# Beyond Volatility:
# A New Way to Look at Risk Managed Index Strategy Performance

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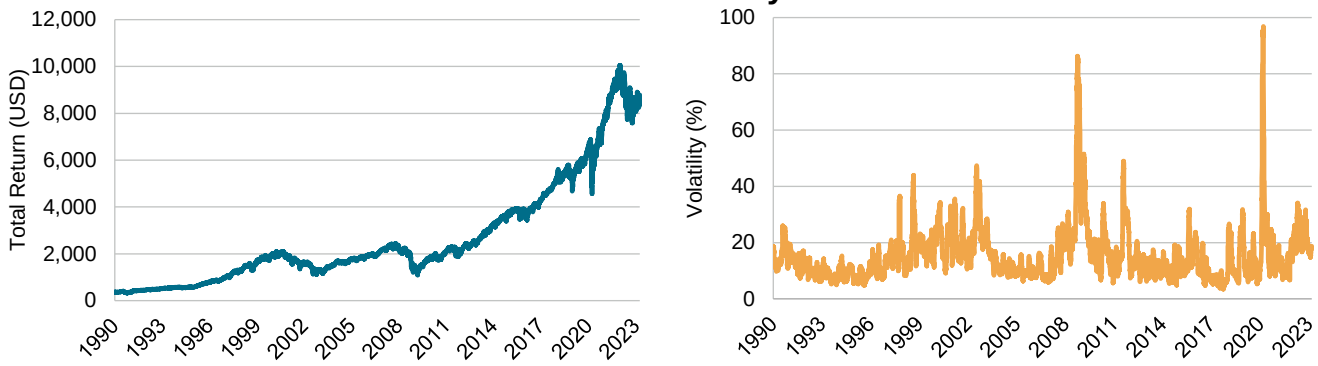
## Introduction

Equity markets have historically offered attractive returns. However, the volatility and risk of a significant pullback can be a notable concern for market participants. For example, the S&P 500®, the leading gauge of U.S. large-cap stocks, had an average annualized total return of 9.88% from Jan. 2, 1990, to March 31, 2023. Over this same period, the index also experienced extreme volatility spikes and periods of losses of over 50%, such as during the 2008 Global Financial Crisis (see Exhibit 4). While its one-year realized volatility has historically tended to be below 20%, during both the financial crisis and the more recent COVID-19 drawdown, volatility exceeded 80% and 90%, respectively. This level of volatility and uncertainty may not be desirable for some market participants.

**Exhibit 1: Cumulative Return and Realized Volatility of the S&P 500**




Source: S&P Dow Jones Indices LLC. Data from Jan. 2, 1990, to March 31, 2023. Index performance based on total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes.

Risk managed index strategies emerged as a solution designed to provide effective downside protection by reshaping the risk-distribution of the underlying equity index. While these index strategies have been historically successful in reducing volatility, their performance during past bull markets and the recent COVID-19 sell off may suggest some shortcomings.

This paper examines various risk managed indices that have the S&P 500 as the underlying equity exposure. We use S&P DJI indices as benchmarks in order to evaluate the performance for each of these index strategies.

## A New Framework for Looking at Risk

Performance is often evaluated by looking at the overall return and volatility, taking the entire history of the index, starting from its launch date. However, performance can differ drastically depending on both the start date and the duration of the employed observation period. In this paper, we take a more thorough approach by considering multiple performance paths and examining tail performance. A new risk management framework is presented that offers an alternative metric for risk, focusing on the amount of protection provided and the cost of providing that protection.

## Improving Hedge Efficiency: Proving Protection with Less Drag

This paper concludes by examining whether a more efficient approach to providing protection is possible in order to maximize equity market participation while simultaneously offering meaningful downside protection.

# Examination of Risk Managed Index Strategies

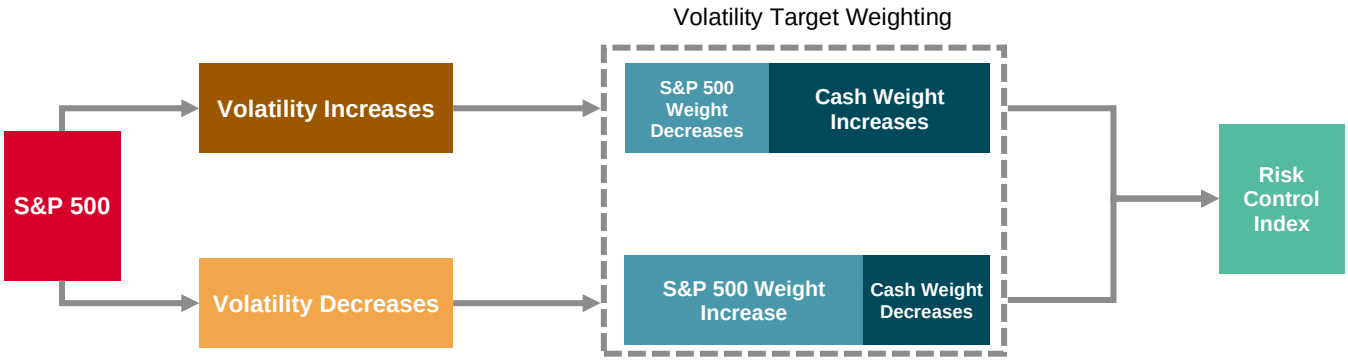
## Target Volatility

### Overview

This group of index strategies seeks to maintain specific volatility targets. Equity exposure is dynamically reduced during volatile market environments, generally leading to smoother performance compared to a broad investment in the underlying asset. These strategies utilize volatility clustering and the generally negative relationship between equity returns and volatility.

S&P DJI offers a variety of risk control indices with different volatility target levels, volatility calculation methods, weight limits, underlying assets and rebalancing frequencies, tailoring to different risk appetites and unique requirements. One example of a benchmark in this category is the S&P 500 Daily Risk Control 10% Index. This index shifts weight between the S&P 500 and cash, weighting the S&P 500 by the inverse of its realized volatility such that the index volatility level targets 10%.

**Exhibit 2: S&P Risk Control Indices Methodology**




Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

The weight is determined by a simple, rules-based framework based on the underlying index's historical volatility. When volatility is high, the risk control index moves out of the equity index and into cash. Conversely, if volatility decreases, the risk control index places more weight into the equity index and less in cash. The index adjusts exposure to the equity component and the cash component daily. This daily rebalancing allows the risk control index to quickly respond to changes in the market.

The downside of using historical volatility as the weight signal is the lack of distinction between upside and downside volatility. Capping volatility will reduce participation in the underlying index during volatile bull markets, potentially leading to some returns being sacrificed. Additionally, this linear transformation of investment outcomes means that during periods of sustained market declines, downside could still be significant, although reduced.

If the volatility of the underlying index falls below the target levels, the exposure to the index can be leveraged up to 150% to help meet the target volatility. The exposure to the underlying index is a simple ratio of the target volatility level and the historical volatility, capped by the maximum leverage. For example, when the historical volatility of the S&P 500 falls to 8%, the S&P 500 Daily Risk Control 10% index can weight 125% into the S&P 500.

Another implementation of target volatility index strategies is the S&P Risk Control 2.0 (RC2) Indices; in this series, the cash aspect of the standard risk control strategy is replaced with a liquid bond index for more upside participation. The S&P 500 Daily RC2 10% Index is an example of these next generation risk control strategies on equities and bonds. Among risk managed index strategies, risk control frameworks are the simplest and easiest to understand.

## Analysis

Exhibit 3 shows that the risk control mechanism effectively lowered and stabilized the volatility to a tight band around 10%. Over the past three years, the risk control index had less than half the volatility of the S&P 500.

Annualized returns were slightly lower across all periods compared to the benchmark, meaning some upside participation was passed over. However, on a risk-adjusted basis, the Sharpe and Sortino ratios are all higher than the benchmark over the longer-term 10-year and 17-year periods.

The index has a beta less than half that of the benchmark, which means it will tend to outperform in down markets and underperform in up markets.

## Exhibit 3: Risk/Return Statistics of S&P 500 Risk Control and RC2 Indices

| Category | S&P 500 Daily Risk Control 10% TR | S&P 500 Daily RC2 10% TR | S&P 500 TR |
|---|---|---|---|
| **Annualized Return (%)** | | | |
| 1-Year | -1.81 | -5.21 | -7.73 |
| 3-Year | 7.62 | 5.19 | 18.60 |
| 5-Year | 5.61 | 5.47 | 11.19 |
| 10-Year | 8.11 | 7.57 | 12.24 |
| Since Dec. 21, 2005 | 7.00 | 7.60 | 9.26 |
| **Annualized Volatility (%)** | | | |
| 3-Year | 9.34 | 9.52 | 20.15 |
| 5-Year | 10.04 | 10.01 | 21.74 |
| 10-Year | 10.21 | 9.89 | 17.71 |
| Since Dec. 21, 2005 | 10.13 | 10.31 | 20.11 |
| **Sharpe Ratio** | | | |
| 3-Year | 0.70 | 0.43 | 0.87 |
| 5-Year | 0.41 | 0.40 | 0.45 |
| 10-Year | 0.70 | 0.67 | 0.64 |
| Since Dec. 21, 2005 | 0.57 | 0.62 | 0.40 |
| **Sortino Ratio** | | | |
| 3-Year | 0.97 | 0.59 | 1.24 |
| 5-Year | 0.51 | 0.50 | 0.54 |
| 10-Year | 0.87 | 0.83 | 0.77 |
| Since Dec. 21, 2005 | 0.72 | 0.77 | 0.48 |
| **Beta (%)** | | | |
| 3-Year | 0.42 | 0.38 | - |
| 5-Year | 0.40 | 0.37 | - |
| 10-Year | 0.50 | 0.46 | - |
| Since Dec. 21, 2005 | 0.42 | 0.39 | - |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 4 shows that drawdowns for the risk control index were significantly reduced during the Global Financial Crisis and COVID-19 Market Sell-Off events. In addition, during the 2008 financial crisis, the risk control index recovered in less than 2/3 the time it took for the benchmark to recover to its previous high.

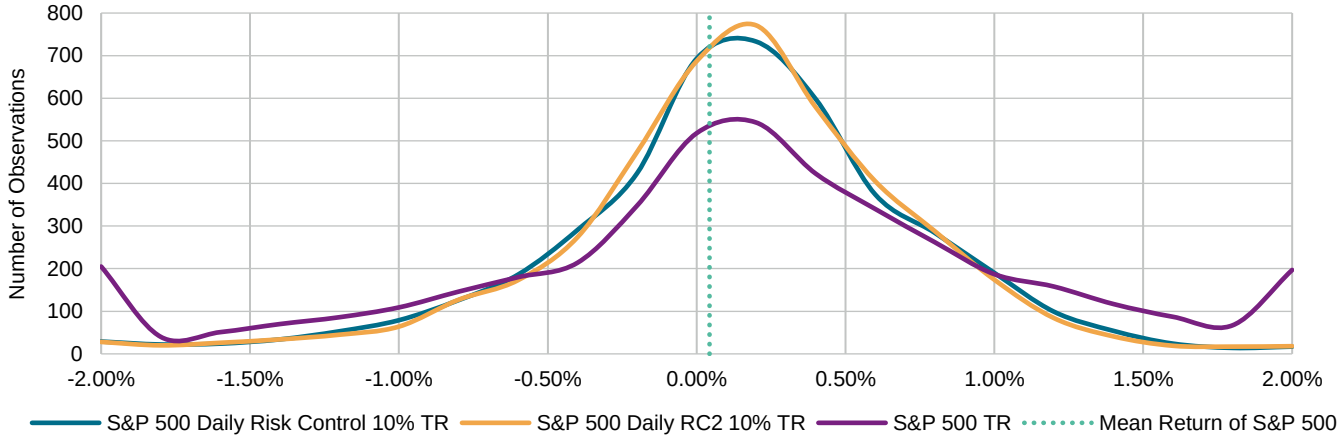
## Exhibit 4: Drawdown Analysis of S&P 500 Daily Risk Control 10% Index

| Category | S&P 500 Daily Risk Control 10% TR | S&P 500 TR |
|---|---|---|
| **Global Financial Crisis Drawdown** | -19.67% | -55.25% |
| Peak Date | July 19, 2007 | Oct. 9, 2007 |
| Trough Date | March 9, 2009 | March 9, 2009 |
| Number of Trading Days Peak-Trough | 412 | 355 |
| Recovery Length | 689 | 1129 |
| **COVID-19 Market Sell-Off** | -13.74% | -33.79% |
| Peak Date | Feb. 19, 2020 | Feb. 19, 2020 |
| Trough Date | March 23, 2020 | March 23, 2020 |
| Number Trading Days Peak-Trough | 23 | 23 |
| Recovery Length | 232 | 120 |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 5 shows that the magnitude of fat tails was reduced compared to the S&P 500 in the risk control index by effectively managing volatility. Moreover, the risk control index had a slight left skew, which means a slightly higher probability of delivering positive returns.

## Exhibit 5: Return Distribution of S&P 500 Risk Control and RC2 Indices

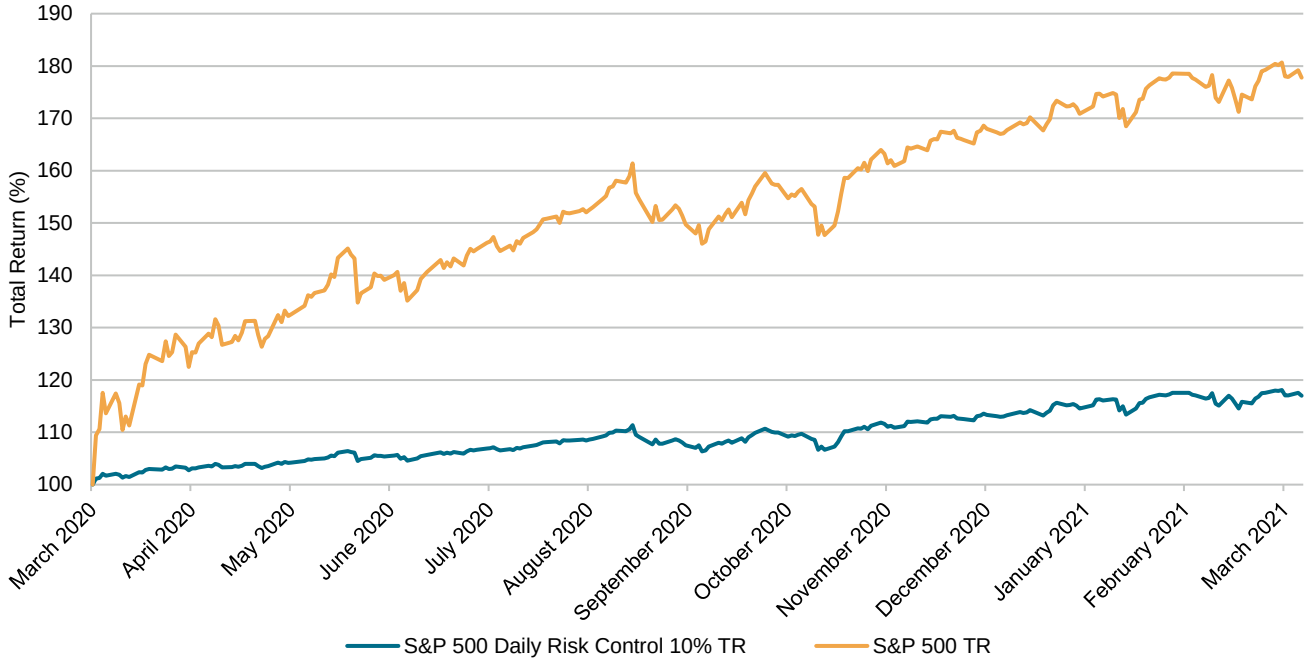



| Category | S&P 500 Daily Risk Control 10% TR | S&P 500 Daily RC2 10% TR | S&P 500 TR |
|---|---|---|---|
| Annualized Skew | -0.049 | -0.026 | -0.016 |
| Annualized Excess Kurtosis | 0.004 | 0.068 | 0.036 |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart and table are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 6 shows that the worst-case performance relative to the S&P 500 over all historical one-year performance paths would have been made at the bottom of the COVID-19 sell-off as of March 23, 2020. Exhibit 6 showcases an underperformance rate of 60.8% compared to the S&P 500 over this one-year period. In this scenario, a lot of upside was given up to provide the downside protection. By relying solely on realized volatility to hedge risk, market exposure under this strategy may be limited during prolonged periods of highly volatile markets, irrespective of whether it is upside or downside volatility. Volatility often takes a while to return to a more normal level after an event that causes a spike in volatility, and as a result, target volatility index strategies may not be able to participate in market recoveries that follows such volatility spikes.

**Exhibit 6: Worst 1-Year Relative Performance of the S&P 500 Daily Risk Control 10% Index**




Source: S&P Dow Jones Indices LLC. Data as of March 31, 2023. Index performance based on total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

# Managed Risk

## Overview

The S&P Managed Risk Indices seek to regulate volatility levels akin to the target volatility indices, but they aim to provide further capital protection by dynamically hedging the equity exposure using a synthetic put option. By replicating put options, these indices seek to provide downside protection without the prohibitive cost that would be associated with buying put options. The additional layer of risk management from the synthetic hedge aims to defend against losses during sustained market declines.

An example of a managed risk index is the S&P 500 Managed Risk Index, which uses the realized volatility of the underlying equity and fixed income indices, as well as the covariance between the two assets, to target a volatility level of 18%. The replicated put option has a constant maturity of five years and has a forward strike calculated from the moving average of a scalar multiple of the underlying equity index.

The S&P 500 Managed Risk Index has three components:

- A dynamic equity component (the S&P 500);
- A fixed bond component (the S&P U.S. Aggregate Bond Index); and
- A cash equivalent component (the U.S. Overnight Federal Funds Rate).

The S&P 500 Managed Risk Index starts with the S&P 500 and applies the managed risk overlay, which consists of three steps. First, the methodology tests all combinations and seeks to identify a hypothetical portfolio of equity and bond components with a historic volatility equal to the target. As the bond allocation is fixed, the equity weight is adjusted to achieve the desired volatility. Then, the equity allocation is adjusted based on a put overlay calculation, reduced by the delta of the option. Lastly, there is an allocation to cash if equity and bond exposure is less than 100%.

## Analysis

Exhibit 7 shows that the managed risk strategy has historically enabled higher participation in the upside than the risk control indices, resulting in improved annualized returns over the 3-, 5-, 10- and 17-year periods. The annualized return over the long term is the second closest to the benchmark of all risk managed indices studied, while still reducing the risk profile. The Sharpe and Sortino ratios were all higher compared to the benchmark apart from those for the three-year period. Looking at the period since 2005, the Sortino and Sharpe ratios were 58% and 45% higher, respectively, and the risk-adjusted return was 48% higher.

## Exhibit 7: Risk/Return Profile of the S&P 500 Managed Risk Index

| Category | S&P 500 Managed Risk Index TR | S&P 500 TR |
|---|---|---|
| **Annualized Return (%)** | | |
| 1-Year | -4.72 | -7.73 |
| 3-Year | 10.17 | 18.60 |
| 5-Year | 7.99 | 11.19 |
| 10-Year | 9.66 | 12.24 |
| Since Dec. 21, 2005 | 8.25 | 9.26 |
| **Annualized Volatility (%)** | | |
| 3-Year | 12.45 | 20.15 |
| 5-Year | 12.66 | 21.74 |
| 10-Year | 11.96 | 17.71 |
| Since Dec. 21, 2005 | 12.06 | 20.11 |
| **Sharpe Ratio** | | |
| 3-Year | 0.73 | 0.87 |
| 5-Year | 0.51 | 0.45 |
| 10-Year | 0.73 | 0.64 |
| Since Dec. 21, 2005 | 0.58 | 0.40 |
| **Sortino Ratio** | | |
| 3-Year | 1.03 | 1.24 |
| 5-Year | 0.67 | 0.54 |
| 10-Year | 0.93 | 0.77 |
| Since Dec. 21, 2005 | 0.76 | 0.48 |
| **Beta (%)** | | |
| 3-Year | 0.57 | - |
| 5-Year | 0.51 | - |
| 10-Year | 0.61 | - |
| Since Dec. 21, 2005 | 0.52 | - |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Managed Risk Index was launched April 11, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

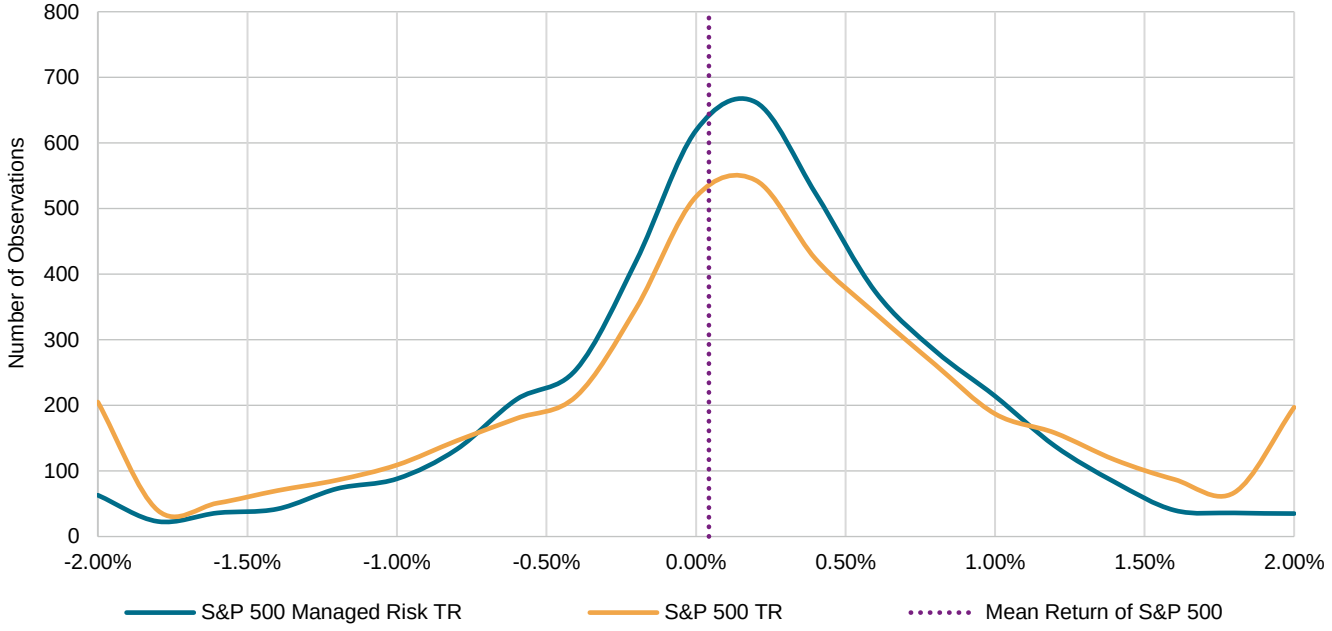
While the upside performance improved, the index still posted double-digit drawdowns during the financial crisis and COVID-19 sell-off (see Exhibit 8).

## Exhibit 8: Drawdown Analysis of the S&P 500 Managed Risk Index

| Category | S&P 500 Managed Risk Index TR | S&P 500 TR |
|---|---|---|
| **Global Financial Crisis Drawdown** | -25.34% | -55.25% |
| Peak Date | July 19, 2007 | Oct. 9, 2007 |
| Trough Date | Sept. 3, 2008 | March 9, 2009 |
| Number of Trading Days Peak-Trough | 412 | 355 |
| Recovery Length | 856 | 1129 |
| **COVID-19 Market Sell-Off** | -15.87% | -33.79% |
| Peak Date | Feb. 19, 2020 | Feb. 19, 2020 |
| Trough Date | March 23, 2020 | March 23, 2020 |
| Number of Trading Days Peak-Trough | 23 | 23 |
| Recovery Length | 211 | 120 |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Managed Risk Index was launched April 11, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

## Exhibit 9: Return Distribution of the S&P 500 Managed Risk Index

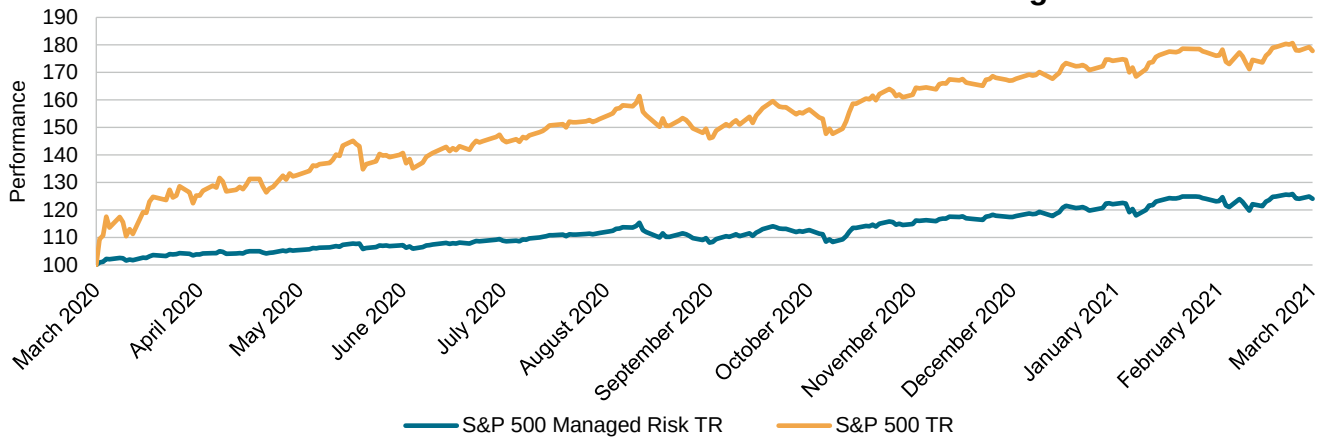



| Category | S&P 500 Managed Risk Index TR | S&P 500 TR |
|---|---|---|
| Skew | -0.034 | -0.016 |
| Kurtosis | 0.004 | 0.036 |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Managed Risk Index was launched April 11, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart and table are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Similarly, even though managed risk indices have historically provided better protection than risk control indices, there were still some declines observed during strong market recoveries. The one-year historical performance window starting at the bottom of the COVID-19 sell-off as of March 23, 2020, shows the managed risk index trailing the S&P 500 benchmark by 53.6% during this period.

**Exhibit 10: Worst 1-Year Relative Performance of the S&P 500 Managed Risk Index**




Source: S&P Dow Jones Indices LLC. Data as of March 31, 2023. Index performance based on total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

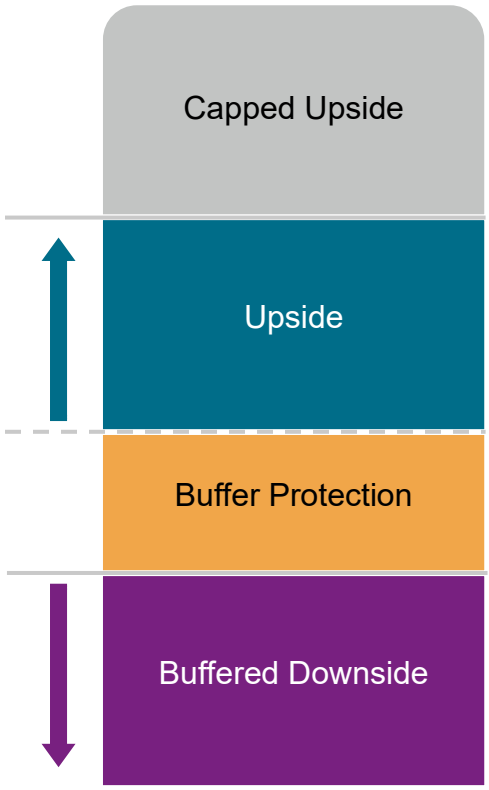
# Defined Outcome

## Overview

These strategies are designed to provide defined payout characteristics at the end of a specified period. They seek to provide buffer protection against losses up to a predetermined level, while also providing participation up to a capped level. The cap is determined such that the downside buffer is exactly financed by the premium received from giving up the upside potential, therefore negating the need for the strategy to bear additional cost premium. The return profile aims to be like that of the underlying index—with lower volatility and downside risks—in most market environments except for when the market is in a strong rally.

The Cboe S&P 500 Buffer Protect Index Series uses a basket of hypothetical S&P 500 FLEX options to achieve this buffer protection, providing protection against the first 10% of losses. Launched in 1993, Flexible Exchange (FLEX) options) allow users to specify key contract terms, including strike prices fixed and in percent terms at time of trade, European and American exercise style, and expiration dates out to 15 years. In addition to defined outcome benchmarks, FLEX options are used in overwrite strategies where the options can be European style, meaning no early exercise or assignments. ETFs, unit investment trusts (UITs), variable insurance trusts (VITs), structured annuities, registered index linked annuities, indexed annuities (point-to-point call spreads) and other bespoke may use these option strategies.

**Exhibit 11: Defined Outcome Strategies**




Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

In this paper, we focus on the Cboe S&P 500 Buffer Protect Index Balanced Series (SPRO). The balanced series is a composite of the 12 monthly series with laddered options maturities, where each monthly series is equally weighted at each monthly roll date. Each monthly series targets a 10% buffer on the downside for a 12-month term. The balanced series does not provide the target returns of the buffer protect strategy, but instead the average of the monthly series of the annual buffer protect strategy.

The index series uses systematic options and option overwriting to achieve a target outcome. The performance cap resets annually for each series. On each roll date:

- Buy 2 call options with strike = 50% of S&P 500 closing price
- Write 2 type A put options with strike = 50% of S&P 500 closing price
- Write 1 type B put option with strike = 90% of S&P 500 closing price
- Buy 2 put options with strike = 100% of S&P 500 closing price
- Write1 type A call option with strike = 100% of S&P 500 closing price
- Write1 type B call option with strike = Cap on roll date

This is a simple, transparent and cost-effective index-based alternative to traditional structured products and structured annuities. Market participants gain contractual certainty in the outcome by using options. The risk-mitigation characteristics with bond-like payouts could make this strategy potentially suitable as a complement to other income sources in retirement plans.

## Analysis

Exhibit 12 shows the defined outcome strategy achieved lower volatility than the benchmark, while the risk-adjusted returns were higher for all periods and Sharpe ratios were slightly higher than the benchmark over the 3- and 5-year periods.

**Exhibit 12: Risk/Return Statistics of the Cboe S&P 500 Buffer Protect Index**

| Category | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 TR |
|---|---|---|
| **Annualized Return (%)** | | |
| 1-Year | -1.02 | -7.73 |
| 3-Year | 13.12 | 18.60 |
| 5-Year | 8.15 | 11.19 |
| 10-Year | 7.83 | 12.24 |
| Since Dec. 21, 2005 | 6.71 | 9.26 |
| **Annualized Volatility (%)** | | |
| 3-Year | 12.53 | 20.15 |
| 5-Year | 14.40 | 21.74 |
| 10-Year | 11.22 | 17.71 |
| Since Dec. 21, 2005 | 13.89 | 20.11 |
| **Sharpe Ratio** | | |
| 3-Year | 0.96 | 0.87 |
| 5-Year | 0.46 | 0.45 |
| 10-Year | 0.62 | 0.64 |
| Since Dec. 21, 2005 | 0.40 | 0.40 |
| **Sortino Ratio** | | |
| 3-Year | 1.29 | 1.24 |
| 5-Year | 0.54 | 0.54 |
| 10-Year | 0.69 | 0.77 |
| Since Dec. 21, 2005 | 0.45 | 0.48 |
| **Beta (%)** | | |
| 3-Year | 0.60 | - |
| 5-Year | 0.61 | - |
| 10-Year | 0.59 | - |
| Since Dec. 21, 2005 | 0.65 | - |

Source: S&P Dow Jones Indices LLC, Cboe. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 13 shows that the defined outcome strategies had slightly improved drawdowns over the benchmark, in a similar magnitude when compared to the individual monthly target buffer percentage of 10%.

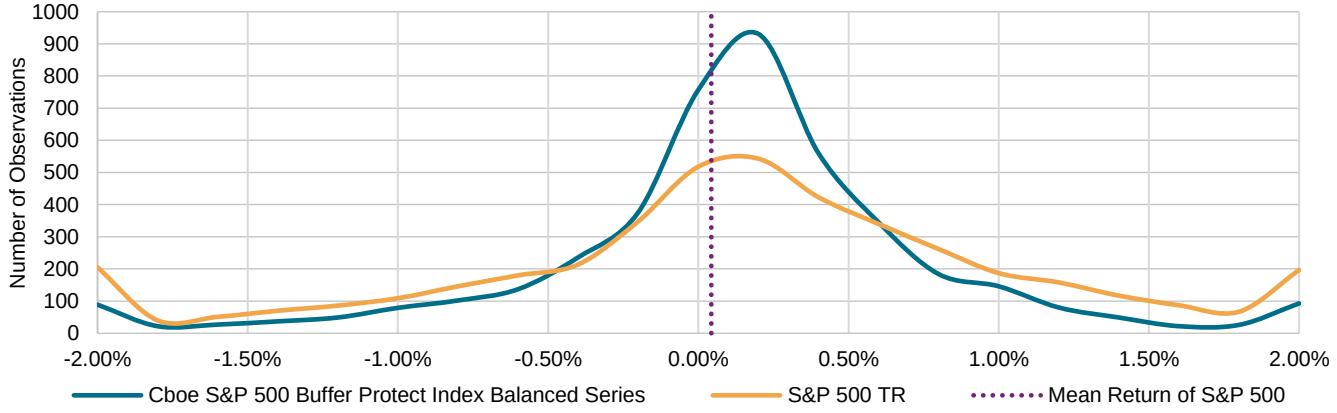
### Exhibit 13: Drawdown Analysis of the Cboe S&P 500 Buffer Protect Index

| Category | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 TR |
|---|---|---|
| **Global Financial Crisis Drawdown** | -43.79% | -55.25% |
| Peak Date | Oct. 9, 2007 | Oct. 9, 2007 |
| Trough Date | March 9, 2009 | March 9, 2009 |
| Number of Trading Days Peak-Trough | 355 | 355 |
| Recovery Length | 894 | 1129 |
| **COVID-19 Market Sell-Off** | -23.65% | -33.79% |
| Peak Date | Feb. 19, 2020 | Feb. 19, 2020 |
| Trough Date | March 23, 2020 | March 23, 2020 |
| Number of Trading Days Peak-Trough | 23 | 23 |
| Recovery Length | 116 | 120 |

Source: S&P Dow Jones Indices LLC, Cboe. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 14 shows the returns distributions have relatively high peaks around the mean (positive kurtosis) among the risk managed index strategies, demonstrating that the index has effectively targeted more stabilized returns.

### Exhibit 14: Return Distribution of the Cboe S&P 500 Buffer Protect Index

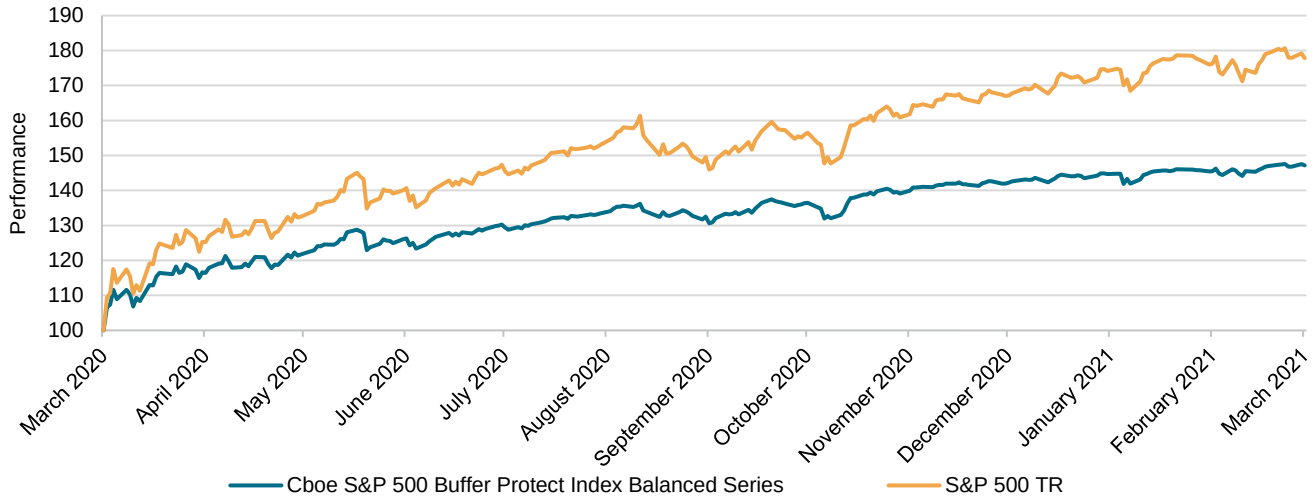



| Category | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 TR |
|---|---|---|
| Annualized Skew | -0.018 | -0.016 |
| Annualized Excess Kurtosis | 0.061 | 0.036 |

Source: S&P Dow Jones Indices LLC, Cboe. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart and table are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

This index performed better than other risk managed indices over the one-year period following the COVID-19 sell-off, but by design it tracks the S&P 500 performance also on the downside, as evidenced by the rather large drawdowns aligned with the S&P 500 drawdowns.

**Exhibit 15: Worst 1-Year Relative Performance of the Cboe S&P 500 Buffer Protect Index**




Source: S&P Dow Jones Indices LLC, Cboe. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

# Tail Risk

## Overview

We define tail risk index strategies as benchmarks that provide equity market exposure with control over large losses. They tend to perform well in bear markets, but otherwise suffer from the cost of hedging, and thus, the efficiency of the hedge is vital to the long-term success of these indices.

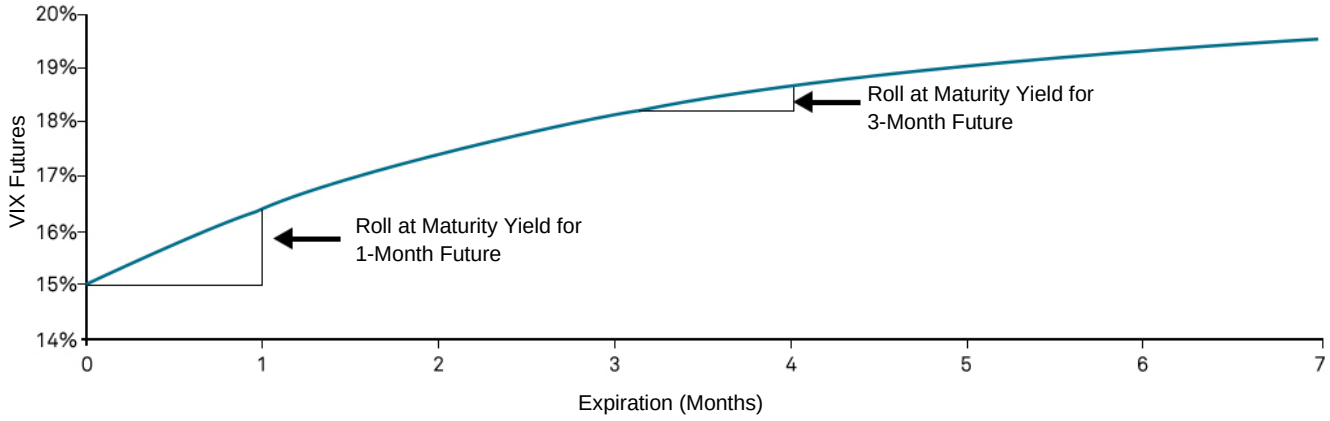
One example of a tail risk benchmark is the S&P 500 Dynamic VEQTOR Index. This index has a direct, built-in control over market volatility. It dynamically allocates among the S&P 500, the CBOE Volatility Index® (VIX®) and cash according to the realized volatility of the equity market and the implied volatility trend of S&P 500 options. It exploits the relationship between high realized volatility and significant market swings and uses VIX trends to observe a potential shift in the market's anxiety level. A stop-loss feature is also included as part of the strategy, which weights the entire position in cash if triggered.

VIX—widely regarded as the equity market's "fear gauge"—measures the market's expectation of 30-day S&P 500 volatility based on prices of near-term S&P 500 put and call options. VIX has a strong negative correlation to equity markets, which means it can be a suitable candidate to act as a hedge to equity allocations.

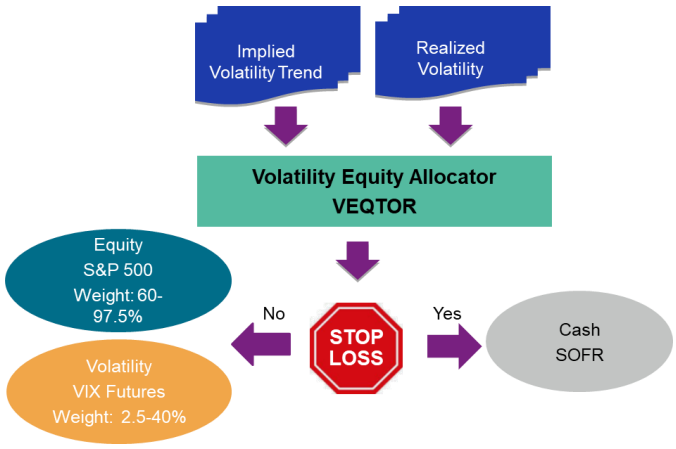
The negative correlation between VIX and the equity market is also convex. This means that when the S&P 500 drops, VIX tends to rise even further. Conversely, when the S&P 500 rises, VIX typically drops less. However, the spot VIX is not directly tradable—participants can take a position on VIX using VIX futures, options, variance swaps and others.

Holding VIX constantly in a portfolio comes with high carry costs and may result in a significant drag on long-term performance. Therefore, building a dynamic strategy that tactically weights to VIX in times of market stress can enable a more cost-efficient hedge strategy.

**Exhibit 16: VIX Term Structure during Rallying/Stable Markets and Equity Allocation**




| Target Equity/Volatility Index Allocation | | | |
|---|---|---|---|
| **Realized Volatility Environment** | **Implied Volatility** | **No Implied Volatility** | **Implied Volatility** |
| | **Downtrend** | **Trend** | **Uptrend** |
| < 10% | 97.5% / 2.5% | 97.5% / 2.5% | 90% / 10% |
| 10% to 20% | 97.5% / 2.5% | 90% / 10% | 85% / 15% |
| 20% to 35% | 90% / 10% | 85% / 15% | 75% / 25% |
| 35% to 45% | 85% / 15% | 75% / 25% | 60% / 40% |
| ≥ 45% | 75% / 25% | 60% / 40% | 60% / 40% |




Source: S&P Dow Jones Indices LLC. Charts and table are provided for illustrative purposes.

The VEQTOR strategy allocates between equity and volatility based on a combination of realized and implied volatility trend decision variables. While the weights are reviewed daily, they may change on a less frequent basis. At the close of any business day, if losses over the prior five business days are greater than or equal to 2%, then the index moves into a 100% cash position.

The characteristics of this index provide embedded protection against volatility spikes in the equity market, in particular tail events, which can inflict long-term damage to portfolio performance. These types of volatility drags can take years or even decades for a pure equity

strategy to recover from. However, this tail risk protection does not come without a cost: some weight is always in VIX, which may drag down performance in bull markets.

## Analysis

Exhibit 17 shows the index strategy has effectively reduced volatility compared to the benchmark historically, while producing slightly lower annualized return over the long term. The Sharpe ratios were lower in the short term, but 69% higher than that of the benchmark over the full period studied. This shows the index strategy is designed with long-term performance in mind.

**Exhibit 17: Risk/Return Statistics of the S&P 500 Dynamic VEQTOR Index**

| Category | S&P 500 Dynamic VEQTOR Index | S&P 500 TR |
|---|---|---|
| **Annualized Return (%)** | | |
| 1-Year | -7.03 | -7.73 |
| 3-Year | 5.27 | 18.60 |
| 5-Year | 4.77 | 11.19 |
| 10-Year | 4.85 | 12.24 |
| Since Dec. 21, 2005 | 8.57 | 9.26 |
| **Annualized Volatility (%)** | | |
| 3-Year | 11.42 | 20.15 |
| 5-Year | 12.54 | 21.74 |
| 10-Year | 10.57 | 17.71 |
| Since Dec. 21, 2005 | 10.86 | 20.11 |
| **Sharpe Ratio** | | |
| 3-Year | 0.36 | 0.87 |
| 5-Year | 0.26 | 0.45 |
| 10-Year | 0.37 | 0.64 |
| Since Dec. 21, 2005 | 0.68 | 0.40 |
| **Sortino Ratio** | | |
| 3-Year | 0.56 | 1.24 |
| 5-Year | 0.32 | 0.54 |
| 10-Year | 0.47 | 0.77 |
| Since Dec. 21, 2005 | 0.90 | 0.48 |
| **Beta (%)** | | |
| 3-Year | 0.36 | - |
| 5-Year | 0.29 | - |
| 10-Year | 0.32 | - |
| Since Dec. 21, 2005 | 0.31 | - |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

In line with the objective of these strategies, we see the most dramatic improvement among prevailing risk managed index strategies during significant drawdown events shown in Exhibit 18.

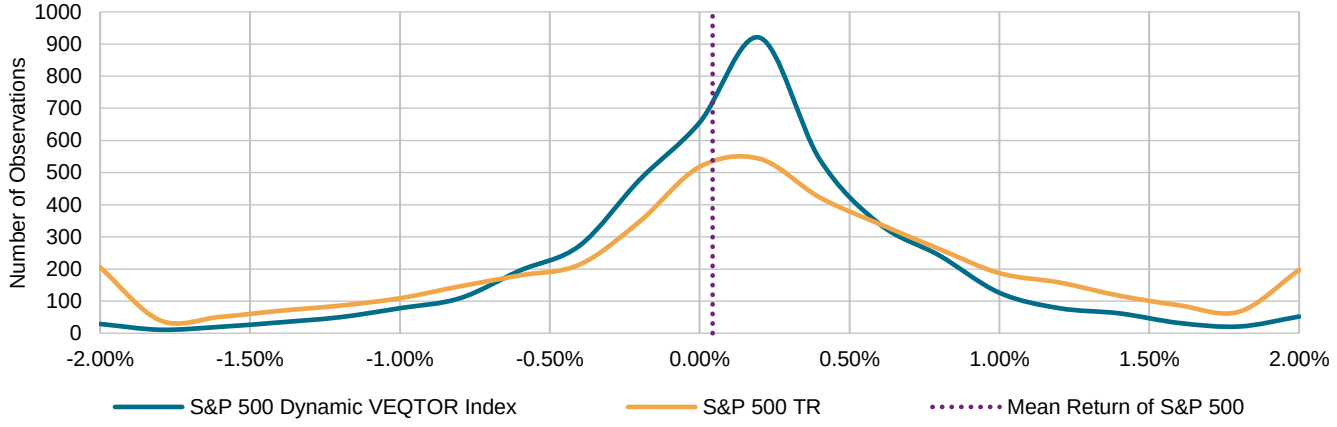
**Exhibit 18: Drawdown Analysis of the S&P 500 Dynamic VEQTOR Index**

| Category | S&P 500 Dynamic VEQTOR | S&P 500 TR |
|---|---|---|
| **Global Financial Crisis Drawdown** | -17.90% | -55.25% |
| Peak Date | Oct. 9, 2007 | Oct. 9, 2007 |
| Trough Date | Sept. 15, 2008 | March 9, 2009 |
| Number of Trading Days Peak-Trough | 235 | 355 |
| Recovery Length | 258 | 1129 |
| **COVID-19 Market Sell-Off** | -16.42% | -33.79% |
| Peak Date | March 18, 2020 | Feb. 19, 2020 |
| Trough Date | April 14, 2020 | March 23, 2020 |
| Number of Trading Days Peak-Trough | 18 | 23 |
| Recovery Length | 112 | 120 |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 19 shows tail events were effectively managed with a notable reduction in the presence of fat tails in the return distribution compared with the benchmark. The returns are also more left skewed with a higher peak around the mean, meaning a higher probability of positive returns.

**Exhibit 19: Return Distribution of the S&P 500 Dynamic VEQTOR Index**

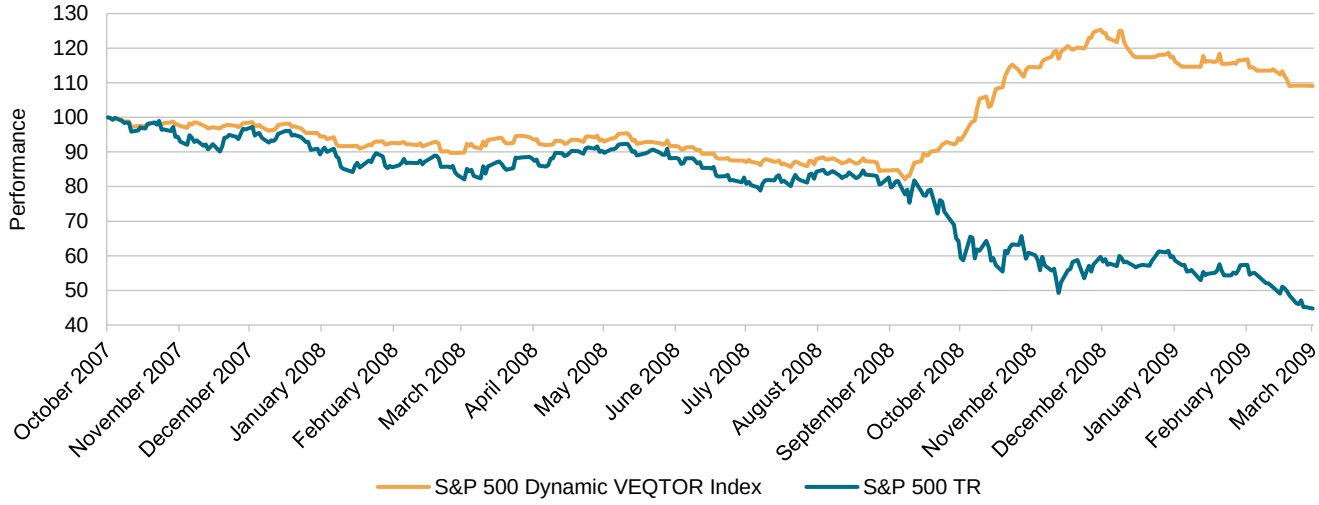



| Category | S&P 500 Dynamic VEQTOR Index | S&P 500 TR |
|---|---|---|
| Annualized Skew | -0.007 | -0.016 |
| Annualized Excess Kurtosis | 0.055 | 0.036 |

Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart and table are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 20 shows the tail risk strategies provided only marginal protection from the onset of the financial crisis through late September 2008. As VIX spiked in the last quarter of 2008, however, the index's performance improved dramatically.

**Exhibit 20: Outperformance of the S&P 500 Dynamic VEQTOR Index over Worst Drawdown of S&P 500**




Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

# An Alternative Approach to Risk Managed Index Strategies

The major risk managed index strategies analyzed in this paper all aim to reduce volatility and provide downside protection compared with the S&P 500 in exchange for potentially giving up some upside participation in the index. However, the amount of upside forfeited can be significant in bull and V-shaped markets, resulting in a high cost of protection and negatively affecting performance.

We examined whether it was possible to construct a risk managed strategy that would provide the same level of protection without forfeiting as much upside market participation. The performance of each major risk managed index was analyzed under different market conditions to understand how the various techniques used in each strategy contributed to providing protection, along with the corresponding drag on performance. This drag on performance is traditionally viewed as the cost of protection. Our examination focused on whether there was a more efficient way of providing protection to improve overall performance.

By moving away from volatility as the sole driver of controlling risk and incorporating the techniques from risk managed index strategies, a new hypothetical strategy that focuses on the cost of protection, which we will reference as the "Risk Managed (RM) Strategy" is presented in this section, which is designed to increase the upside market participation while providing a comparable level of protection.

# A New Risk Managed (RM) Strategy

## Overview

The RM strategy is based on the premise that: 1) not all volatility is bad; and 2) a downside loss or drawdown may be a better measure of risk than volatility alone. The RM strategy uses a signal-based mechanism to dynamically increase or decrease downside protection, and it allows for higher volatility and therefore potentially higher returns when markets are rising. This hypothetical strategy historically had comparable downside protection to other risk managed index strategies, but at times had better performance and higher volatility.

To achieve this, the RM strategy uses a form of protected leverage to increase exposure when market conditions are positive to take advantage of bull markets. It is designed to provide maximum exposure to the S&P 500 in fast rising markets with some downside protection, without reducing upside volatility. The strategy design allows greater upside and seeks to provide downside protection as efficiently as possible.

The RM strategy notionally consists of the following components:

1. Long position in the S&P 500 TR;
2. Long position in liquid bond index or money market instruments;
3. Short position in the short rate assumed in SPX futures;[1] and
4. Contingent rules-based risk management overlay strategy that increases market exposure above or below 100% (providing both leverage and downside protection based on market conditions) and uses options to enhance both returns and protection.

The RM overlay replicates a bespoke put option designed to provide downside protection in bear markets using index futures. The level of protection is determined by the replicated option's strike, which is calculated from a mean reversion process that reverts to the current underlying equity index value with a dynamic reversion rate. The overlay also uses out-of-the-

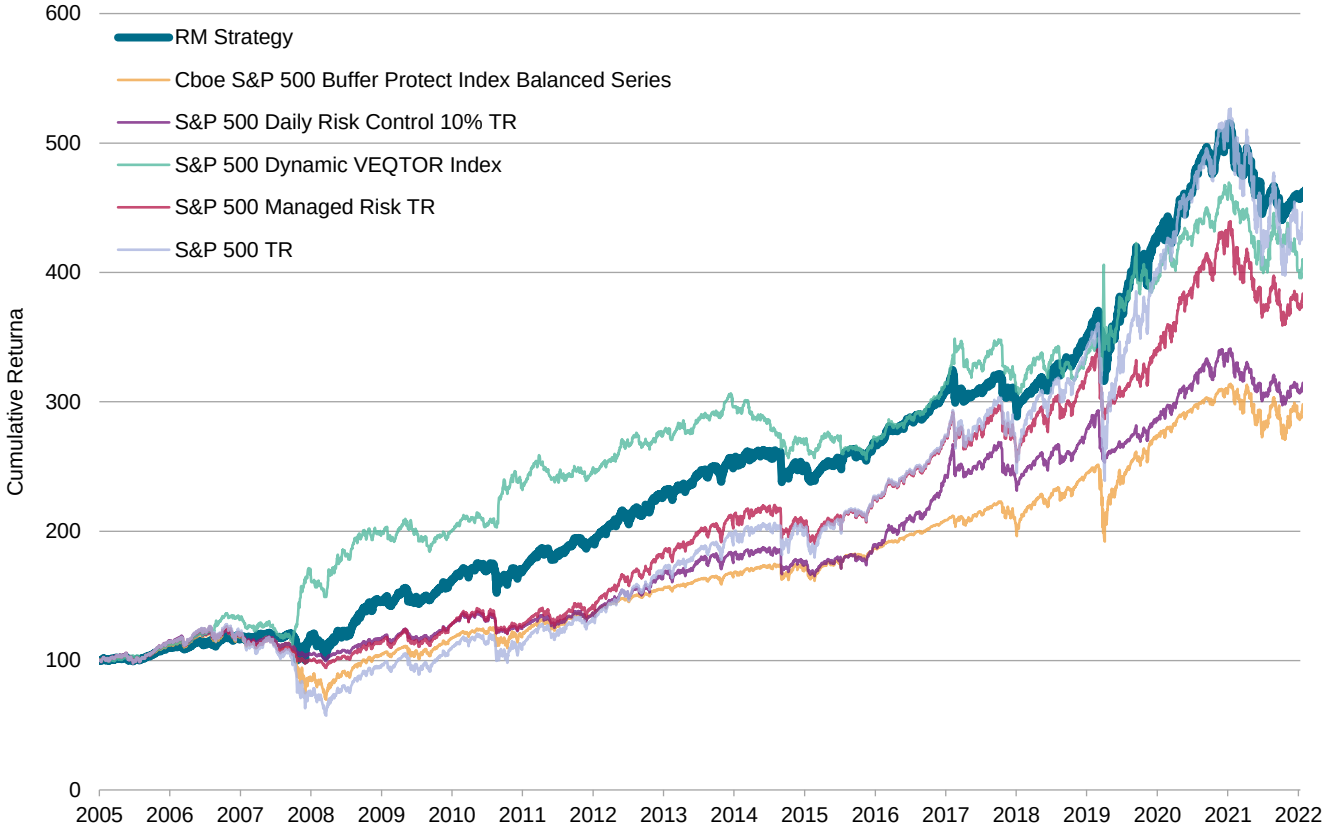
[1] This is a notional short position, since earning the S&P 500 TR would require a long position in SPX futures as well as an investment in money market instruments that earn the short rate assumed in the futures price. Since the protected leverage strategy invests in a liquid bond index or other money market instruments the return earned = S&P 500 TR + return on liquid bond index – return assumed in futures price.

money (OTM) put options to provide further protection during heightened risk environments, while in calm environments, a short position is employed instead to harvest the generally rich premium of these options. The number of options purchased or sold is determined tactically using VIX. This mechanism serves to mitigate gamma losses that result from the high cost of dynamic hedging when realized volatility is high and short put option positions.

## Analysis

The performance of the RM strategy is shown in Exhibit 21, along with the four risk managed benchmarks. As a result of limited drawdowns and higher upside participation, this strategy could potentially outperform the S&P 500 TR in bull and V-shaped markets.

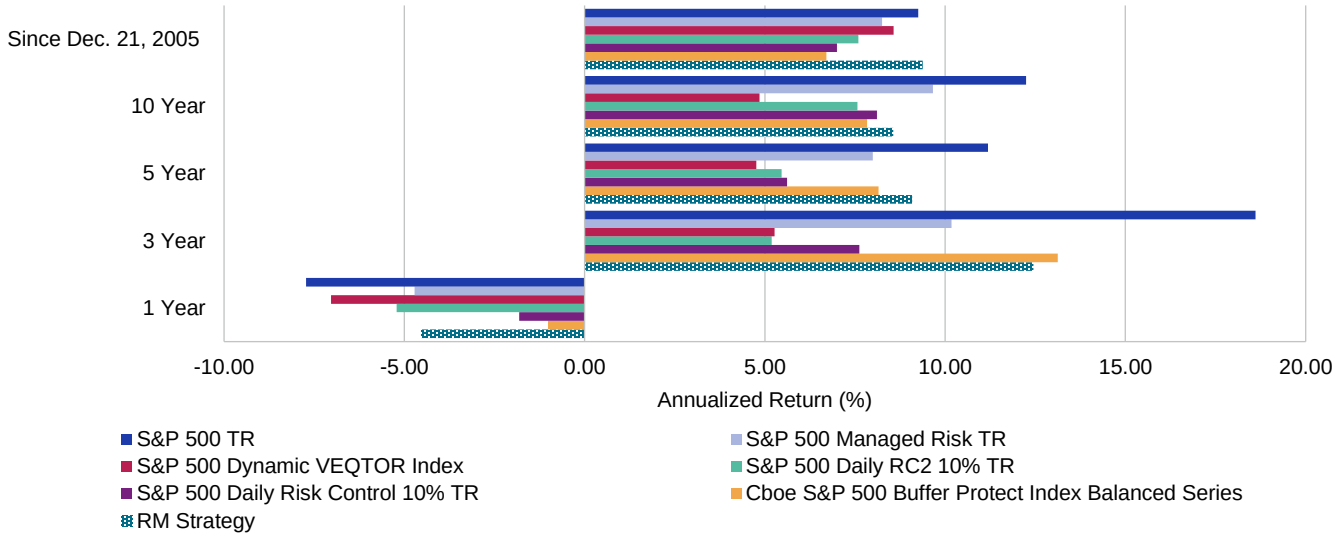
**Exhibit 21: Performance Comparison**




Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 22 shows a comparison of the annualized returns. The RM strategy provided higher annualized returns against the major risk managed index strategies over the entire period studied (Dec. 21, 2005, to March 31, 2023), but not during each time increment.

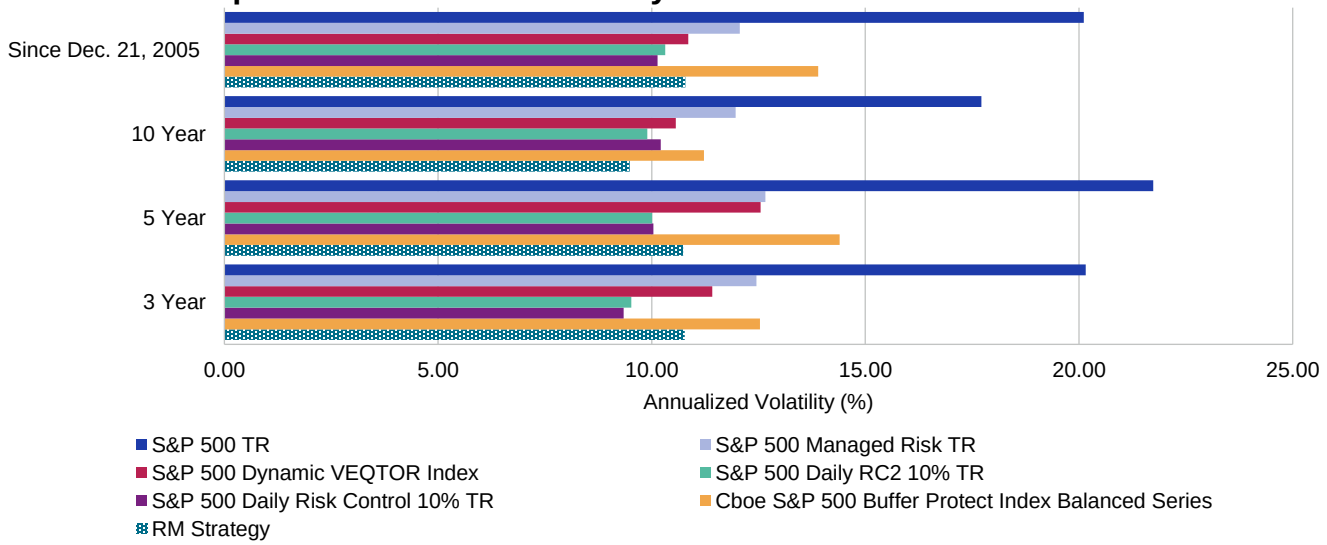
## Exhibit 22: Comparison of Annualized Returns




Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 23 shows a comparison of the realized volatility. Although the RM strategy does not have an explicit volatility control mechanism, it exhibited similar volatility reduction relative to other risk managed indices.

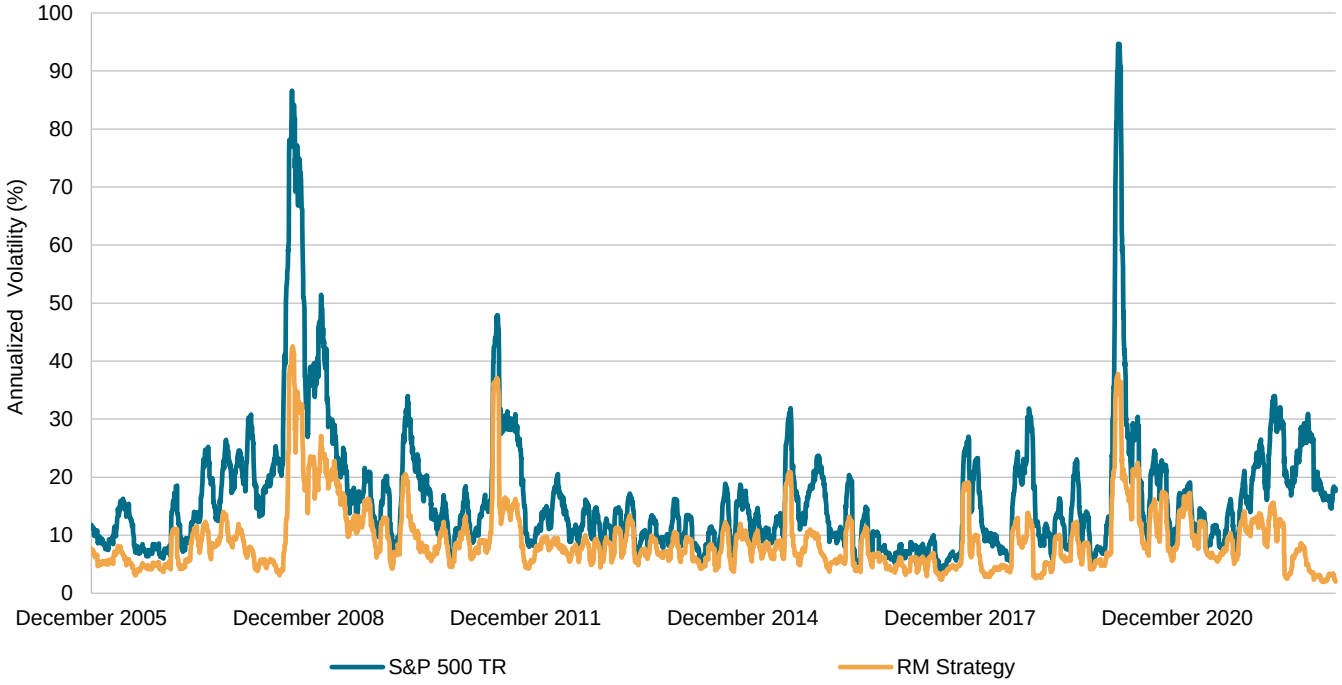
## Exhibit 23: Comparison of Realized Volatility




Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 24 shows the realized volatility of the RM strategy relative to the S&P 500 TR.

## Exhibit 24: Comparison of Realized Volatility




Source: S&P Dow Jones Indices LLC. Data from Jan. 2, 1990, to March 31, 2023. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

The RM strategy had comparably higher returns on both absolute and risk-adjusted bases (see Exhibit 25).

## Exhibit 25: Comparison of Key Statistics

| Category | RM Strategy | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 Daily Risk Control Index 10% TR | S&P 500 Daily RC2 10% Index TR | S&P 500 Dynamic VEQTOR Index | S&P 500 Managed Risk Index TR | S&P 500 TR |
|---|---|---|---|---|---|---|---|
| **Annualized Return (%)** | | | | | | | |
| 1-Year | -4.54 | -1.02 | -1.81 | -5.21 | -7.03 | -4.72 | -7.73 |
| 3-Year | 12.45 | 13.12 | 7.62 | 5.19 | 5.27 | 10.17 | 18.60 |
| 5-Year | 9.09 | 8.15 | 5.61 | 5.47 | 4.77 | 7.99 | 11.19 |
| 10-Year | 8.56 | 7.83 | 8.11 | 7.57 | 4.85 | 9.66 | 12.24 |
| Since Dec. 21, 2005 | 9.37 | 6.71 | 7.00 | 7.60 | 8.57 | 8.25 | 9.26 |

The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

## Exhibit 25: Comparison of Key Statistics (cont.)

| Category | RM Strategy | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 Daily Risk Control Index 10% TR | S&P 500 Daily RC2 10% Index TR | S&P 500 Dynamic VEQTOR Index | S&P 500 Managed Risk Index TR | S&P 500 TR |
|---|---|---|---|---|---|---|---|
| **Annualized Volatility (%)** | | | | | | | |
| 3-Year | 10.77 | 12.53 | 9.34 | 9.52 | 11.42 | 12.45 | 20.15 |
| 5-Year | 10.74 | 14.40 | 10.04 | 10.01 | 12.54 | 12.66 | 21.74 |
| 10-Year | 9.49 | 11.22 | 10.21 | 9.89 | 10.57 | 11.96 | 17.71 |
| Since Dec. 21, 2005 | 10.79 | 13.89 | 10.13 | 10.31 | 10.86 | 12.06 | 20.11 |
| **Annualized Downside Volatility (%)** | | | | | | | |
| 3-Year | 9.09 | 9.30 | 6.72 | 6.93 | 7.42 | 8.84 | 14.14 |
| 5-Year | 9.75 | 12.39 | 8.10 | 8.00 | 10.24 | 9.71 | 17.82 |
| 10-Year | 8.52 | 9.95 | 8.25 | 7.98 | 8.37 | 9.37 | 14.71 |
| Since Dec. 21, 2005 | 9.30 | 12.25 | 8.02 | 8.28 | 8.16 | 9.24 | 16.61 |
| **Return/Risk** | | | | | | | |
| 3-Year | 1.16 | 1.05 | 0.82 | 0.55 | 0.46 | 0.82 | 0.92 |
| 5-Year | 0.85 | 0.57 | 0.56 | 0.55 | 0.38 | 0.63 | 0.51 |
| 10-Year | 0.90 | 0.70 | 0.79 | 0.76 | 0.46 | 0.81 | 0.69 |
| Since Dec. 21, 2005 | 0.87 | 0.48 | 0.69 | 0.74 | 0.79 | 0.68 | 0.46 |
| **Sharpe Ratio** | | | | | | | |
| 3-Year | 1.05 | 0.96 | 0.70 | 0.43 | 0.36 | 0.73 | 0.87 |
| 5-Year | 0.71 | 0.46 | 0.41 | 0.40 | 0.26 | 0.51 | 0.45 |
| 10-Year | 0.81 | 0.62 | 0.70 | 0.67 | 0.37 | 0.73 | 0.64 |
| Since Dec. 21, 2005 | 0.76 | 0.40 | 0.57 | 0.62 | 0.68 | 0.58 | 0.40 |
| **Sortino Ratio** | | | | | | | |
| 3-Year | 1.25 | 1.29 | 0.97 | 0.59 | 0.56 | 1.03 | 1.24 |
| 5-Year | 0.78 | 0.54 | 0.51 | 0.50 | 0.32 | 0.67 | 0.54 |
| 10-Year | 0.90 | 0.69 | 0.87 | 0.83 | 0.47 | 0.93 | 0.77 |
| Since Dec. 21, 2005 | 0.88 | 0.45 | 0.72 | 0.77 | 0.90 | 0.76 | 0.48 |
| **Beta (%)** | | | | | | | |
| 3-Year | 0.46 | 0.60 | 0.42 | 0.38 | 0.36 | 0.57 | - |
| 5-Year | 0.43 | 0.61 | 0.40 | 0.37 | 0.29 | 0.51 | - |
| 10-Year | 0.48 | 0.59 | 0.50 | 0.46 | 0.32 | 0.61 | - |
| Since Dec. 21, 2005 | 0.48 | 0.65 | 0.42 | 0.39 | 0.31 | 0.52 | - |
| **Annualized Skewness** | | | | | | | |
| Since Dec. 21, 2005 | -0.0321 | -0.0176 | -0.0490 | -0.0261 | -0.0073 | -0.0342 | -0.0158 |
| **Annualized Kurtosis** | | | | | | | |
| Since Dec. 21, 2005 | 0.0360 | 0.0605 | 0.0035 | 0.0676 | 0.0553 | -0.0040 | 0.0358 |

The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

All risk managed index strategies provided significant downside protection (see Exhibit 26). For a comparable level of drawdown reduction, the RM strategy excelled at participating in the recovery bull markets and showed shorter recovery duration.

**Exhibit 26: Drawdowns in Global Financial Crisis and COVID-19 Market Sell-Off**

| Category | RM Strategy | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 Daily Risk Control 10% Index TR | S&P 500 Daily RC2 10% Index TR | S&P 500 Dynamic VEQTOR Index | S&P 500 Managed Risk Index TR | S&P 500 TR |
|---|---|---|---|---|---|---|---|
| **Global Financial Crisis Drawdown** | -17.64% | -43.79% | -19.67% | -17.12% | -17.90% | -25.34% | -55.25% |
| Peak Date | May 19, 2008 | Oct. 9, 2007 | July 19, 2007 | Oct. 9, 2007 | Oct. 9, 2007 | July 19, 2007 | Oct. 9, 2007 |
| Trough Date | Oct. 10, 2008 | March 9, 2009 | March 9, 2009 | Oct. 10, 2008 | Sept. 15, 2008 | March 9, 2009 | March 9, 2009 |
| Number of Trading Days Peak-Trough | 101 | 355 | 412 | 254 | 235 | 412 | 355 |
| Recovery Length | 243 | 894 | 689 | 465 | 258 | 856 | 1129 |
| **COVID-19 Market Sell-Off** | -14.67% | -23.65% | -13.74% | -13.95% | -16.42% | -15.87% | -33.79% |
| Peak Date | Feb. 19, 2020 | Feb. 19, 2020 | Feb. 19, 2020 | Feb. 19, 2020 | March 18, 2020 | Feb. 19, 2020 | Feb. 19, 2020 |
| Trough Date | March 20, 2020 | March 23, 2020 | March 23, 2020 | March 18, 2020 | April 14, 2020 | March 23, 2020 | March 23, 2020 |
| Number of Trading Days Peak-Trough | 69 | 23 | 23 | 20 | 18 | 23 | 23 |
| Recovery Length | 182 | 116 | 232 | 202 | 112 | 211 | 120 |

The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April. 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 27 shows the minimum, maximum and mean rolling annual returns for each of the strategies. Here we see that the RM strategy was able to provide a similar level of downside protection as the other risk managed index strategies, while having the highest mean return. The historical worst-case performance relative to the S&P 500 TR is also notable among the strategies, indicating a historical capacity to keep up in fast rising markets, such as the period following the COVID-19 crash, without sacrificng the upside potential.

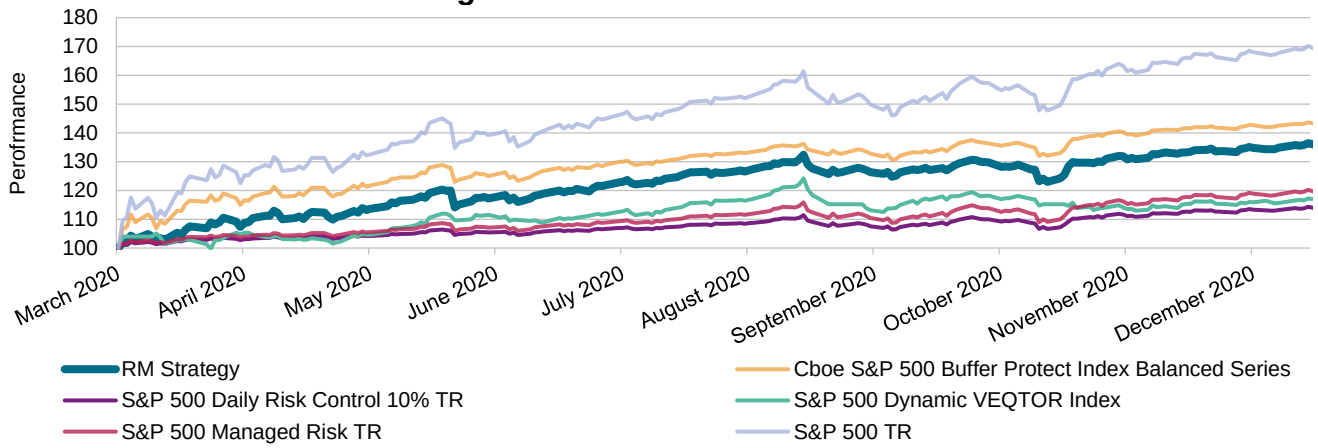
## Exhibit 27: Comparison of Rolling Returns over 1-Year Investment Horizon

| Category | RM Strategy | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 Daily Risk Control 10% Index TR | S&P 500 Daily RC2 10% TR | S&P 500 Dynamic VEQTOR Index | S&P 500 Managed Risk Index TR | S&P 500 TR |
|---|---|---|---|---|---|---|---|
| **Minimum Return** | -16.1% | -37.4% | -15.8% | -17.6% | -15.5% | -21.0% | -47.5% |
| Start Date | Oct. 10, 2007 | March 5, 2008 | Oct. 10, 2007 | Nov. 5, 2021 | Dec. 28, 2021 | Oct. 10, 2007 | March 5, 2008 |
| End Date | Oct. 10, 2008 | March 5, 2009 | Oct. 10, 2008 | Nov. 4, 2022 | Dec. 28, 2022 | Oct. 10, 2008 | March 5, 2009 |
| **Mean Return** | 10.0% | 7.2% | 7.4% | 8.0% | 9.6% | 8.9% | 10.8% |
| **Maximum Return** | 44.5% | 54.4% | 38.8% | 27.9% | 76.7% | 35.3% | 77.8% |
| Start Date | March 9, 2009 | March 9, 2009 | Jan. 23, 2017 | Jan. 23, 2017 | Sept. 15, 2008 | Nov. 15, 2012 | March 23, 2020 |
| End Date | March 9, 2010 | March 9, 2010 | Jan. 23, 2018 | Jan. 23, 2018 | Sept. 15, 2009 | Nov. 15, 2013 | March 23, 2021 |
| **Minimum Relative Return** | -41.5% | -30.7% | -60.8% | -60.6% | -66.2% | -53.6% | -41.5% |
| Start Date | March 23, 2020 | March 23, 2020 | March 23,2020 | March 23,2020 | March 18,2020 | March 23,2020 | - |
| End Date | March 23, 2021 | March 23, 2021 | March 23, 2021 | March 23, 2021 | March 18, 2021 | March 23, 2021 | - |
| **Mean Relative Return** | -0.7% | -3.6% | -3.4% | -2.7% | -1.1% | -1.9% | - |
| **Maximum Relative Return** | 40.3% | 11.8% | 34.4% | 41.7% | 86.0% | 31.4% | - |
| Start Date | Dec. 26, 2007 | Oct. 9, 2007 | March 5, 2008 | March 5, 2008 | Sept. 15, 2008 | March 5, 2008 | - |
| End Date | Dec. 26, 2008 | Oct. 9, 2008 | March 5, 2009 | March 5, 2009 | Sept. 15, 2009 | March 5, 2009 | - |

The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 28 shows the protection provided along with the ensuing performance of each strategy during the COVID-19 crash.

## Exhibit 28: Performance during the COVID-19 Crash

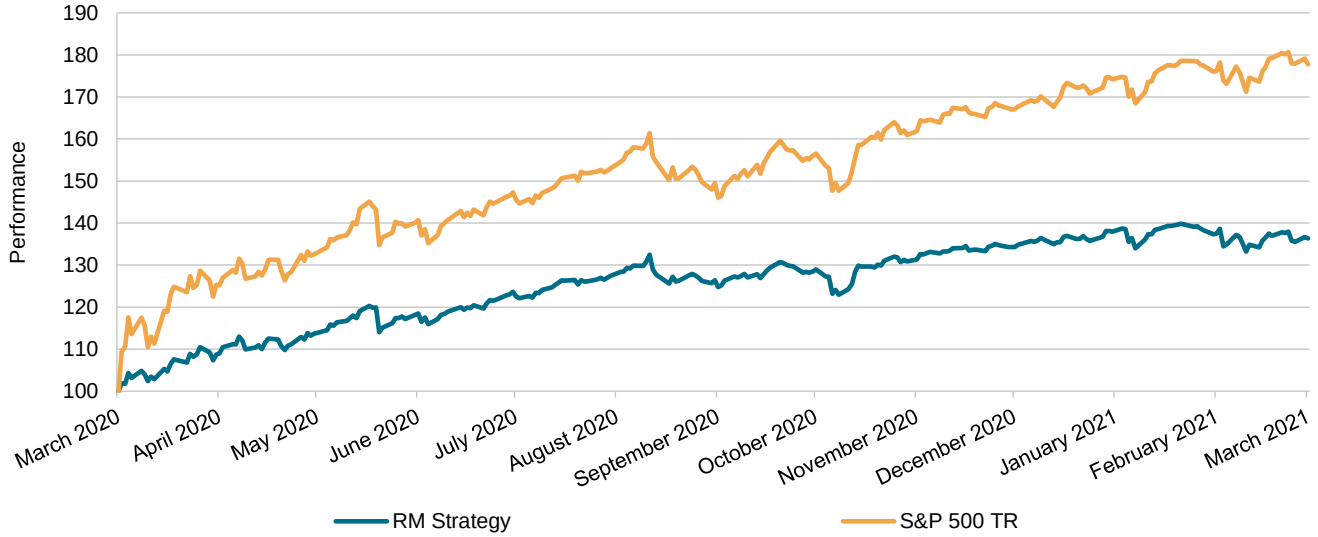



The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data as of March 31, 2023. Index performance based on total return in USD. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects

hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

The RM strategy performed better than other risk managed indices during the COVID-19 market sell-off. In the one-year period immediately following the market sell-off, the RM strategy had less underperformance compared to the S&P 500 than all other risk managed indices except the Cboe S&P 500 Buffer Protect Index Balanced Series.

**Exhibit 29: Worst 1-Year Relative Performance**




The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data as of March 31, 2023. Index performance based on total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

In order to compare the hedge efficiency of risk managed index strategies, this paper introduces a new measure, the cost/protection ratio defined below, that quantifies the amount of protection provided and the cost of providing that protection. As shown in Exhibit 32, each point along the x-axis represents a one-year investment horizon or period. There are 4,097 such periods corresponding to the last trading day of each one-year investment horizon. For each of these periods, the one-year return is recorded for the S&P 500 TR and the RM strategy. When the one-year return of the strategy is greater than the one-year return of the index, this represents protection or negative cost. When the one-year return of the index is greater than the one-year return of the strategy, this represents cost or negative protection.

**The cost/protection ratio = (cost – negative cost) / (protection – negative protection)** (see Exhibit 30). Negative cost occurs when the one-year return of the strategy is greater than the one-year return of the index, when the index is greater than 0. Protection occurs when the one-year return of the strategy is greater than the one-year return of the index, when the index is less than 0. Cost occurs when the one-year return of the index is greater than the one-year return of the strategy, when the index is greater than 0. Negative protection occurs when the one-year return of the index is greater than the one-year return of the strategy and the index is less than 0.

**Exhibit 30: Hedge Efficiency Measurement**

$$Cost = \sum_{t=1}^{n=3971} Max[Max[SPXT_t, 0] - Max[strategy_t, 0], 0] / n$$

$$Negative\ Protection = \sum_{t=1}^{n=3971} Max[Min[SPXT_t, 0] - strategy_t, 0] / n$$

$$Protection = \sum_{t=1}^{n=3971} Max[Min[strategy_t, 0] - SPXT_t, 0] / n$$

$$Negative\ Cost = \sum_{t=1}^{n=3971} Max[Max[strategy_t, 0] - Max[SPXT_t, 0], 0] / n$$

Source: S&P Dow Jones Indices LLC. Provided for illustrative purposes.

The hedge efficiency of the RM strategy is higher than that of the other risk managed indices. Over the period between Dec. 21, 2005, and March 31, 2023, the cost/protection ratio for the respective strategies are as follows.

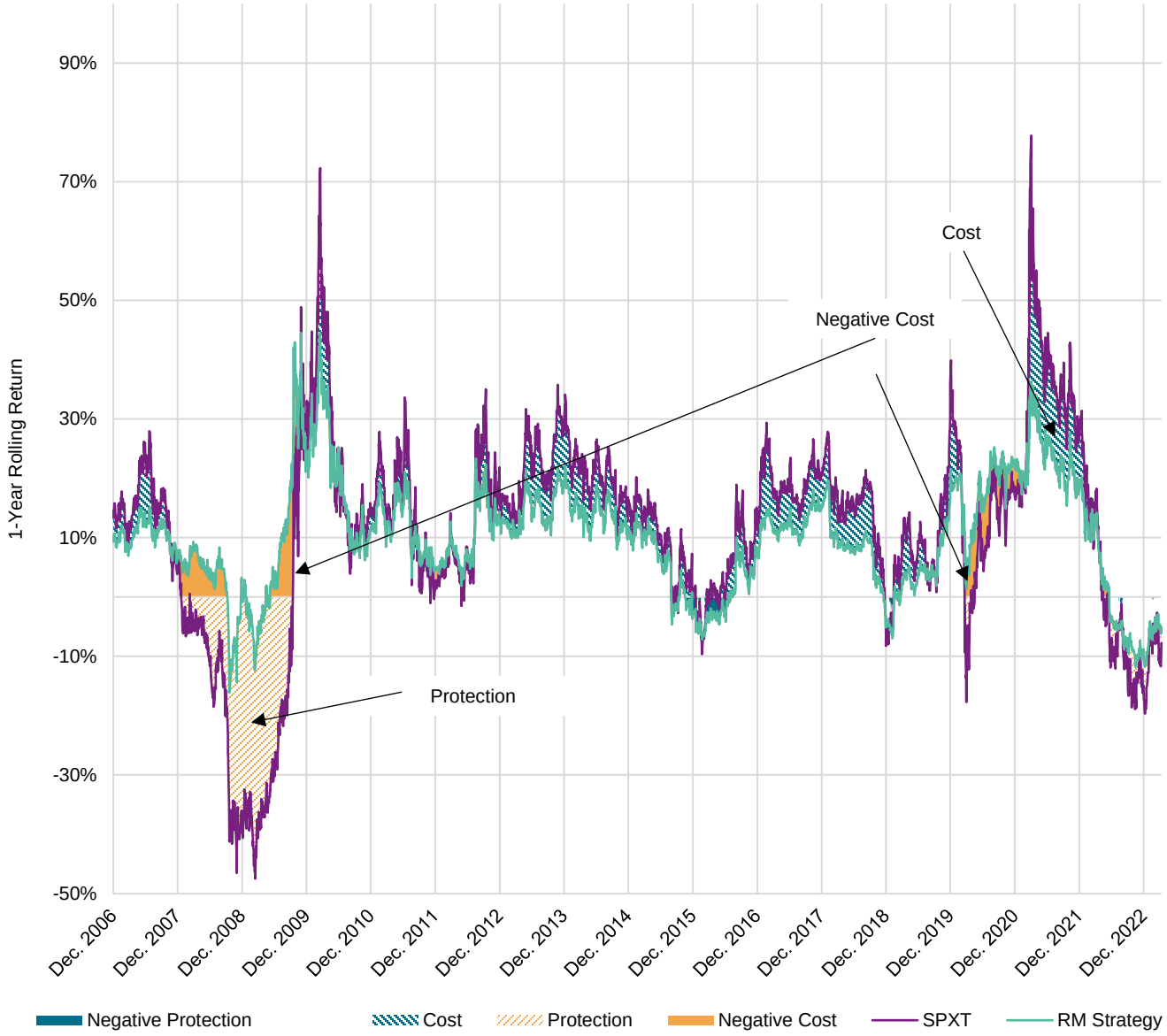
**Exhibit 31: Cost/Protection Ratio**

| Category | RM Strategy | Cboe S&P 500 Buffer Protect Index Balanced Series | S&P 500 Daily Risk Control 10% Index TR | S&P 500 Dynamic VEQTOR Index | S&P 500 Managed Risk Index TR |
|---|---|---|---|---|---|
| Protection | 0.0240 | 0.0116 | 0.0202 | 0.0251 | 0.0160 |
| Negative Cost | 0.0106 | 0.0007 | 0.0046 | 0.0400 | 0.0007 |
| Cost | 0.0412 | 0.0480 | 0.0552 | 0.0695 | 0.0334 |
| Negative Protection | 0.0010 | 0.0000 | 0.0033 | 0.0070 | 0.0021 |
| **Cost / Protection Ratio** | **1.33** | **4.07** | **2.99** | **1.63** | **2.35** |

The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Dynamic VEQTOR Index was launched Nov. 18, 2009. The S&P 500 Managed Risk Index was launched April 11, 2016. All data prior to index launch date is back-tested hypothetical data. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Over the observation period, USD 1 of protection cost an average of USD 1.33 for the RM strategy.

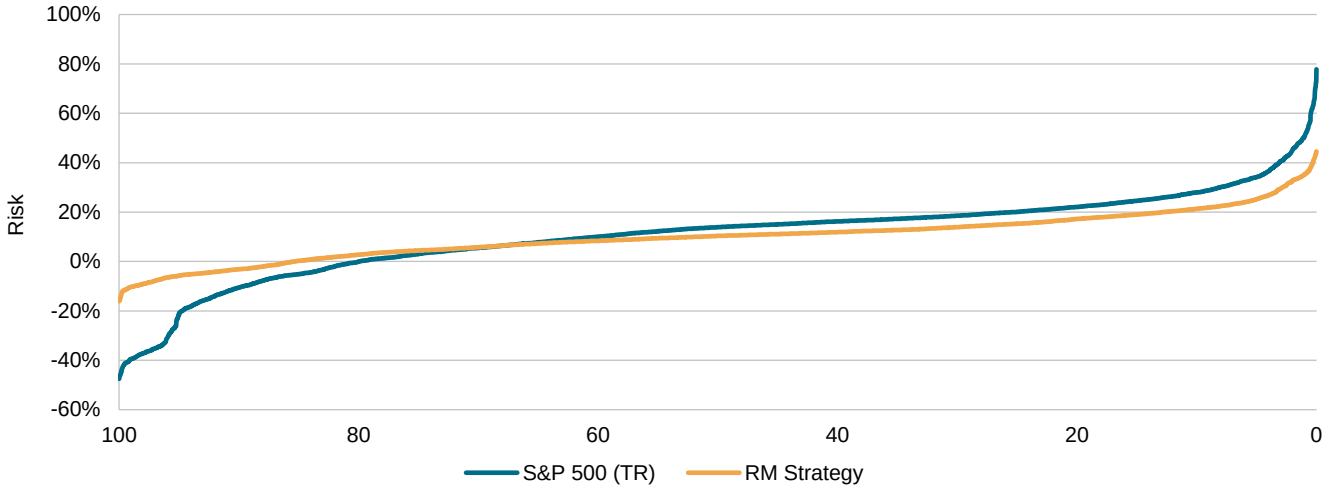
## Exhibit 32: Rolling Returns over 1-Year Investment Horizon




The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data from Dec. 21, 2005, to March 31, 2023. Index performance based on total return in USD. Nexus Risk Management Inc. Data for RM strategy is back-tested hypothetical data. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

The risk distribution of the rolling returns can be obtained for the RM strategy and the S&P 500 TR by ranking the returns (see Exhibit 33). The worst case for risk distribution does not necessarily correspond to the same investment period. The efficiency of providing protection can be seen by comparing the two distributions. In this case, significant downside protection was provided for relatively little forfeiting of upside market participation.

**Exhibit 33: Comparison of Risk Distributions**




The RM Strategy is hypothetical.
Source: S&P Dow Jones Indices LLC. Data as of March 31, 2023. Nexus Risk Management Inc. Data for RM strategy is back-tested hypothetical data. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

# Conclusion

In this paper, we looked beyond volatility as a commonly used proxy for risk and measure of performance to examine worst case losses, drawdowns and time to recovery over multiple investment horizons with varying start and end dates. In addition to measuring the downside protection provided, we calculated the cost of protection and evaluated the efficiency of each risk managed index strategy.

The major risk managed index strategies studied in this paper all reduced volatility and provided downside protection over the period studied. However, the cost of protection for these strategies has historically shown to be material.

This paper shows that the performance of risk managed index strategies was historically improved by incorporating a strategy with a lower cost/protection ratio. Each index strategy presented in the paper has its own unique approach to delivering a risk managed solution, with potential trade-offs for each. The RM strategy seeks to efficiently provide protection, rather than solely focusing on volatility, and historically provided relatively high returns with similar drawdown protection. Among S&P DJI indices, the S&P 500 Daily Risk Control Index 10% and the S&P 500 Daily RC2 10% Index offered the best volatility protection—particularly downside volatility protection—across the studied periods. The unique risk management strategy of the Cboe S&P 500 Buffer Protect Index Balanced Series enabled the latter to offer the least underperformance compared to the S&P 500 during the COVID-19 market sell-off. In conclusion, the RM strategy introduced in this paper takes an innovative approach to risk management and stands as a potential complement to S&P DJI's existing suite of strategies, offering a powerful toolkit of risk management solutions.

# Performance Disclosure

The S&P 500 Daily Risk Control 10% Index was launched May 13, 2009. The S&P 500 Daily RC2 10% was launched May 16, 2022. The S&P 500 Managed Risk Index was launched April 11, 2016. The Cboe S&P 500 Buffer Protect Index Balanced Series was launched March 30, 2016. The S&P 500 Dynamic VEQTOR Index was launched November 18, 2009. All information presented prior to an index's Launch Date is hypothetical (back-tested), not actual performance. The back-test calculations are based on the same methodology that was in effect on the index Launch Date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. Complete index methodology details are available at www.spdji.com. Past performance of the Index is not an indication of future results. Prospective application of the methodology used to construct the Index may not result in performance commensurate with the back-test returns shown.

S&P Dow Jones Indices defines various dates to assist our clients in providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the Index is set at a fixed value for calculation purposes. The Launch Date designates the date upon which the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P Dow Jones Indices defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its datafeed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

The back-test period does not necessarily correspond to the entire available history of the Index. Please refer to the methodology paper for the Index, available at www.spdji.com for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations.

Another limitation of using back-tested information is that the back-tested calculation is generally prepared with the benefit of hindsight. Back-tested information reflects the application of the index methodology and selection of index constituents in hindsight. No hypothetical record can completely account for the impact of financial risk in actual trading. For example, there are numerous factors related to the equities, fixed income, or commodities markets in general which cannot be, and have not been accounted for in the preparation of the index information set forth, all of which can affect actual performance.

The Index returns shown do not represent the results of actual trading of investable assets/securities. S&P Dow Jones Indices LLC maintains the Index and calculates the Index levels and performance shown or discussed, but does not manage actual assets. Index returns do not reflect payment of any sales charges or fees an investor may pay to purchase the securities underlying the Index or investment funds that are intended to track the performance of the Index. The imposition of these fees and charges would cause actual and back-tested performance of the securities/fund to be lower than the Index performance shown. As a simple example, if an index returned 10% on a US $100,000 investment for a 12-month period (or US $10,000) and an actual asset-based fee of 1.5% was imposed at the end of the period on the investment plus accrued interest (or US $1,650), the net return would be 8.35% (or US $8,350) for the year. Over a three year period, an annual 1.5% fee taken at year end with an assumed 10% return per year would result in a cumulative gross return of 33.10%, a total fee of US $5,375, and a cumulative net return of 27.2% (or US $27,200).

# General Disclaimer