | 0.00% | 0.21% | 2.62 | 21.34 |
| | | | | | |
| **By Risk** | | | | | |
| Market Risk (S&P 500 + Delta) | 0.37% | 0.75% | 2.14% | −1.18 | 2.60 |
| Lottery Risk (Gamma + Theta) | 0.23% | 0.31% | 0.49% | −3.25 | 16.23 |
| Implied Volatility Risk (Vega) | −0.01% | 0.02% | 0.40% | −0.50 | 4.44 |
| Other Option Risk (Residual) | 0.03% | 0.00% | 0.21% | 2.62 | 21.34 |

*Source: OptionMetrics.*

on substantial negative skewness (−3.25) and positive kurtosis (16.23). In other words, the call option tends to be "overpriced" because option writers require an extra skew risk premium for accepting a potentially unlimited loss, clearly suggesting that mean–variance dominance[15] is an inappropriate measure of performance for portfolios that include options (Leland [1999]).

Finally, the slightly negative return driven by the change of implied volatility is reasonable intuitively. Writing an option is essentially shorting implied volatility, a pricing input that is especially undesirable as it rapidly increases in times of crisis. Nonetheless, over the course of the market meltdown, implied volatility as a measure of market sentiment will reverse its uptrend and return to a normal level. The large negative return

**Daily Implied Volatility of the Three-Month ATM Call Option, February 1996–December 2012**
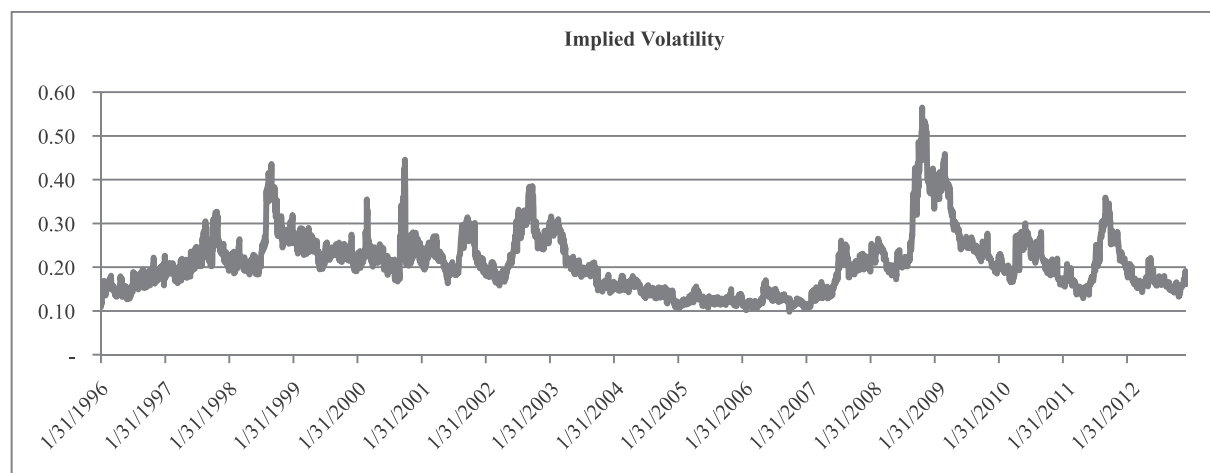


*Source: OptionMetrics.*

realized before the crisis is therefore offset by a subsequent positive return. Consequently, ex ante volatility risk is small in the long run. Exhibit 9 shows that empirically implied volatility demonstrates a long-term mean reversion pattern, indicating that this factor return is time-varying, depending on the holding period of the covered call strategy.

## CONCLUSION

Empirical evidence spanning the 17-year period from 1996–2012 supports the strategy of writing covered call options on the S&P 500 to improve the overall portfolio's risk-adjusted returns. The improvement results from earning a higher return with lower volatility relative to a buy-and-hold index portfolio. Unlike the traditional strategy of writing call options and holding them to maturity, the proposed approach involves rebalancing long-dated options on a monthly basis. Implementation of this strategy provides a cushion for large drawdowns, as experienced during the last two crises, and results in enhanced risk-adjusted performance. Our research, which covered various buy–write strategies over a range of strike price levels, indicates that the improvement in risk-adjusted performance results from the skewness premium that option writers gain in exchange for assuming the tail risk of a potentially unlimited loss. This finding, in conjunction with the preference-for-lottery hypothesis, suggests that the success of buy–write strategies can be quite satisfactorily explained in a traditional low-volatility framework. Because the factor loadings are mutually complementary, covered call writing also offers low-volatility investors a viable means of diversifying risk exposures.

## ENDNOTES

[1]Li [2013] observed the exponentially rising growth in both total assets under management and the number of managers engaged in low-volatility investing.

[2]Feldman and Roy [2005] noted that overvaluing call options is consistent with overconfidence and the confirmation bias; they described call purchasers as extremely confident investors who tend to discount evidence that conflicts with their upwardly biased expectations.

[3]Board et al. [2000] reported that all empirical studies of covered calls found a reduction in the variance of returns.

[4]See Whaley [2002] for a review.

[5]See Baker et al. [2011] for a review.

[6]BAB factor is proposed in Frazzini and Pedersen [2014] by creating a zero-beta factor portfolio, which includes long low-beta stocks and short high-beta stocks.

[7]The duration factor is proposed in Chow et al. [2014] by using the concatenated excess return time series from the Barclays Capital Long U.S. Treasury Index and the Ibbotson SBBI U.S. Government Long Treasury.

[8]Ideally, we would like to include the developed market, excluding the United States, and emerging markets in our research. Although the Morgan Stanley Capital International (MSCI), Europe, Australasia and Far East (EAFE), and Emerging Markets (EM) indexes serve as good representatives for the two markets, the corresponding option data on the MSCI iShares exchange-traded funds are incomplete and have mostly zero trading volume to conduct the covered call strategy. Thus, this article will mainly focus on the U.S. market.

[9]We exclude the January 1996 and January 2013 data to maintain similarity with the result of the other low-volatility strategies. The total sample size is 203 monthly holding periods.

[10]See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[11]The time series returns of low-volatility portfolios based on the optimization and heuristic approaches come from Chow et al. [2014].

[12]We also examined five different strikes for all the strategies and observed results that are consistent with the at-the-money scenario.

[13]The covariance matrix of our minimum-variance portfolio is estimated using statistical factors from a principle component analysis (PCA), with the 1,000 largest U.S. companies' trailing five years of monthly returns taken as input. This covariance matrix is then used as input to a numerical optimizer to generate a set of non-negative stock weights such that the resulting predicted portfolio volatility is minimized. Long-only constraints with 5% position limits are imposed to avoid overconcentration on single stocks for practical concerns. The low-volatility (low-beta) construction selects the bottom 30% of stocks by volatility (beta) from the universe of the 1,000 largest U.S. companies. For further details, see Chow et al. [2014].

[14]Industry portfolio data from Kenneth French Data Library.

[15]Applying the Stutzer [2000] index and Leland's alpha [1999] might provide more accurate estimates of risk-adjusted performance. Both tend to penalize negative skewness and high kurtosis.

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