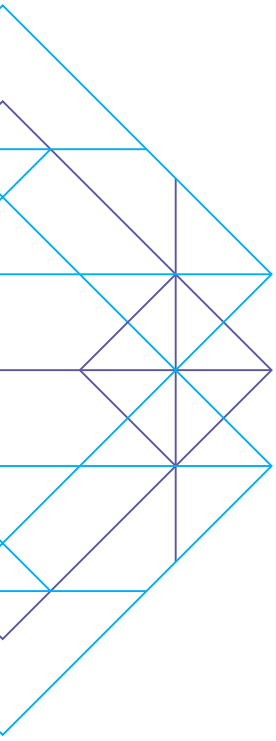
May 2018

Understanding the Volatility Risk Premium



Executive Summary

The volatility risk premium (VRP) reflects the compensation investors earn for providing insurance against market losses. The financial instruments that allow investors to protect against such downside exposure, primarily options, tend to trade at a premium, as with all insurance. This insurance risk premium embedded in options reflects investors' risk aversion and their tendency to overestimate the probability of significant losses. An investor may be able to exploit these risk preferences and behavioral biases by systematically selling options to underwrite financial insurance for profit. We illustrate the VRP with a simple S&P 500 option-selling strategy example and show how it may generate positive returns with moderate risk over the long run. We further demonstrate that the option selling strategy exhibits low correlation to many traditional and alternative return sources, further making the case for its inclusion in an investor's portfolio.

We thank Marco Hanig, Ronen Israel, Bradley Jones, Aaron Kelley, Lars Nielsen, and Daniel Villalon for helpful comments and suggestions.

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Introduction

The volatility risk premium (VRP) represents the reward for bearing an asset's downside risk. It exists across geographies and in many asset classes for the same basic reason as any insurance premium: investors seek downside protection against adverse events.

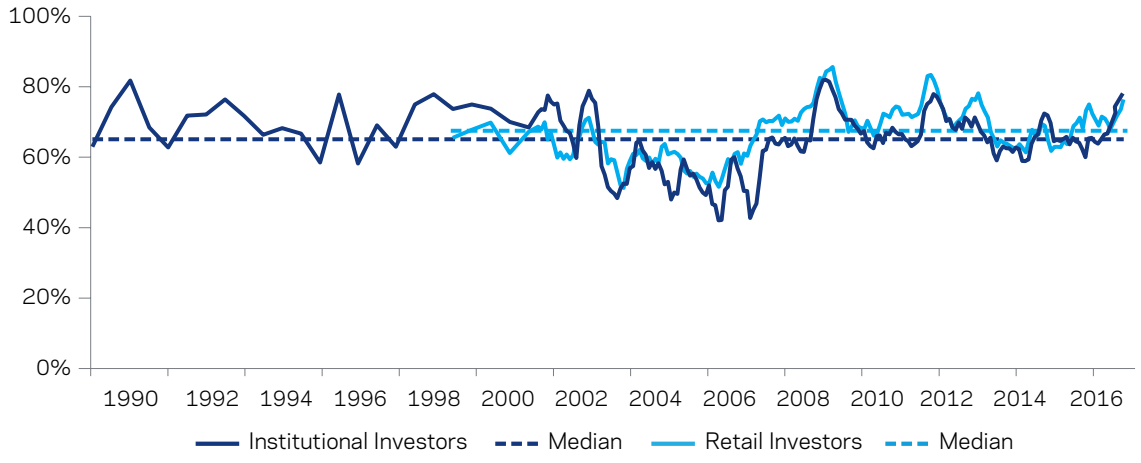
We believe that in the case of financial insurance, investor demand for and value placed on such insurance is underpinned by risk aversion and the tendency to overestimate the probability of extreme market events. These investor traits may give rise to the ability to systematically harvest the VRP across time and markets. To illustrate this investor behavioral bias to overestimate downside risk, we point to a survey conducted by Yale University (see Goetzmann et al. 2016) that asks both retail and institutional investors to estimate the probability of a "catastrophic stock market crash" within the next six months.[1] **Exhibit 1** shows the percentage of participants over time who believe the risk of such a catastrophic event is greater than 10%. From the graph we see that since 1989, with a few exceptions, a majority of both institutional and retail investors (roughly two-thirds of them on average) consistently believe that there is greater than a 10% chance of a catastrophic crash occurring within the next six months. In reality, the historical likelihood of such an event has been only approximately 1%!

Such overestimation of crash risk may lead to investors' willingness to pay and insurers' demand to receive a high price for portfolio protection. Some investors seek to protect their portfolios by purchasing options, and we find that such demand for hedging leads to financial insurance being systematically profitable, giving rise to the existence of the VRP.

Exhibit 1

Investors Frequently Overestimate the Risk of a Market Crash

Percent of Yale U.S. Crash Confidence Survey Participants Who Believe the Probability of a Catastrophic Crash within the Next Six Months Is Greater Than 10%



Source: AQR, Yale School of Management. See footnote 1 for more information. Data from April 1989 to December 2016. For illustrative purposes only.

1 The question asked by the Yale Confidence Survey is "What do you think is the probability of a catastrophic stock market crash in the U.S., like that of October 28, 1929 or October 19, 1987 in the next six months, including the case that a crash occurs in the other countries and spreads to the U.S.?"

Accessing the Volatility Risk Premium

Option contracts are the financial market's standardized version of insurance and provide access to the VRP. An option buyer's objective is generally to hedge an asset against losses. An option seller's objective, conversely, is generally to profit from selling (also called "writing") the option contract. The option buyer pays an upfront cost, known as an option premium, that is collected by the seller.

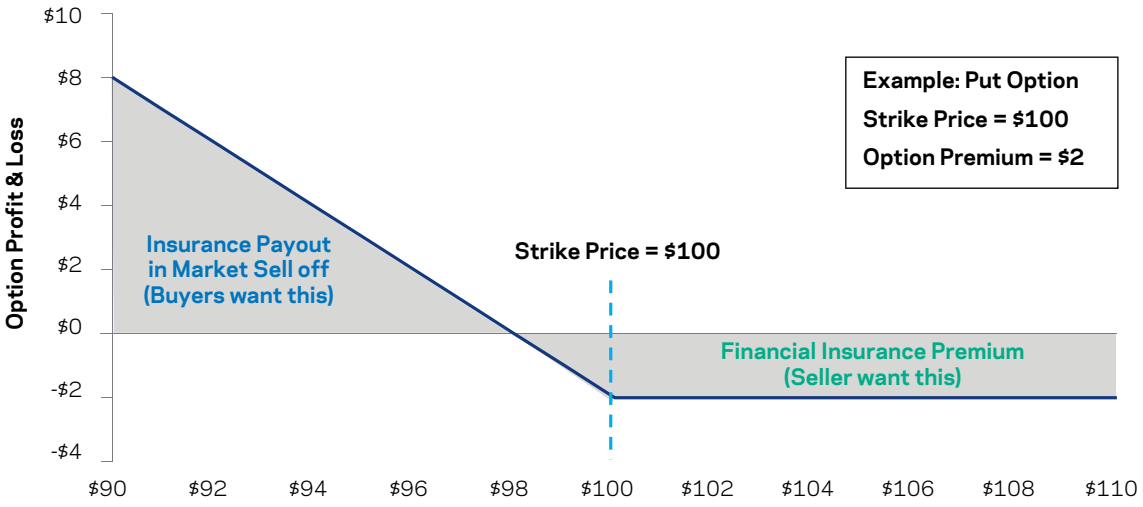
Exhibit 2 provides an example of an investor who wants to hedge against a decline in the stock price below $100. The investor buys a cash-settled put option with a strike price of $100, for which he pays a premium of $2. At expiration, the option will expire worthless if the stock price is above $100 — the seller will have earned $2 and the buyer will have lost/paid $2. However, if the stock price were to drop below $100, the buyer would exercise the option and the seller would be required to provide a payment to the buyer equal to the difference between the strike price and the current stock price to make up for the shortfall below $100.

With options, similar to most insurance contracts, we expect the buyer to pay the seller a premium as compensation for bearing this downside risk. As we discussed earlier, for options, the premium may persistently exist over time for several reasons. First, the option seller needs to be incentivized to enter the agreement because the seller is exposed to the risk of sharp price movements. Second, as the Yale study indicates, market participants consistently overestimate the likelihood of market crashes and thus possibly the value of downside protection. This spread between an option's purchase price and its fair value — the seller's expected profit over time — is commonly referred to as the volatility risk premium.[2] We next turn to explore the historical evidence of the VRP.

Exhibit 2

Option Contracts Provide Access to the VRP

Put Option Payoff: Right to Sell Security



Source: AQR. For illustrative purposes only.

2 More technically, volatility risk premium refers to the spread between an option's implied volatility (as calculated using, for example, the Black-Scholes option pricing model) and the underlying asset's subsequent realized volatility.

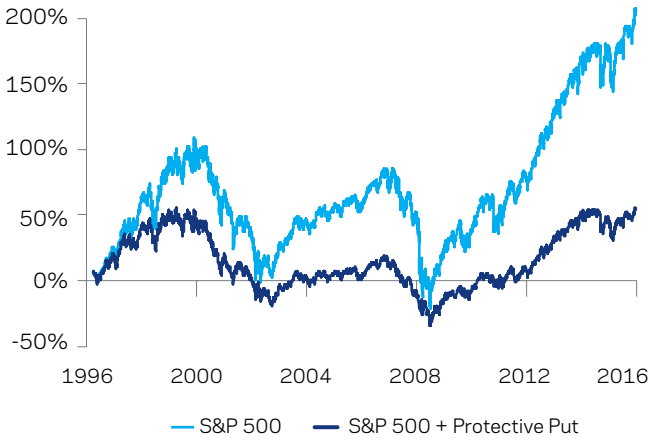
Empirical Evidence

We next illustrate the historical results from the perspectives of both buyers and sellers of options — in this case, put options.

Put Buyer's Perspective:
We model an equity investor concerned about drawdowns, who thus seeks to hedge the portfolio against losses. For the period 1996 to 2016, we construct a hypothetical portfolio that is long the S&P 500 and a continuously rolled one-month, 5% out-of-the-money "protective put" to hedge against losses.

Exhibit 3 reports the results for the option buyer ("S&P 500 + protective put") in comparison to simply holding the S&P 500 index. The hedged strategy achieves its objective of lowering portfolio risk. It reduces portfolio volatility from 16.1% to 12.7% and shrinks the maximum peak-to-trough drawdown from 62% to 57%. However, these benefits come at a hefty cost as average portfolio returns decline from 5.1% to 1.8%. The strategy's diminished returns more than offset the benefits of volatility reduction as the portfolio's Sharpe ratio declined from 0.32 to 0.14. These results demonstrate that continuously buying puts to hedge against market risk can be quite expensive.[3]

Exhibit 3
The Option Buyer's Perspective
Protective Put Cumulative Returns



1996-2016	S&P 500	S&P 500 + Protective Put
Annualized Return	5.1%	1.8%
Annualized Volatility	16.1%	12.7%
Sharpe Ratio	0.32	0.14
Max. Drawdown	-62%	-57%
Beta to S&P 500	1.00	0.73

Source: AQR, Bloomberg, and OptionMetrics. Data from January 4, 1996, through December 31, 2016. For the protective put backtest, the options used were front month S&P 500 put options, selected to be 5% out of the money, sized to unit leverage, and held to expiry. Returns are net of estimated transaction costs and excess of cash (US three-month LIBOR). No representation is being made that any investment will achieve performance similar to those shown. For illustrative purposes only and not representative of a portfolio AQR currently manages. Hypothetical data have inherent limitations, some of which are discussed in the disclosures.

3 Furthermore, Israelov (2017) looks at an in-depth analysis of protective put options and finds that the protection provided is not compelling due to path dependency.

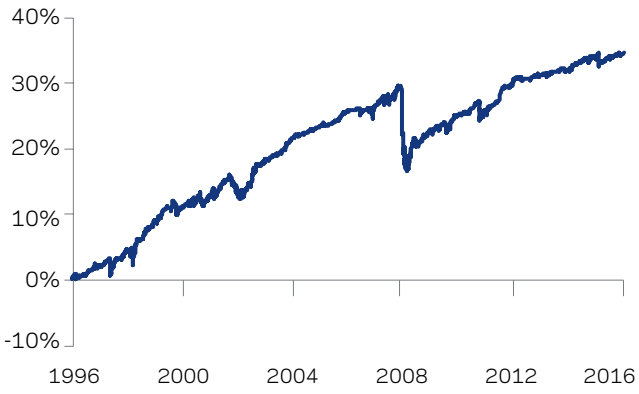
Put Seller's Perspective: How does the option writer fare? We model the returns of an investor that sells the same 5% out-of-the-money put option every month, holding it to expiration. Additionally, this investor hedges the equity exposure embedded in the options[4], a common practice to reduce risk known as delta-hedging.

From **Exhibit 4**, we observe that this option selling strategy over the same 1996–2016 period as before has been profitable, generating annualized returns of 1.5% with a volatility of 2.2%.[5] The strategy's Sharpe ratio is 0.68, which is higher than the 0.32 Sharpe ratio generated for a passive S&P 500 strategy (as seen in **Exhibit 3**). We see also that its drawdowns coincided with equity market crashes (as seen in 2008). We emphasize that as with most insurance, option contracts pay out during bad times. Overall, the strategy generated positive returns and an attractive Sharpe ratio over the long term, with little beta to equities.[6]

Exhibit 4

The Option Seller's Perspective

Short Options Cumulative Returns



1996-2016	Short Options
Annualized Return	1.5%
Annualized Volatility	2.2%
Sharpe Ratio	0.68
Max. Drawdown	-10%
Beta to S&P 500	0.04

Source: AQR, Bloomberg, and OptionMetrics. Data from January 4, 1996, through December 31, 2016. For the short options backtest, the options used were Front Month S&P 500 put options, selected to be 5% out of the money, sized to unit leverage, and held to expiry.

The short options backtest was also delta-hedged daily. Returns are net of estimated transaction costs, gross of fees, and excess of cash (US three-month LIBOR). No representation is being made that any investment will achieve performance similar to those shown. For illustrative purposes only and not representative of a portfolio AQR currently manages. Hypothetical data have inherent limitations, some of which are in the disclosures.

4 In this case, by shorting an appropriate amount of S&P 500 futures to offset the short put option's positive exposure to the underlying equity market.

5 Our illustrative example sells a unit-levered 5% out-of-the-money monthly put option to match the other side of the option buyer's position. A portfolio seeking to harvest the volatility risk premium would generally be constructed differently across a number of dimensions in order to build a more optimal portfolio.

6 Additionally, Fallon et. al. (2015) show evidence of the volatility risk premium across a wide range of option markets across asset classes.

Return & Risk Characteristics

Potential Benefits: Beyond providing a potentially profitable source of returns over the long run, a VRP strategy has another important potential benefit: It is diversifying to other well-known sources of return.

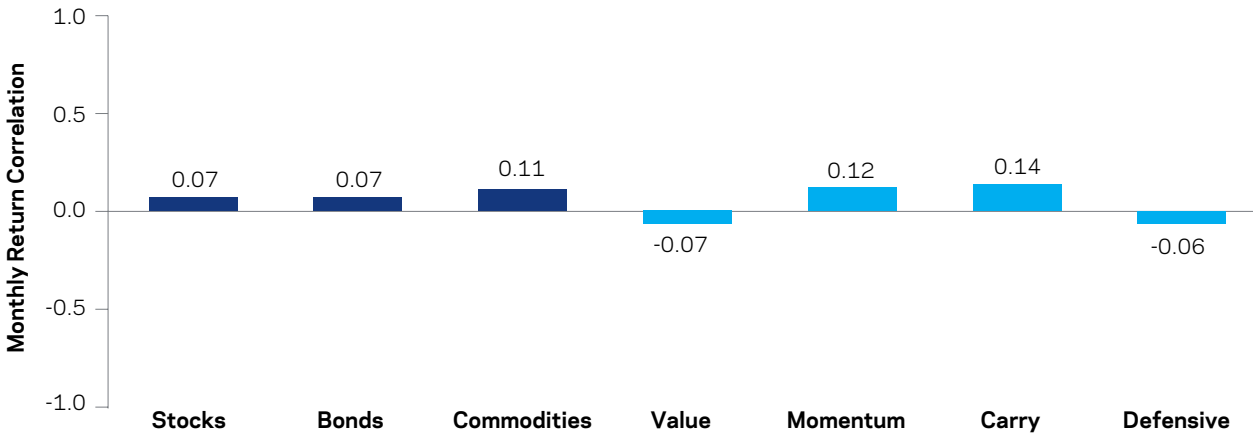
Exhibit 5 shows the correlations of a simple, beta- hedged equity option selling strategy (including selling options at multiple strikes) to common return sources.[7] The strategy exhibits fairly low correlation to both traditional asset classes (stocks, bonds, and commodities) and well-known style premia (value, momentum, carry, and defensive), indicating that the VRP may be a diversifying source of return for many investors.[8]

Potential Risks: Simply looking at the average correlation between an option selling strategy and the returns of the underlying market, however, does not tell the complete story. This is because, as mentioned earlier, the primary risk of a beta-hedged, short options strategy is the exposure to sudden, large market movements.[9] These sharp movements are the events that the option seller has underwritten insurance against. This exposure is also the very reason that the option seller expects to be compensated over the long run (and historically has been, as shown in **Exhibit 4**).

Exhibit 5

S&P 500, Beta-Hedged Short Options Strategy Return Correlations

February 1996 - December 2016



Source: AQR, Bloomberg, and OptionMetrics. Stocks are represented by the S&P 500, Bonds are represented by the Barclays US Aggregate, and Commodities are represented by the Bloomberg Commodity Index. The beta-hedged short options strategy sells an equal amount of the following front-month S&P 500 options: 25-delta put, 25-delta call, and 50-delta straddle. These options are held to expiration and beta-hedged daily. Results are gross of transaction costs and fees. See footnote 7 for more information. No representation is being made that any investment will achieve performance similar to those shown. For illustrative purposes only and not representative of a portfolio AQR currently manages. Hypothetical data have inherent limitations, some of which are in the disclosures. Diversification does not eliminate the risk of experiencing investment losses.

7 We backtest a strategy that sells an equal amount of the following front-month S&P 500 options: 25-delta put, 25-delta call, and 50-delta straddle. These options are held to expiration and beta-hedged daily. Hull and White (2016) describe methods to adjust standard Black-Scholes delta to hedge equity market beta.

8 Styles are defined in Asness et al. (2015). These style premia are captured in numerous asset classes: stock selection, industry allocation, country allocation in equity, fixed income, and currency markets, and commodities, by combining several indicators in each asset class and forming hypothetical long–short style portfolios that are rebalanced monthly while seeking to ensure the portfolio is market neutral. See disclosures for more detail.

9 A beta-hedged short options strategy typically has little exposure to small market moves. Options are nonlinear instruments, however, and the strategy is exposed to the market during large market moves due to an option contract's convexity.

Investors should also consider the conditional nature of the VRP strategy's correlations. That is, it's not just average correlations that matter but also how the strategy performs in specific market environments. **Exhibit 5** reports that the full-period correlation between the strategy and the S&P 500 was fairly low (0.07). However, as seen in **Exhibit 6**, the strategy can experience losses during more extreme market moves, both positive and negative, such as in March 2000 and September 2008, when the S&P 500 gained and lost approximately 10%, respectively.

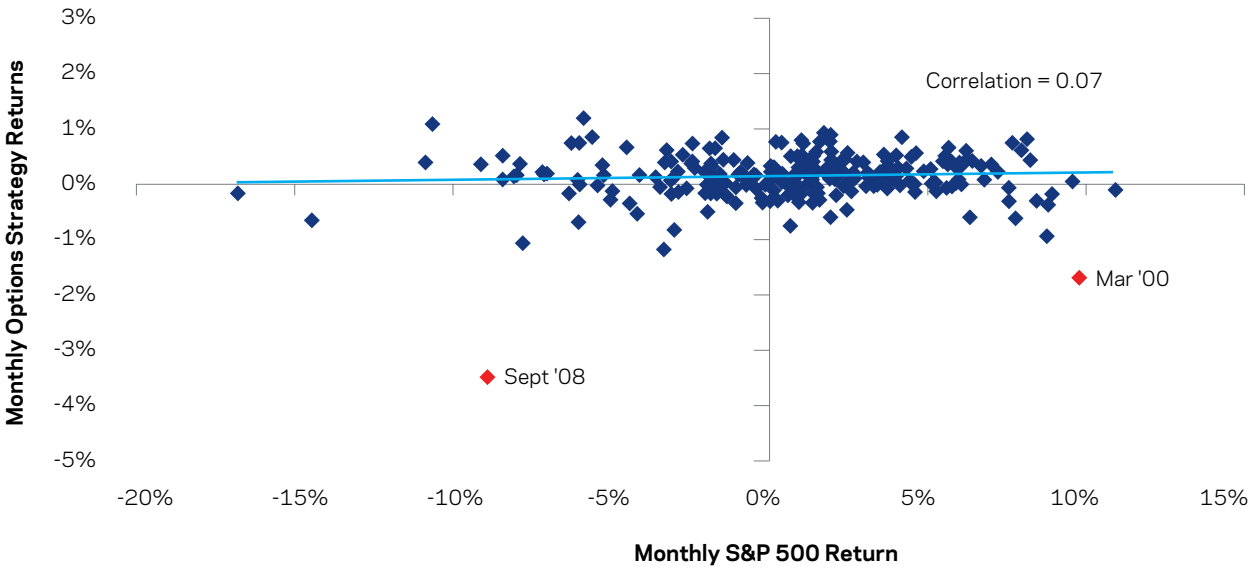
The key point is that the nature of equity market returns matters. Again, sharp equity market movements (with high daily realized volatility) can lead to losses for a short options strategy. However, during gradually declining equity markets (with low daily realized volatility), the strategy may experience flat or even positive returns. So, contrary to common belief, an equity market decline does not necessarily lead to losses for a short options strategy.

Some investors may also question whether selling options makes sense when volatility is low and correspondingly option prices are "cheap." Israelov and Nielsen (2015) show however, that the VRP persists across volatility regimes. Even in a low volatility environment, implied volatility has tended to be higher than realized volatility, meaning that selling options in such environments has still been profitable on average. In sum, we believe that the rationale behind the existence of the VRP — providing insurance against large market moves — prevails regardless of the current level of volatility.

Exhibit 6

VRP Strategies Tend to Have Their Worst Performance during Sudden Market Changes — Either Up or Down

S&P 500, Beta-Hedged Short Options Strategy Returns versus S&P 500 Returns
February 1996 – December 2016



Source: AQR, Bloomberg, and OptionMetrics. Beta-hedged short options strategy that sells an equal amount of the following front-month S&P 500 options: 25-delta put, 25-delta call, and 50-delta straddle. These options are held to expiration and beta-hedged daily. Results are gross of transaction costs and fees. See footnote 7 for more information. No representation is being made that any investment will achieve performance similar to those shown. Hypothetical data have inherent limitations, some of which are in the disclosures. For illustrative purposes only.

Adding the Volatility Risk Premium to a Portfolio

Investors interested in adding the VRP to their portfolio have multiple options. The strategy can be a standalone portfolio, one of multiple sleeves of a multi-alternative portfolio, part of a buy-write strategy, or part of a volatility-enhanced equity strategy. We discuss briefly each of these approaches.

Standalone VRP Strategy (Beta = 0.0): A beta-neutral short options portfolio (the primary focus of this paper) maybe an attractive stand-alone strategy within an overall portfolio. As we've shown, the strategy typically has steady, positive returns in most market environments and may be a good diversifier to equity, fixed income, and alternative allocations. While having a strong Sharpe over the long haul, the strategy can experience meaningful drawdowns during sharp market swings. Therefore allocations to it should be sized appropriately to reflect this tail risk.

Part of a Multi-Alternative Portfolio (Beta = 0.0): For some investors, a standalone allocation to a VRP strategy (even if judiciously sized) may be undesirable. For these investors, a diversified multi-strategy portfolio that includes VRP as one of multiple alternative investment strategies may be the preferred way to access this strategy.

Buy-Write Strategy (Beta = 0.5): This strategy type goes by various names: buy-write, put-write, or covered call. While the specific implementation details differ among these strategies, they have similar economic exposures. The strategy's objective is to generate equity-like returns with lower risk and beta to equity markets. Although it generally has a beta of around 0.5, it seeks to replace the lower expected returns due to a lower allocation to the equity risk premium by allocating to the VRP.[10] Because a VRP allocation has a low correlation to equities, the strategy generally has lower volatility than a pure equity investment and thus a higher Sharpe ratio.

Volatility-Enhanced Equity (Beta = 1.0): Another interesting, though less common, approach overlays a beta- neutral VRP strategy onto a beta-1 equity portfolio in order to outperform an equity benchmark. With this approach, the portfolio remains fully invested in equities and generates active risk through the VRP. The strategy seeks to outperform an equity benchmark over the long run with similar risk.

Both the buy-write and volatility-enhanced equity implementations can also incorporate stock selection in an attempt to add alpha by tilting away from a market-cap-weighted portfolio.

In seeking to add VRP to their portfolio from among the above alternatives, investors should consider their allocations in the context of their overall objectives and asset allocation preferences.

10 See Israelov, Klein, and Tummala (2017) who provide global evidence on covered call strategies.

Conclusion

The VRP is the compensation that investors earn for providing protection against market losses. As such, VRP is viewed as a type of insurance, and as with all insurance, the underwriter seeks a risk premium. The VRP embedded in options further reflects investors' risk aversion and their tendency to overestimate the probability of significant market downturns. A VRP strategy employs these ideas by systematically selling options to underwrite financial insurance for profit. Option contracts are the financial market's version of insurance and offer a liquid instrument to harvest the VRP.

Historical analysis of a simple delta-hedged option-selling strategy on the S&P 500 shows positive returns and a respectable Sharpe ratio over time. Moreover, the strategy has had low correlations to well-known return sources, suggesting that the strategy can be diversifying when added to a portfolio.

The strategy can be accessed in multiple ways: An investor may consider it alongside traditional long-only equities or use it in conjunction with other nontraditional return sources. In all, we find compelling evidence in support of allocating to the VRP, which may improve outcomes for investors.

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Momentum is the tendency for investments that have recently performed well (or poorly) relative to other investments to continue performing well (or poorly) over the near term.

Carry is the tendency for higher-yielding assets to provide higher returns than lower-yielding assets.

Defensive is the tendency for lower-risk and higher-quality assets to generate higher risk-adjusted returns.

Volatility risk premia arises because financial instruments that allow investors to protect against downside or hedge extreme market events, primarily options, tend to trade at a premium — as with all insurance.

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