Expected Return and Risk of Covered Call Strategies

ILYA FIGELMAN

ILYA FIGELMAN
is a vice president and quantitative analyst at AllianceBernstein in New York, NY.
ilya.figelman@alliancebernstein.com

Covered call (CC) strategies, also known as buy-write strategies, have grown significantly in popularity in recent years. Most current literature either analyzes these strategies by evaluating their historical performance, which has been quite strong over the last approximately 15 years (Whaley [2002], Feldman and Dhruv [2004], and Hill et al. [2006]), or provides a theoretical framework that seems to contradict such strong performance (Rendleman [1999, 2001]). This article introduces a simple theoretical framework which allows for the decomposition of the observed historical performance of CC strategies into three market components: 1) risk-free rate, 2) equity risk premium (ERP), and 3) implied-realized volatility spread. More importantly, this framework allows investors to evaluate CC strategies on a forward-looking basis, since their expectations for future market conditions may differ from history. Even though the emphasis is on CC strategies, the concepts in this article can be easily extended to other options-based strategies.

A CC strategy involves buying an underlying and shorting a call option on that underlying.[1] This article concentrates on stock index CC strategies, although its framework can easily be applied to CC strategies on individual stocks. The CC strategy is treated as a separate asset class, perhaps as an alternative to a portion of equities. Its expected return and risk characteristics are compared to those of the underlying stock index.[2] In addition, the correlation between the CC strategy and the stock index is briefly discussed. Qualitatively, a CC strategy will do the following: 1) outperform the underlying stock index during flat equity markets, 2) significantly underperform the underlying stock index during extreme up equity markets, and 3) slightly outperform the underlying stock index during extreme down equity markets.

This article is the first to synthesize a formula for the expected return of the CC strategy, which allows for an insightful analysis. Specifically, the Rubinstein [1984] variation of the Black–Scholes formula is used to calculate the real world expected return of the call option. The call risk premium (CRP) is emphasized, which is defined as the difference between a call option's real world expected value and its price. As Rendleman [1999] explained, this difference is not very well understood by many investors of options-based strategies. In addition to "shorting" realized volatility, the CC strategy (when compared to the stock index) also replaces some equity exposure with cash exposure. The higher the implied–realized volatility spread, the more appealing the CC strategy is relative to the stock index.[3] For a given level of equity market volatility, the higher the ERP,[4] the less appealing the CC strategy is relative to the stock index.[5]

Historically, implied volatility has on average been higher than the corresponding realized volatility. Figelman [forthcoming] will show that for at-the-money options this cannot be due to expected jumps in stock index returns or other nongeometric Brownian motion dynamics of the stock index, such as stochastic volatility. Thus, the existence of these dynamics does not have a significant effect on CC strategies implemented with at-the-money options. The positive implied–realized volatility spread is probably driven by the demand for options by natural buyers; this assertion will be discussed in the following section and is based on the research of Bollen and Whaley [2004] and Garleanu, Pedersen, and Poteshman [2005].

An interesting finding, based on the research presented in this article, is that as the time to call option expiration decreases, the volatility spread effect significantly strengthens and the ERP effect slightly weakens. Hence, it is usually better to implement the CC strategy with short-dated call options, which is consistent with the intuition of most practitioners.

Since the CC strategy's return distribution is highly asymmetric, I followed the lead of Whaley [2002] in using semi-standard deviation, or the square root of semivariance, as a risk measure. Formulas for semi-standard deviation are derived in Appendix C. I also chose the Sharpe ratio with semi-standard deviation as the measure of risk-adjusted return.

The rest of this article is organized as follows. The next section provides the theoretical framework, the section following provides the empirical analysis, and the last section concludes.

THEORETICAL FRAMEWORK

In this section, I derive the expected return and risk for both the CC strategy and the stock index itself. Assume that the CC strategy is implemented as follows. Initially, the stock index is purchased and a European call option is written, and the payment from the call option is invested in the stock index. The strategy has a single holding period, which is equal to the time to expiration of the call option.[6] For simplicity, assume that the stock index pays a continuous dividend, which is reinvested in the stock index.

The single holding period return of the CC strategy is

$$R_{CC,t} = (S_t e^{qt} - S_0 - C_t + C_0)/(S_0 - C_0) \qquad (1)$$

The corresponding stock index return is

$$R_{S,t} = (S_t e^{qt} - S_0)/S_0 \qquad (2)$$

where S is the stock index price, C is the call value, q is the known continuous stock index dividend yield, and t is the time to call option expiration in years. Whaley [2002, p. 36] shows similar formulas. As in standard options theory, it is assumed that the stock price follows a geometric Brownian motion process,[7]

$$dS_t / S_t = \mu dt + \sigma_r \sqrt{dt} dW_t \qquad (3)$$

where μ is the expected instantaneous annualized stock index price return (stock index price drift), σ_r is the deterministic realized annualized volatility of the stock index return, and dW is a standard normal random variable. Taking the expectation of Equation (2) yields the expected total return of the stock index for a holding period of t,[8]

$$E[R_{S,t}] = e^{(\mu+q)t} - 1 \qquad (4)$$

The goal of this article is to compare the holding period expected return and risk of the CC strategy to that of the stock index. Taking the expectation of Equation (1) yields

$$E[R_{CC,t}] = (S_0 e^{(\mu+q)t} - S_0 - E[C_t] + C_0)/(S_0 - C_0) \qquad (5)$$

The value for the call piece of the CC strategy will now be determined. The price of the call option (C_0) is determined by the standard Black–Scholes formula, including continuous dividends, following Hull [2003, p. 268, Equation 13.4],

$$C_0 = BS(S_0, K, \sigma_i, r, q, t) \qquad (6)$$

where K is the call option strike price, σ_i is the stock index volatility implied by the call option market price, r is the annualized continuously compounded risk-free rate, and BS is the Black–Scholes formula. A version of the Rubinstein [1984, p. 1504] formula is used to calculate the expected value of the call option on its expiration date.[9] The Rubinstein formula is the Black–Scholes formula with the following changes:

1. S_0 replaced by $S_0 e^{\mu t}$,
2. r and q set to zero,
3. σ_i replaced by σ_r:

Thus,

$$E[C_t] = BS(S_0 e^{\mu t}, K, \sigma_f, 0, 0, t) \quad (7)$$

where σ_f is the forecasted stock index volatility,[10]

$$\sigma_f^2 = E[\sigma_r^2] \quad (8)$$

Notice that the expected value of the call option does not depend on the dividend yield or the risk-free rate, but does depend on the expected price return (μ). A derivation of Equation (7) is provided in Appendix A.

In the Black–Scholes world, the call option price, as described by Equation (6), is the risk-neutral expected value of the option discounted to the option purchase date. In theory, it is calculated by replicating the option payoff via delta hedging the underlying stock index. However, in reality, other market factors, such as supply and demand, also affect the call option price. The call option expected value, as defined in Equation (7), is the real world expected value of the option payoff at its expiration date with no assumed delta hedging. The forecast stock index price return (μ) and the forecast realized volatility (σ_f) are investor specific. Thus, different investors can have different expectations for the real world call value ($E[C_t]$). Exhibit 1 summarizes the differences between these two values. Option market makers are not affected by the real world expected stock index price return (μ), because they dynamically hedge their option positions with underlying securities. However, investors in CC strategies usually do not dynamically hedge their option positions and thus are affected by the real world expected stock index price return (μ). It is assumed that investors in the CC strategy obtain the call price and implied volatility from the market; thus, they are price takers.

Exhibit 1

Characteristics of Call Option Price vs. Expected Value

	Call Option Price	Call Option Expected Value
Stock Index Instantaneous Annualized Expected Price Return (Drift)	$r - q$	μ^*
Annualized Volatility	σ_i^{**}	σ_f^*
Calculated as of	Purchase date	Expiration date
Delta Hedging Assumed	Yes	No
Affected by Option Supply and Demand	Yes	No

*Determined by each investor's forecast
**Determined by the market

The main concept an investor should consider when evaluating the CC strategy relative to the stock index is the call risk premium (CRP).[11] The CRP is the difference between the call option's real world expected value at expiration and the call option price grown at the risk-free rate to expiration,

$$CRP_t = (E[C_t] - C_0 e^{rt})/S_0 \quad (9)$$

Because the CC strategy contains a short call option, all else being equal, the lower the CRP, the higher the expected return of the CC strategy. If the payment from the call option is invested in the risk-free rate instead of the stock index, as originally assumed, Equation (5) would become

$$E[R_{CC,t}] = (e^{(\mu+q)t} - 1) - (E[C_t] - C_0 e^{rt})/S_0 \quad (10)$$

Combining Equations (4), (9), and (10) yields

$$E[R_{CC,t}] = E[R_{S,t}] - CRP_t \quad (11)$$

Equation (5) is used instead of Equation (11) in this article because the call payment is usually invested in the stock index instead of the risk-free rate. However, the difference between the two is marginal and Equation (11) directly shows how the CRP affects the CC strategy's expected return.

The equity risk premium (ERP) and the implied–realized volatility spread affect the CRP in opposite ways,

$$ERP_t = (\mu + q - r)t \quad (12)$$

The ERP is generally greater than zero, which has a positive effect on the CRP, and thus a negative affect on the expected return of the CC strategy relative to the stock index.[12] As will be discussed later in the article, implied volatility tends to be, on average, higher than the corresponding realized volatility. This has a negative effect on the CRP, and thus a positive effect on the CC strategy relative to the stock index.

The effect of the ERP on the annualized CRP slightly increases with time to call option expiration (t), while the effect of the implied–realized volatility spread on the annualized CRP significantly diminishes with time to call option expiration. Thus, the annualized CRP tends to be higher for long-dated options. This is a key reason why most practitioners prefer to implement the CC strategy with short-dated options. Exhibit 10 graphically shows that the annualized CRP is an increasing function of t.

Now, consider the risk of both strategies. Since the CC return distribution is highly asymmetric, standard deviation does not accurately reflect the strategy's downside risk due to its negative skew. Thus, semi-standard deviation is a more appropriate risk measure for the CC strategy. Semi-standard deviation differs from regular standard deviation in that the deviations are from the risk-free rate instead of the mean, and the deviations above the risk-free rate are set to zero. Whaley [2002, p. 39, Equation (10)] also used semi-standard deviation in his historical analysis of the CC strategy. The formulas for the stock index and CC strategy semi-standard deviations follow and their derivations are provided in Appendix C.[13]

The stock index semi-standard deviation is

$$
\begin{aligned}
SSD_{s,t} &= \sqrt{e^{(2\mu+\sigma^2+2q)t}N(g_1) - 2e^{(\mu+r+q)t}N(g_2) + e^{2rt}N(g_3)} \\
g_1 &= \frac{(r-q-\mu-(3/2)\sigma_f^2)t}{\sigma_f\sqrt{t}} \\
g_2 &= \frac{(r-q-\mu-(1/2)\sigma_f^2)t}{\sigma_f\sqrt{t}} \\
g_3 &= \frac{(r-q-\mu+(1/2)\sigma_f^2)t}{\sigma_f\sqrt{t}}
\end{aligned}
\tag{13}
$$

The CC strategy semi-standard deviation is[14]

$$
\begin{aligned}
SSD_{CC,t} &= \sqrt{\left(\frac{S_0}{S_0-C_0}\right)^2 e^{(2\mu+\sigma^2+2q)t}N(g_4) - 2\left(\frac{S_0}{S_0-C_0}\right)e^{(\mu+r+q)t}N(g_5) + e^{2rt}N(g_6)} \\
g_4 &= \frac{\ln((S_0-C_0)/S_0) + (r-q-\mu-(3/2)\sigma_f^2)t}{\sigma_f\sqrt{t}} \\
g_5 &= \frac{\ln((S_0-C_0)/S_0) + (r-q-\mu-(1/2)\sigma_f^2)t}{\sigma_f\sqrt{t}} \\
g_6 &= \frac{\ln((S_0-C_0)/S_0) + (r-q-\mu+(1/2)\sigma_f^2)t}{\sigma_f\sqrt{t}}
\end{aligned}
\tag{14}
$$

As with any risk measure, semi-standard deviation has its drawbacks, which are described in Appendix B. However, it is a good measure of risk for comparing the CC strategy to the stock index. Feldman and Dhruv [2004] provided alternative risk measures for the CC strategy.

Equations (5) and (14) can be used to determine the current expected return and forward risk of the CC strategy. In addition, they can also be used to decompose the historical performance of the CC strategy, which is done in the next section.

EMPIRICAL ANALYSIS

In this section, I provide an empirical analysis that supports the framework proposed in this article.

Performance of CC Strategy Relative to Stock Index

In this subsection, I demonstrate how the theoretical framework developed in the previous section can be applied to actual market data in order to evaluate the historical performance of the CC stock index strategy.

First, the historical performance of the Chicago Board Options Exchange (CBOE) BXM Index is presented. The index is based on a buy-and-hold, at-the-money, one-month S&P 500 Index CC strategy. Exhibit 2 shows that the actual historical returns of the BXM Index are very similar to the historical returns of the S&P 500 Index (both include dividends).[15] However, the semi-standard deviation of the BXM Index is significantly smaller, resulting in a higher Sharpe ratio with semi-standard deviation. As in Whaley [2002], semi-standard deviation is calculated using the deviations of monthly returns from the risk-free rate.[16] Exhibit 2 shows two performance start dates—June 1988, when the BXM Index was launched, and March 1994, when at-the-money implied volatility data was first available from Bloomberg (this will be used in subsequent analyses).

Exhibit 2 also shows the theoretical historical expected return, semi-standard deviation, and Sharpe ratio of the CC strategy based on the formulas derived in the previous section. For consistency with the BXM Index construction, the time to expiration of the call option is assumed to be one month and the strike price is assumed to be at the money, using the forward stock index price level,

EXHIBIT 2
CC and Stock Index Historical Performance

	Mar 1994 - Sep 2005			Jun 1988 - Sep 2005	
	BXM (CC)		**S&P 500**	**BXM (CC)**	**S&P 500**
	Actual	Theoretical Based on Historical Inputs	Actual	Actual	Actual
Annualized Return	*10.63%*	*10.34%*	*10.67%*	*11.90%*	*11.60%*
Monthly Statistics					
Return	0.85%	0.82%	0.85%	0.94%	0.92%
Standard Deviation	3.12%	2.48%	4.45%	2.73%	4.09%
Semi-standard Deviation	2.14%	1.95%	2.96%	1.92%	2.73%
Libor -- 1 Month	0.34%	0.34%	0.34%	0.40%	0.40%
Sharpe Ratio w/ Semi-standard Deviation	0.23	0.25	0.17	0.28	0.19

$$K = S_0 e^{(r-q)t} \tag{15}$$

The inputs to these formulas, provided in Exhibit 3, are annualized historical market averages for the period from March 1994 to September 2005 and are obtained from Bloomberg. For this time period, the average risk-free rate was 4.2%, the stock index price return was 7.5% (corresponding to an ERP of 5.9%), and the average dividend yield was 2.6% (all annualized). The realized volatility was 15.7% and the average bid implied volatility was 17.7%, corresponding to an average implied–realized volatility spread of 2.00%.[17]

These historical averages are input into Equation (5) to obtain the theoretical historical expected return from the CC strategy. Exhibit 2 shows that the theoretical expected monthly return of the CC strategy based on average historical market conditions is 0.82%, which is very close to the actual historical monthly return of 0.85% for the BXM Index. Likewise, the monthly semi-standard deviations are similar,[18] 1.95% is obtained by inputting average historical values into Equation (14) and 2.14% is the actual BXM Index historical semi-standard deviation. These results verify that the theoretical framework developed in the previous section can be used to realistically evaluate the efficacy of CC strategies.

This framework also allows the decomposition of the historical returns of the CC strategy into various market components. Equations (4) and (5) are used to isolate the effect of the risk-free rate, ERP, and implied–realized volatility spread on the CC strategy relative to the stock index. Exhibit 4 shows the results of this decomposition.

Consider the contribution of the ERP, which is shown in the third column of Exhibit 4. If an ERP of 5.90%[19] is plugged into Equation (5), while setting both the risk-free rate and the implied–realized volatility spread to zero, the theoretical historical expected monthly return of the CC strategy would be 0.24%. Plugging the same inputs into Equation (4) yields a stock index theoretical historical expected monthly return of 0.49%. This clearly demonstrates that the ERP does affect the return of the

EXHIBIT 3
CC and Stock Index Expected Return and Risk

Annualized, Continuous	
Parameter estimation period	03/94 to 09/05
Time horizon (t)	1 Month
Strike (K)	100.13%
Risk-free rate (r)	4.2%
Stock index (drift) price return (μ)	7.5%
Stock index dividend yield (q)	2.6%
Equity risk premium (ERP)	5.9%
Call option implied volatility (σ_I)	17.7%
Implied–realized volatility spread (σ_I-σ_R)	2.0%
Stock index price realized volatility (σ_R)	15.7%

Exhibit 4

Decomposition of CC and Stock Index Historical Performance, March 94–September 05

Annualized Inputs				
Risk Free Rate (r)	4.20%			
Equity Risk Premium (ERP)	5.90%			
Stock Index Continuous Dividend Yield (q)	2.60%			
Stock Index Price Return (μ)	7.50%			
Implied-Realized Volatility Spread (σ_i - σ_r)	2.00%			
		Contributions		
Theoretical "Expected" Monthly Return	**Total**	Risk-Free Rate	Equity-Risk Premium	Implied-Realized Volatility Spread
CC Strategy	0.82%	0.35%	0.24%	0.24%
(percent of total)	*(100.0%)*	*(42.6%)*	*(28.8%)*	*(28.5%)*
Stock Index	0.85%	0.35%	0.49%	0.00%
(percent of total)	*(100.0%)*	*(41.5%)*	*(58.3%)*	*(0.0%)*

BXM Index relative to the stock index, because the BXM Index is a fully invested and unlevered CC strategy.

Now, consider the contribution of the implied–realized volatility spread, which is show in the fourth column of Exhibit 4. If 2.00% is used as the implied–realized volatility spread in Equation (5), and both the risk-free rate and the ERP are set to zero, the theoretical historical CC strategy expected monthly return equals 0.24%.[20] (Obviously, the contribution from the implied–realized volatility spread to the stock index return is zero.) Finally, the contribution from the risk-free rate to the CC strategy monthly expected return is 0.35% (~4.20%/12); this number is the same for the stock index since the BMX Index is fully invested and not leveraged.

A very nice property of the framework developed in this article, mainly Equations (4) and (5), is that the contributions of the theoretical expected returns generally add to the total expected return for both the CC strategy and the stock index.[21] Thus, this framework can be used to perform an economically meaningful decomposition for these strategies. To summarize, Exhibit 4 shows the components of the total historical CC stock index strategy return: 42.6% from the risk-free rate, 28.8% from the ERP, and 28.5% from the implied–realized volatility spread. Exhibit 4 also shows the components of the stock index return: 41.5% from the risk-free rate, 58.3% from the ERP, and no contribution from the implied–realized volatility spread. This demonstrates the point made in the introduction that when comparing the CC strategy to the stock index, investors need to consider the positive effect of the implied–realized volatility spread relative to the negative effect of the ERP (i.e., if the ERP increases, the expected return of the stock index will increase more than the expected return of the CC strategy).

Implied–Realized Volatility Spread

As shown in the preceding subsection, the reason the BXM Index exhibited such strong historical performance relative to the S&P 500 Index is due primarily to the historical spread between implied and the corresponding realized volatility. The S&P 500 implied volatility provided by Bloomberg for at-the-money one-month call options is compared to the corresponding S&P 500 realized volatility for the period from March 1994 to September 2005. A rolling daily implied–realized volatility spread is computed by subtracting the forward annualized 22-day realized standard deviation from the implied volatility for each day in the study period. The average annualized implied–realized volatility spread was found to be approximately 2.5%.

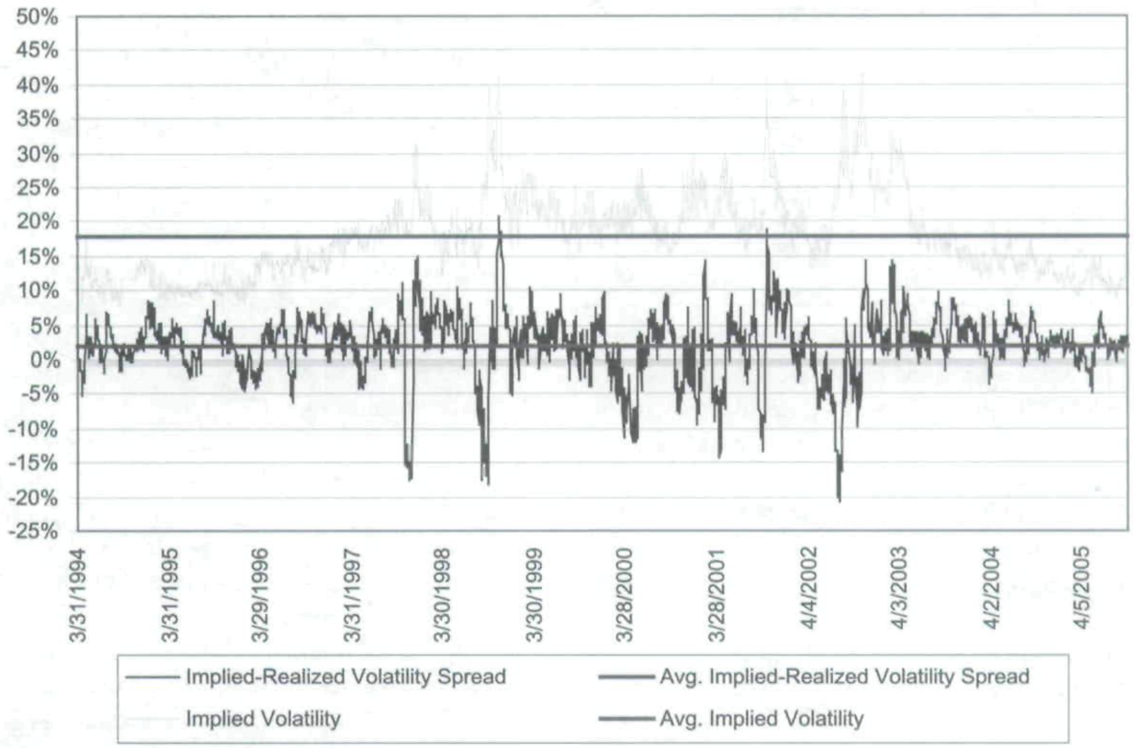
The Bloomberg implied volatility is calculated from the last call trade price, and thus should be, on average, higher than the implied volatility associated with the call bid price. Because investors in CC strategies are price takers and would usually obtain the bid price, the 2.5% average annualized implied–realized volatility spread should be reduced by approximately half of the implied volatility bid–ask spread. (It is assumed that the last price is, on average, equal to the mid-price.) To be conservative, it is assumed that the implied volatility bid–ask spread is approximately 1% for S&P 500 at-the-money call options; thus, an implied–realized volatility spread of approximately 2%, or 2.5% minus 1.0%/2, is a reasonable estimate of the average historical experience of CC strategy investors.[22] Exhibits 5 and 6 show how this spread has varied historically.

Exhibit 7 shows how this implied–realized volatility spread is affected by the level of implied volatility. First, the data is ranked and placed into quintiles by the level of implied volatility. Then, the average forward realized volatility spread is computed for each quintile. As mentioned earlier, the implied volatility based on the bid call price is assumed to be 0.5% lower than the implied volatility based on the last call price. Exhibit 7 shows that, on average, there is a positive implied–realized volatility spread for all levels of implied volatility. Even the lowest quintile of implied volatility has historically had a positive implied–realized volatility spread.

One explanation for the difference between implied and realized volatility is that there are more natural buyers than sellers of index options. Thus, option sellers provide liquidity and generally reduce market-maker hedging costs. As a result, market makers prefer option sellers to option buyers. This tends to increase option prices and the corresponding implied volatilities.[23] In support of this argument, Bollen and Whaley [2004] and Garleanu, Pedersen, and Poteshman [2005] empirically showed that implied volatility is influenced by supply and demand dynamics. Specifically, both articles showed that for index options, there are significantly more natural buyers than sellers, causing the average implied volatility to be significantly higher than realized volatility. Both articles also showed that for single stock options, there is a much smaller difference between option buyers and sellers, which causes the average implied–realized spread to be close to zero.[24]

Another possible explanation for this positive implied–realized volatility spread is the existence of non-normal stochastic dynamics in the stock index process, such as jumps in returns and stochastic volatility. However, Figelman [forthcoming] will show that these dynamics cannot explain the positive implied–realized volatility spread for at-the-money stock index options.

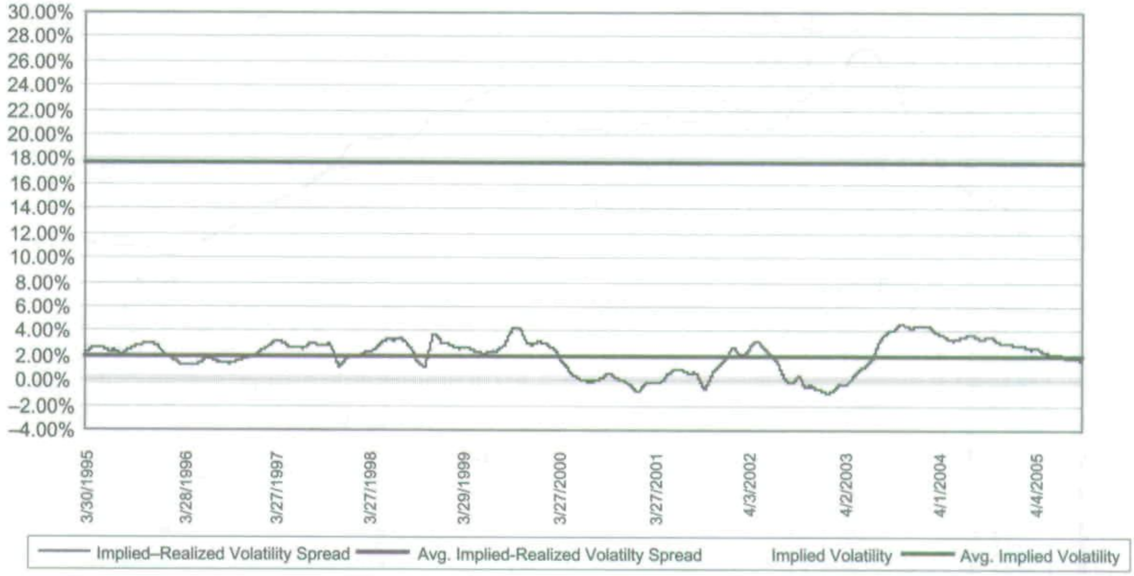
EXHIBIT 5
Historical Implied–Realized Volatility Spread and Implied Volatility for S&P 500



Note: Annualized difference between implied at-the-money volatility and corresponding realized volatility for the next 22 days.
Source: Implied volatility of the last call trade price obtained from Bloomberg.

EXHIBIT 6

Historical Implied–Realized Volatility Spread for S&P 500 and Implied Volatility, One-Year Rolling Average



Note: Annualized rolling 1-year difference between implied at-the-money volatility and corresponding realized volatility for the next 22 days.
Source: Implied volatility of the last call trade price obtained from Bloomberg.

EXHIBIT 7

Implied–Realized Volatility Spread by Implied Volatility Quintiles

Quintile	Implied Volatility (last call price)	Implied Volatility (bid call price)	Implied-Realized Volatility Spread (last call price)	Implied-Realized Volatility Spread (bid call price)
1	11.0%	10.5%	2.0%	1.5%
2	14.3%	13.8%	3.0%	2.5%
3	17.8%	17.3%	2.1%	1.6%
4	20.8%	20.3%	2.1%	1.6%
5	27.5%	27.0%	3.3%	2.8%
All	18.2%	17.7%	2.5%	2.0%

Other finance literature analyzes the implied–realized volatility spread from different angles. Bollerslev, Gibson, and Zhou [2006] defined the implied–realized volatility spread as the *volatility risk premia*, and asserted that it is dynamic and related to several macroeconomic variables.[25] In contrast, Bondarenko [2003] argued that no reasonable asset pricing model can explain the positive implied–realized volatility spread anomaly.[26]

Effect of Call Expiration Time on the CC Strategy Relative to Stock Index

In this subsection, I examine how the time to call option expiration influences the CC strategy, which is the focus of much debate. Most practitioners believe that the shorter the expiration, the stronger the performance of the CC strategy, but Rendleman [2001, p. 72] argues that "there is no inherent advantage to employing short-term calls in covered writing over long-term calls." The findings presented in this subsection, based on the theoretical framework developed in this article, are in general agreement with practitioners.[27] When the implied–realized volatility spread is positive, a greater benefit results from implementing the CC strategy with short-dated calls rather than long-dated calls, assuming that this (annualized) spread is the same for short- and long-dated options. (But if there is no spread between implied and realized volatility, there is no significant advantage to using short-dated rather than long-dated calls in the CC strategy.)

Exhibit 8 compares the CC strategy to the stock index for different call option expiration dates—one month, six months, and one year. The holding periods are assumed to equal the time to call option expiration. In order to compare the 1-month holding period to the 1-year holding period, assume that for the 1-month holding period a different call option is sold each month in a 12-month period and the returns of the CC strategy are compounded. The 6-month holding period is treated similarly. The annualized semi-standard deviation for the CC strategy with a 1- and 6-month holding period is calculated via a Monte Carlo simulation, while the rest of

EXHIBIT 8
Sensitivity to Time to Call Option Expiration (t)

Annualized Metrics	Call Option Maturity 1 Month	6 Months	1 Year
Call Risk Premium	0.46%	2.54%	3.22%
Expected Return			
Stock Index	10.6%	10.6%	10.6%
Covered Call	10.3%	8.4%	8.0%
Standard Deviation			
Stock Index	17.5%	17.5%	17.5%
Covered Call	9.4%	8.3%	7.8%
Semi-standard Deviation			
Stock Index	8.1%	8.1%	8.1%
Covered Call	4.1%	5.0%	5.4%
Sharpe Ratio with Standard Deviation			
Stock Index	0.37	0.37	0.37
Covered Call	0.65	0.50	0.48
Sharpe Ratio with Semi-standard Deviation			
Stock Index	0.80	0.80	0.80
Covered Call	1.52	0.84	0.70

Note: Annualized implied–realized volatility spread = 2.00%, annualized ERP = 5.9%, at-the-forward-money call option risk-free rate = 4.2%, and dividend yield = 2.6%.

the values in Exhibit 8 use the equations derived in the previous section. The remaining parameters are shown in Exhibit 3 and were historically estimated.

Exhibit 8 shows that the annualized expected return for the CC strategy decreases as the time to call option expiration increases. The annualized CC strategy return is 10.3% using one-month call options and 8.0% using a one-year call option. As illustrated in Exhibit 10 this occurs primarily because the implied–realized volatility spread has a much stronger negative effect on the annualized CRP for shorter-dated relative to longer-dated options. In addition, the ERP has a slightly weaker positive effect on the CRP for shorter-dated relative to longer-dated options. Specifically, the annualized CRP is 0.46% for one-month calls and 3.22% for a one-year call.[28] Thus, the annualized CRP is positively related to t, which causes the annualized CC strategy expected return, shown in Exhibit 8, to be inversely related to t.

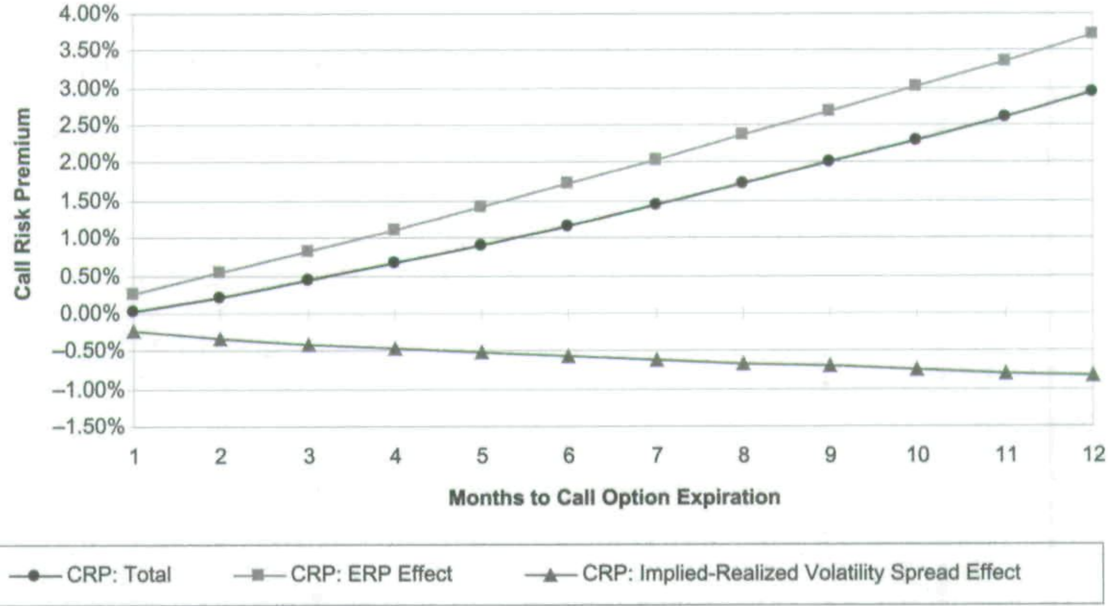
Exhibit 8 also shows that the annualized semi-standard deviation, which is calculated using a Monte Carlo simulation, is lower when the CC strategy is implemented with short-dated call options.[29] In conclusion, implementing the CC strategy with short-dated options, assuming the annualized ERP and implied–realized volatility spread are consistent for all option expiration times, is the most desirable alternative.

Exhibits 9 and 10 decompose the effect of the ERP and the volatility spread on the CRP with respect to time to option expiration, t. The ERP portion of the CRP is computed by setting the volatility spread to zero. The volatility spread portion of the CRP is computed by setting the ERP to zero. The total CRP is the sum of the two portions with a very small residual. Exhibit 9 illustrates that the CRP increases with t because its ERP portion increases with t at a faster rate than its volatility spread portion decreases with t. Another way to describe this phenomenon is that for at-the-money call options, the shorter the time to expiration, the faster the value of the option decays with time—this is sometimes called the theta effect. Thus, shorting short-dated call options translates the implied–realized volatility spread into profit faster than shorting long-dated call options. Exhibit 10 shows that the annualized CRP increases with the time to expiration, thus verifying that it is beneficial to implement the CC strategy with shorter-dated options. This benefit derives mainly from the implied–realized volatility spread effect on short-dated options. However, the ERP effect also slightly favors CC strategies with short-dated options.

Effect of the Equity Risk Premium on the Call Risk Premium

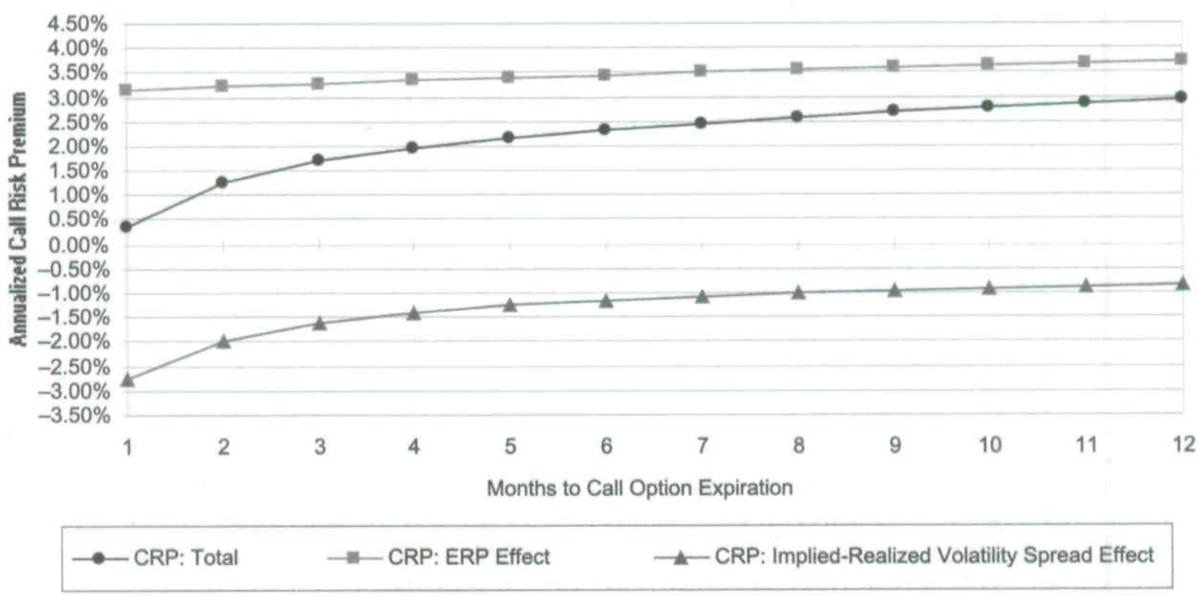
Now, further consider the effect of the ERP on the annualized CRP for one-year versus one-month call options. Exhibit 11 shows that, for both call options, the CRP is positively related to the ERP—an obvious result. Exhibit 11 also shows that the difference between the annualized CRP for a one-year call option and one-month call options is always positive. This confirms that the annualized one-month call option's value decays faster than the one-year call option's value, assuming a positive implied–realized volatility spread. Finally, Exhibit 11 demonstrates that the difference between the annualized CRP for a one-year call option and one-month call options depends on the level of the ERP. In fact, this difference is smallest when the ERP is close to zero and increases as the ERP moves away from zero. This result implies that the higher the ERP, assuming it is positive, the faster the annualized one-month call option's value decays relative to the one-year call option's value.[30]

EXHIBIT 9
Call Risk Premium (CRP) vs. Time to Call Option Expiration



Note: Base annualized implied–realized volatility spread for all horizons = 2.00%, base annualized ERP = 5.9%, at-the-forward-money call options, risk-free rate = 4.2%, and dividend yield = 2.6%.

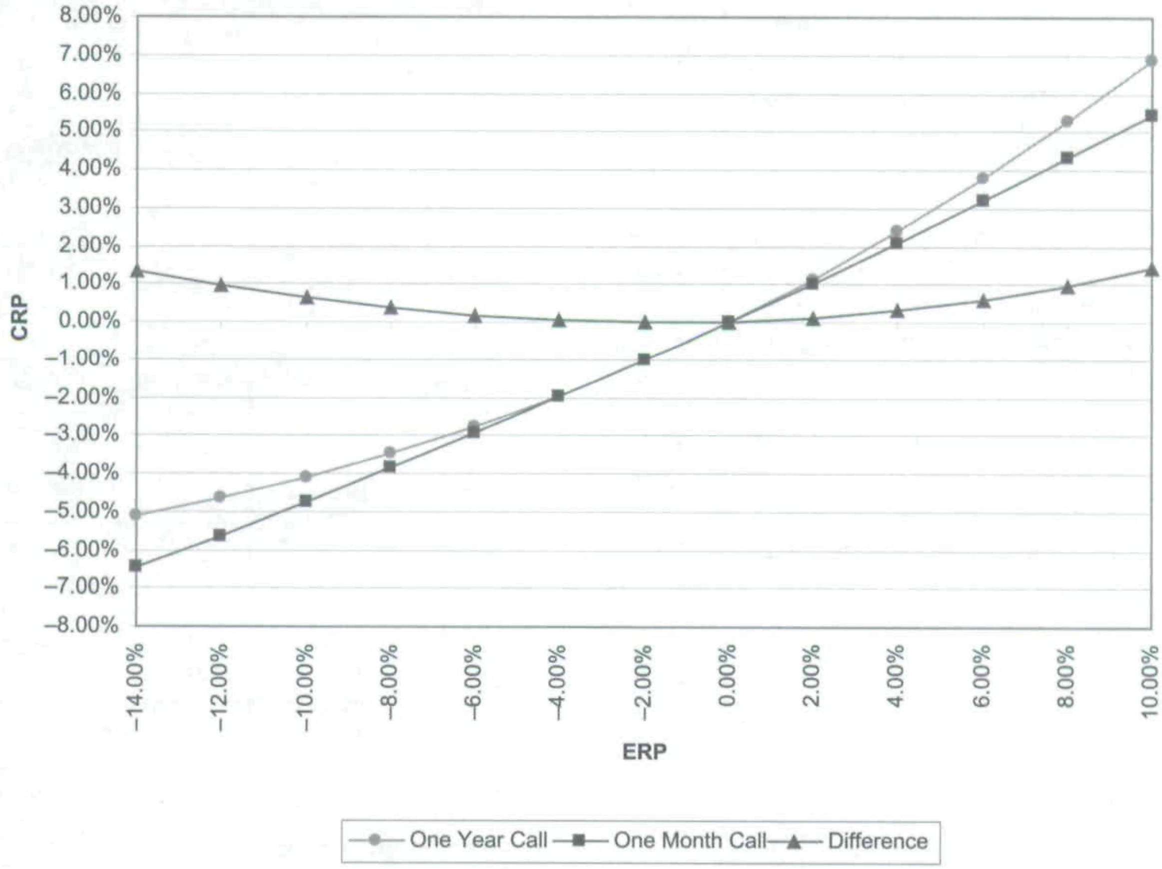
EXHIBIT 10
Annualized Call Risk Premium (CRP) vs. Time to Call Option Expiration



Note: Base annualized implied–realized volatility spread for all horizons = 2.00%, base annualized ERP = 5.9%, at-the-forward-money call options, risk-free rate = 4.2%, and dividend yield = 2.6%.

EXHIBIT 11

Annualized Call Risk Premium (CRP) vs. Equity Risk Premium (ERP)



Note: Annualized implied–realized volatility spread for all horizons = 2.00%, at-the-forward-money call option, risk-free rate = 4.2%, and dividend yield = 2.6%.

To summarize, the higher the ERP, the higher the annualized CRP of a one-year call option relative to the one-month call options. This implies that the higher the ERP, the more attractive the CC strategy when implemented with one-month call options rather than with one-year call options. In addition, the one-month CC strategy is always more attractive than the one-year CC strategy. These findings are predicated on the assumption that the annualized implied–realized volatility spread is positive and is the same for all time horizons.

Comment on Correlation between CC Strategy and Stock Index

When considering the CC strategy as a potential asset class, it is also important to factor in its correlation with the stock index. Covering the period from June 1988 to September 2005, the historical correlation of the CBOE BXM Index daily return and the S&P 500 Index daily total return is very high at 0.9. As with regular standard deviation, regular correlation is biased when the distribution of returns of at least one variable is asymmetric. The short call limits the CC strategy's gain when the stock index has positive returns, but does not limit its loss when the stock index has negative returns. Investors are much more concerned with returns being concurrently negative than concurrently positive. Thus, a correlation metric that incorporates the asymmetry of CC returns would be even greater than the computed regular correlation of 0.9. The CC strategy, therefore, should not be regarded as a diversifier of equities.

CONCLUSION

The CC strategy on the S&P 500 Index has exhibited strong historical risk-adjusted performance relative to the stock index itself. In order for investors to find the CC strategy attractive, they must be convinced that going forward, implied volatility will be higher, on average, than the corresponding realized volatility. In addition, this volatility spread needs to be high enough to counteract the negative influence that the ERP has on the CC strategy relative to the stock index. An investor can somewhat isolate the implied–realized volatility spread effect from the ERP effect by changing their existing equity exposure based on the CC position.

For short-dated options, the CC strategy expected return is influenced more by the implied–realized volatility spread than by the ERP. Therefore, assuming that the annualized implied–realized volatility spread and ERP are similar for all option expiration times, implementing the CC strategy with short-dated rather than long-dated call options provides a greater benefit to the investor. This reaffirms the intuition of most practitioners. Finally, the CC strategy is highly correlated with the stock index—especially on the downside—which significantly diminishes its diversification benefits.

APPENDIX A

Derivation of Real World Expected Call Value

The following basic relationships will be used in the derivation:

$$\int_a^b f(x;m,v)dx = N((b-m)/\sqrt{v}) - N((a-m)/\sqrt{v}) \tag{A1}$$

$$\int_a^b e^x f(x;m,v)dx = e^{m+v/2}\int_a^b f(x;m+v,v)dx \tag{A2}$$

$$\int_a^b e^{2x} f(x;m,v)dx = e^{2m+2v}\int_a^b f(x;m+2v,v)dx \tag{A3}$$

$$N(-z) = 1-N(z) \tag{A4}$$

where f(x; m, v) is a normal probability density function with mean m and variance v, and N is the standardized cumulative normal distribution.

The expected value of a call that expires in time t is

$$E[C_t] = \int_{-\infty}^{\infty} \min(S_0 e^{Y_t} - K, 0) f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \tag{A5}$$

If $Y_t < \ln(K/S_0)$, then $E[C_t] = 0$, thus,

$$E[C_t] = \int_{\ln(\frac{K}{S_0})}^{\infty} (S_0 e^{Y_t} - K) f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \tag{A6}$$

$$\begin{aligned} E[C_t] = {} & S_0 \int_{\ln(\frac{K}{S_0})}^{\infty} e^{Y_t} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \\ & - K \int_{\ln(\frac{K}{S_0})}^{\infty} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \end{aligned} \tag{A7}$$

Combining Equation (A7) with Equations (A1) and (A2) yields

$$\begin{aligned} E[C_t] = {} & S_0 e^{\mu t}\left(1 - N\left(\frac{\ln\left(\frac{K}{S_0}\right) - (\mu + \sigma_f^2/2)t}{\sigma_f\sqrt{t}}\right)\right) \\ & - K\left(1 - N\left(\frac{\ln\left(\frac{K}{S_0}\right) - (\mu - \sigma_f^2/2)t}{\sigma_f\sqrt{t}}\right)\right) \end{aligned} \tag{A8}$$

Combining Equation (A8) with Equation (A4) yields

$$\begin{aligned} & E[C_t] = S_0 e^{\mu t} N(d_3) - KN(d_4) \\ & d_3 = (\ln(S_0/K) + (\mu + \sigma_f^2/2)t)/(\sigma_f\sqrt{t}) \\ & d_4 = d_3 - \sigma_f\sqrt{t} \end{aligned} \tag{A9}$$

Equation (A9) is identical to Equation (7).

APPENDIX B

More on Semi-standard Deviation

This appendix discusses the weaknesses of semi-standard deviation as a measure of risk. Semi-standard deviation has several drawbacks, but overall is a good risk measure for comparing the CC strategy to the stock index. Therefore, it is used without any adjustments in the empirical analysis.

Unlike regular standard deviation, semi-standard deviation is affected by the assumed expected return. Because deviations are relative to the risk-free rate and not the distribution mean, the higher the assumed mean, the lower the semi-standard deviation.

If the assumed mean is a very accurate estimate of the true mean, this is not a problem. In many practical situations, however, it is very difficult to accurately estimate the true mean of a return distribution. Furthermore, there is a natural bias toward projecting optimistic expected returns, which not only inflates expected returns but also causes the semi-standard deviation to be artificially low. If necessary, two equivalent ways are available to correct for this potential bias in the semi-standard deviation of the stock index and CC strategy. Either the stock index's total return can be set equal to the risk-free rate—μ can be replaced with $r - q$ in Equations (13) and (14)—or the deviations can be calculated relative to the mean instead of the risk-free rate—r can be replaced with $\mu + q$ in Equations (C4) and (C10) in Appendix C. These adjustments can only be made when computing semi-standard deviations; the given projections must be accepted when computing expected returns.

A second drawback of semi-standard deviation as a risk measure is that it does not account for non-normal stochastic dynamics in the stock index return distribution, such as the ones modeled by Eraker, Johannes, and Polson [2003]; regular standard deviation also has this weakness. (I leave evaluating CC strategies with measures of risk that incorporate these dynamics, such as VAR and CVAR, for further research.) The semi-standard deviation of the stock index itself has the same drawback. This weakness of semi-standard deviation is somewhat mitigated, however, because the semi-standard deviation of the CC strategy is compared to the semi-standard deviation of the stock index. Nevertheless, semi-standard deviation does properly incorporate the negative skew in the returns of the CC strategy; regular standard deviation does not.

APPENDIX C

Derivation of Semi-Standard Deviations

The semi-standard deviation for the stock index described by Equation (13) and for the CC strategy described by Equation (14) will be derived in this appendix. The following basic relationships will be used in the derivations:

$$\int_a^b f(x;m,v)dx = N((b-m)/\sqrt{v}) - N((a-m)/\sqrt{v}) \quad \text{(C1)}$$

$$\int_a^b e^x f(x;m,v)dx = e^{m+v/2}\int_a^b f(x;m+v,v)dx \quad \text{(C2)}$$

$$\int_a^b e^{2x} f(x;m,v)dx = e^{2m+2v}\int_a^b f(x;m+2v,v)dx \quad \text{(C3)}$$

where $f(x; m, v)$ is a normal probability density function with mean m and variance v.

The semivariance, or square of the semi-standard deviation, is defined as the average square difference between a strategy's return and the return of a risk-free investment, where positive differences are set equal to zero (see Whaley [2003, p. 39]). The stock index semivariance will be defined first as

$$SV_{S,t} = \int_{-\infty}^{\infty} \min(R_{S,t} - (e^{rt}-1), 0)^2 f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \quad \text{(C4)}$$

where Y_t is defined in Equation (5). Combining Equations (7) and (C4) gives

$$SV_{S,t} = \int_{-\infty}^{\infty} \min(e^{Y_t+qt} - e^{rt}, 0)^2 f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \quad \text{(C5)}$$

$$e^{Y_t+qt} - e^{rt} > 0 \Leftrightarrow Y_t > (r-q)t \quad \text{(C6)}$$

Combining Equation (C5) with inequality (C6) yields

$$SV_{S,t} = (\int_{-\infty}^{(r-q)t} (e^{Y_t+qt} - e^{rt})^2 f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \quad \text{(C7)}$$

Expanding the expression inside the integral gives

$$\begin{aligned} SV_{S,t} = {} & e^{2qt}\int_{-\infty}^{(r-q)t} e^{2Y_t} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t - \\ & 2e^{(r+q)t}\int_{-\infty}^{(r-q)t} e^{Y_t} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t + \\ & e^{2rt}\int_{-\infty}^{(r-q)t} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \end{aligned} \quad \text{(C8)}$$

Combining Equations (C1), (C2), (C3), and (C8), and taking the square root gives

$$\begin{aligned} SSD_{s,t} &= \sqrt{e^{(2\mu+\sigma^2+2q)t}N(g_1) - 2e^{(\mu+r+q)t}N(g_2) + e^{2rt}N(g_3)} \\ g_1 &= \frac{(r-q-\mu-(3/2)\sigma_f^2)t}{\sigma_f\sqrt{t}} \\ g_2 &= \frac{(r-q-\mu-(1/2)\sigma_f^2)t}{\sigma_f\sqrt{t}} \\ g_3 &= \frac{(r-q-\mu+(1/2)\sigma_f^2)t}{\sigma_f\sqrt{t}} \end{aligned} \quad \text{(C9)}$$

Equation (C9) is identical to Equation (13).

Similar to the semivariance of the stock index, the semivariance of the CC strategy is

$$SV_{CC,t} = \int_{-\infty}^{\infty} \min(R_{CC,t} - (e^{rt} - 1), 0)^2 f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t \tag{C10}$$

It is assumed that the holding period is equal to the call option time to expiration, thus

$$C_t = \max(S_t - K, 0) \tag{C11}$$

The strike price of the call option is assumed to be either at the money or out of the money, using the forward stock index price level,

$$K \geq S_0 e^{(r-q)t} \tag{C12}$$

Combining Equations (9), (C10), and (C11) yields

$$\begin{aligned} SV_{CC,t} = {} & \int_{-\infty}^{\infty} \min\left(\frac{S_0 e^{Y_t + qt} - \max(S_0 e^{Y_t} - K, 0)}{S_0 - C_0} - e^{rt}, 0 \right)^2 \\ & \times f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t \end{aligned} \tag{C13}$$

$$S_0 e^{Y_t} - K > 0 \Leftrightarrow Y_t > \ln \frac{K}{S_0} \tag{C14}$$

Combing Equation (C13) with the Inequality (C14) yields

$$\begin{aligned} SV_{CC,t} = {} & \int_{-\infty}^{\ln(K/S_0)} \min\left(\frac{S_0 e^{Y_t + qt}}{S_0 - C_0} - e^{rt}, 0 \right)^2 \\ & \times f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t \\ & + \int_{\ln(K/S_0)}^{\infty} \min\left(\frac{S_0 e^{Y_t + qt}(e^{Y_t} - 1) + K}{S_0 - C_0} - e^{rt}, 0 \right)^2 \\ & \times f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t \end{aligned} \tag{C15}$$

The first integral of Equation (C15) will now be now examined:

$$\frac{S_0 e^{Y_t + qt}}{S_0 - C_0} - e^{rt} < 0 \Leftrightarrow Y_t < \ln\left(\frac{S_0 - C_0}{S_0} \right) + (r - q)t \tag{C16}$$

Inequality (C12) implies that

$$\ln\left(\frac{S_0 - C_0}{S_0} \right) + (r - q)t < \ln\left(\frac{K}{S_0} \right) \tag{C17}$$

Inequalities (C16) and (C17) result in

$$\begin{aligned} & \int_{-\infty}^{\ln(K/S_0)} \min\left(\frac{S_0 e^{Y_t + qt}}{S_0 - C_0} - e^{rt}, 0 \right)^2 f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t \\ & = \int_{-\infty}^{\ln(\frac{S_0 - C_0}{S_0}) + (r-q)t} \left(\frac{S_0 e^{Y_t + qt}}{S_0 - C_0} - e^{rt} \right)^2 f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t \end{aligned} \tag{C18}$$

The second integral of Equation (C15) will now be examined:

$$\frac{S_0 e^{Y_t}(e^{qt} - 1) + K}{S_0 - C_0} - e^{rt} > 0 \Leftrightarrow Y_t > \ln\left(\frac{(S_0 - C_0)e^{rt} - K}{S_0(e^{qt} - 1)} \right) \tag{C19}$$

Inequality (C12) implies that

$$\ln\left(\frac{(S_0 - C_0)e^{rt} - K}{S_0(e^{qt} - 1)} \right) < \ln\left(\frac{K}{S_0} \right) \tag{C20}$$

Inequalities (C19) and (C20) result in

$$\begin{aligned} & \int_{\ln(K/S_0)}^{\infty} \min\left(\frac{S_0 e^{Y_t}(e^{qt} - 1) + K}{S_0 - C_0} - e^{rt}, 0 \right)^2 \\ & \times f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t = 0 \end{aligned} \tag{C21}$$

Combining Equations (C15), (C18), and (C21) gives

$$\begin{aligned} SV_{CC,t} = {} & \int_{-\infty}^{\ln(\frac{S_0 - C_0}{S_0}) + (r-q)t} \left(\frac{S_0 e^{Y_t + qt}}{S_0 - C_0} e^{rt} \right)^2 \\ & \times f(Y_t; (\mu - \sigma_f^2 / 2)t, \sigma_f^2 t) dY_t \end{aligned} \tag{C22}$$

Expanding the expression inside the integral gives

$$SV_{CC,t} = \left(\frac{S_0}{S_0 - C_0}\right)^2 e^{2qt} \int_{-\infty}^{\ln\left(\frac{S_0-C_0}{S_0}\right)+(r-q)t} e^{2Y_t} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t$$

$$-2\left(\frac{S_0}{S_0 - C_0}\right) e^{(r+q)t} \int_{-\infty}^{\ln\left(\frac{S_0-C_0}{S_0}\right)+(r-q)t} e^{Y_t} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY +$$

$$e^{2rt} \int_{-\infty}^{\ln\left(\frac{S_0-C_0}{S_0}\right)+(r-q)t} f(Y_t;(\mu - \sigma_f^2/2)t, \sigma_f^2 t)dY_t \tag{C23}$$

Combining Equations (C1), (C2), (C3), and (C23), and taking the square root gives

$$SSD_{CC,t} = \sqrt{\begin{array}{l} \left(\frac{S_0}{S_0 - C_0}\right)^2 e^{(2\mu+\sigma^2+2q)t} N(g_4) \\ -2\left(\frac{S_0}{S_0 - C_0}\right) e^{(\mu+r+q)t} N(g_5) + e^{2rt} N(g_6) \end{array}}$$

$$g_4 = \frac{\ln((S_0 - C_0)/S_0) + (r - q - \mu - (3/2)\sigma_f^2)t}{\sigma_f \sqrt{t}}$$

$$g_5 = \frac{\ln((S_0 - C_0)/S_0) + (r - q - \mu - (1/2)\sigma_f^2)t}{\sigma_f \sqrt{t}}$$

$$g_6 = \frac{\ln((S_0 - C_0)/S_0) + (r - q - \mu + (1/2)\sigma_f^2)t}{\sigma_f \sqrt{t}} \tag{C24}$$

Equation (C24) is identical to Equation (14).

For completion, the formulas for regular standard deviations (with respect to means, not the risk-free rate) of the stock index and the CC strategy are also provided. Their derivation is very similar to that of semi-standard deviation:

$$SD_{s,t} = \sqrt{e^{(2\mu+2q)t} e^{\sigma_2 t} - 1} \tag{C25}$$

$$SD_{CC,t} = \sqrt{\begin{array}{l} \left(\frac{S_0}{S_0 - C_0}\right)^2 e^{(2\mu+\sigma^2+2q)t} N(c_1) - 2\left(\frac{S_0}{S_0 - C_0}\right) e^{(\mu+ER\alpha+q)t} \\ \times N(c_2) + e^{2ER\alpha t} N(c_3) \left(\frac{S_0}{S_0 - C_0}(e^{qt} - 1)\right)^2 N(-c_1) \\ + \left(\frac{2KS_0}{(S_0 - C_0)^2}(e^{qt} - 1)\right) N(-c_2) \\ + \left(\frac{K}{S_0 - C_0}\right)^2 N(-c_3) - 2\left(\frac{S_0}{S_0 - C_0}(e^{qt} - 1)e^{ER_\alpha t}\right) \\ \times N(-c_2) - 2\left(\frac{K}{S_0 - C_0} e^{ER_\alpha t}\right) N(-c_3) + e^{2ER_\alpha t} N(-c_3) \end{array}}$$

$$c_1 = \frac{\ln(K/S_0) - (\mu + (3/2)\sigma_f^2)t}{\sigma_f \sqrt{t}}$$

$$c_2 = \frac{\ln(K/S_0) - (\mu + (1/2)\sigma_f^2)t}{\sigma_f \sqrt{t}}$$

$$c_3 = \frac{\ln(K/S_0) - (\mu - (1/2)\sigma_f^2)t}{\sigma_f \sqrt{t}}$$

$$ER_\alpha = \ln(1 + E[R_{\alpha,t}])/t \tag{C26}$$

ENDNOTES

I would like to thank Oleg Bondarenko, Francis Diebold, Michael Johannes, Tom Phillips and Jonathan Reiss for their helpful feedback as well as Yevgeniy Gendelman, Lilya Popovetsky, Natalie Rosenberg and Jennifer Wilson.

[1]Due to put–call parity, the CC strategy is similar to a short-put-option/long-cash strategy.

[2]Alternatively, the CC strategy could be compared to a weighted average (based on the option's delta) of the stock index and cash. In this article, however, in order to be consistent with the other empirical literature on CC strategies (e.g., Whaley [2002]), I compare the efficacy of the CC strategy to the stock index itself. Regardless, this theoretical framework can easily handle any benchmark comparison selected for the CC strategy.

[3]In this case, realized volatility is the future stock index volatility that corresponds to the same time horizon as the time to option expiration.

[4]When analyzing the implications of the theoretical framework proposed in this article, it is assumed that an investor's view on the value of the ERP does not necessarily vary in a market efficient manner with their view on equity market risk. In addition, it is assumed that investors can differ in their views on the value of the ERP, even if they happen to agree on the level of equity market risk. These assumptions are realistic given the wide range of views held by well-respected academics and practitioners on the value of the ERP. The theoretical framework itself, however, does not depend on these assumptions.

[5]In a portfolio context, investors can somewhat control for the ERP effect, and thus isolate the implied–realized volatility spread effect of the CC strategy by changing their existing equity exposure based on their CC position. However, as mentioned previously, this article concentrates on comparing a fully invested and unlevered CC strategy to the stock index. Alternatively, investors can capture the implied–realized volatility spread by entering into volatility and variance swaps (or dynamically delta hedging short option positions with the stock index); however, this approach results in very different risks that need to be carefully analyzed.