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In-depth analysis and insights to inform your decision-making.

Sean McWilliams
Portfolio Manager and Multi-Asset Quantitative Investment Analyst

Anna Dreyer, CFA, Ph.D.
Portfolio Manager and Associate Director of Research, Multi-Asset

Justin Harvey, ASA, CFA
Multi-Asset Solutions Strategist

Portfolio Toolkit

MANAGED VOLATILITY STRATEGIES

KEY POINTS

- Financial asset volatilities have been shown to vary through time. If a portfolio's exposures to financial assets are not adjusted accordingly, its volatility can be expected to change as well. Financial asset volatility can be forecast based on well-studied properties of clustering and mean reversion.
- For certain investors, such as insurance companies offering variable annuities with benefit guarantees or defined benefit plans nearing wind-down, changes in portfolio volatility may meaningfully impact their ability to meet investment objectives.
- To meet the demand for portfolios with stable volatility profiles, T. Rowe Price offers managed volatility strategies. These strategies target stated volatility levels and ranges with a portfolio construction process that dynamically adjusts portfolio-level exposures based on volatility and correlation forecasts.
- Managed volatility strategies are commonly implemented as derivatives-based overlays. This approach retains the structural characteristics of the underlying actively managed portfolio. We believe T. Rowe Price's managed volatility strategies are especially attractive in this regard, as they incorporate T. Rowe Price's proprietary actively managed strategies.

Asset returns are difficult to forecast. Simple linear models of past returns have been found to contain little predictive value for future returns, especially over short investment horizons. Richer models that incorporate additional information potentially predictive of returns remain elusive.[1]

On the other hand, simple estimates *do* exhibit significant correlation between current and future volatility over short horizons. It also is well documented that asset return volatility tends to cluster persistently. In other words, large-magnitude returns tend to be followed by large-magnitude returns, and small-magnitude returns by small-magnitude returns. This pattern strongly suggests that volatility is forecastable, especially over short horizons.[2]

There is a large body of academic and practitioner research on modeling and forecasting financial asset volatility.[3] This research continues to evolve as new models are developed, the volume and

[1]Boudoukh, Jacob, Ronen Israel, and Mathew P. Richardson, 2018, "Long Horizon Predictability: A Cautionary Tale," working paper, available at SSRN: https://ssrn.com/abstract=3142575.
[2]For more information please see Dreyer, Anna and Stefan Hubrich, 2017, "Tail Risk Mitigation with Managed Volatility Strategies," working paper, available at SSRN: https://ssrn.com/abstract=3074529.
[3]Engle, Robert F. and Andrew J. Patton, 2001, "What is a good volatility model?" *Quantitative Finance* 1: 237-45.

density of market data increases, and computational resources become cheaper and more accessible. Additionally, markets for options and other securities that directly reference asset volatility continue to grow, providing rich sources for extracting market-implied views on volatility.

T. Rowe Price research analysts leverage this rich myriad of modeling approaches to develop volatility forecasts that are appropriate for the investment objectives of particular portfolios. Similar modeling work informs our forecasts of cross-asset correlations as well.

In addition to well-researched volatility and correlation forecasts, successful management of managed volatility strategies also requires thoughtful portfolio construction and implementation. Portfolio positions need to be adjusted periodically based on the volatility and correlation forecasts in order to keep the strategy aligned with the desired volatility target. This process also must take into account any portfolio constraints.

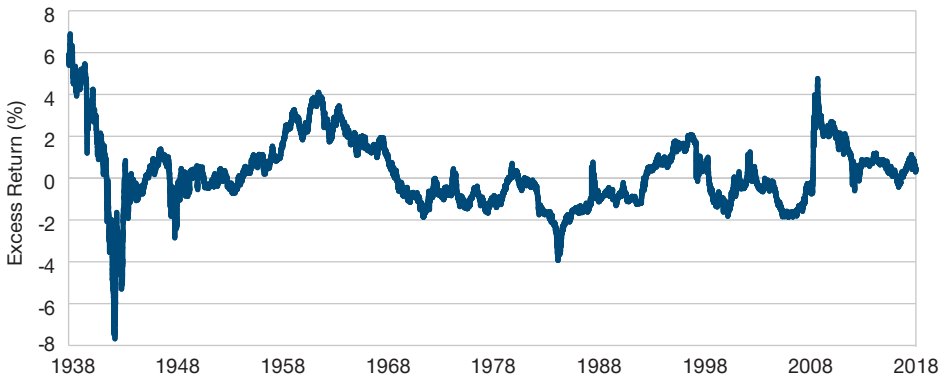
COMPONENTS OF A MANAGED VOLATILITY STRATEGY

An individual managed volatility strategy can be customized to address specific investor objectives and constraints. The main levers at the investor's disposal include:

- **The underlying strategy:** This can be single- or multi-asset, and may be actively managed. Strategies with exposure to higher-volatility assets, such as equities, are most common.
- **The volatility target:** Generally expressed as an annualized percentage, the target level reflects the desired standard deviation of returns for the strategy.
- **Volatility tolerance bands:** To reduce transaction costs, a managed volatility strategy typically will have tolerance bands around the volatility target. If portfolio volatility is forecast to remain within those bands, trading for volatility management purposes is avoided. The bands can be customized to balance trading costs and the investor's tolerance for deviations from the target. Asymmetrical bands may offer an interesting variation on this approach.
- **Volatility management instruments:** Managed volatility strategies typically are implemented as portfolio overlays. A cash allocation within the portfolio is used to collateralize liquid futures contracts, and these instruments are used to implement the desired volatility management positions. This allows the overlay to have minimal impact on the underlying portfolio. For investors who are unwilling or

FIGURE 1: Hypothetical Excess Returns for a Managed Volatility Model Versus the S&P 500 Index

Rolling 10-Year Periods, February 5, 1928, Through June 30, 2018



Contains hypothetical model results. See page 4 for important information regarding model portfolios and for modeling methodology.

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FIGURE 2: Hypothetical Performance Summary for a Managed Volatility Model Versus the S&P 500 Index

February 5, 1928, Through June 30, 2018

	Full Period		10 Years Ended June 30, 2018		5 Years Ended June 30, 2018	
	S&P 500	S&P 500 + MVol. Model	S&P 500	S&P 500 + MVol. Model	S&P 500	S&P 500 + MVol. Model
Annualized Return	10.80%	10.70%	9.90%	10.00%	12.60%	12.90%
Annualized Volatility	18.80%	14.70%	14.90%	11.30%	9.80%	11.30%
Sharpe Ratio	0.40	0.50	0.64	0.86	1.26	1.11
Maximum Drawdown	86.0%	52.60%	46.40%	20.70%	8.40%	10.10%

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unable to use derivatives (due to regulatory restrictions, for example), a managed volatility strategy could seek to alter expected volatility using exchange-traded funds, cash, and Treasury bonds, or the positions in the underlying portfolio could be dynamically reallocated. The choice of implementation will depend on the investor's objectives and constraints, as well as the liquidity of the specific instruments used.

- **Time horizons:** Volatility can be forecast most accurately over shorter time horizons, so a managed volatility strategy with an explicit target is more likely to adjust exposures over a relatively short horizon. However, some investors may prefer longer horizons or may be constrained from frequent trading.

IMPACT ON PORTFOLIO PERFORMANCE AND RISK

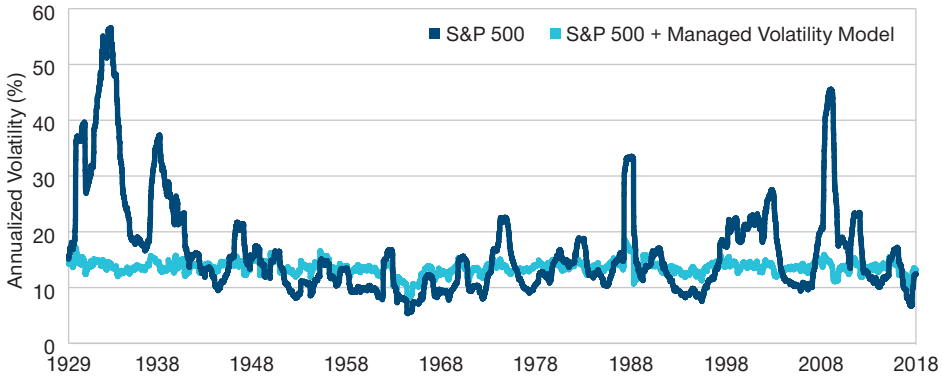
One potential benefit of a managed volatility strategy is the absence of a structural performance drag. An investor concerned about downside risk could systematically purchase put options to protect his or her portfolio, but the drag on portfolio returns imposed by the option costs could create a structural performance deviation from a static benchmark over time.

If structured properly, a managed volatility strategy potentially can maintain average allocations that are similar to those in the underlying portfolio across time, but that still can be altered based on the forecast market environment. Historical empirical analysis suggests that a managed volatility strategy that is implemented with minimal constraints and that targets the long-term volatility of the underlying portfolio potentially could provide relatively stable volatility without degrading long-term average performance.

Figures 1 and 2 show the potential impacts on performance and volatility from the implementation of a hypothetical managed volatility strategy over more than 90 years of market history ending in June 2018.[4] Figure 2 shows that the strategy's long-term average performance could have been commensurate with that of the underlying asset (in this case, the S&P 500 Index), while long-term volatility could have been closer to the desired target of 13.5%. Figures 3 and 4 highlight the substantial reduction in volatility that could have been achieved by the strategy compared with the S&P 500.

FIGURE 3: Volatility of the S&P 500 Index With and Without a Hypothetical Managed Volatility Model

Rolling One-Year Periods, February 5, 1928, Through June 30, 2018



Contains hypothetical model results. See page 4 for important information regarding model portfolios and for modeling methodology.

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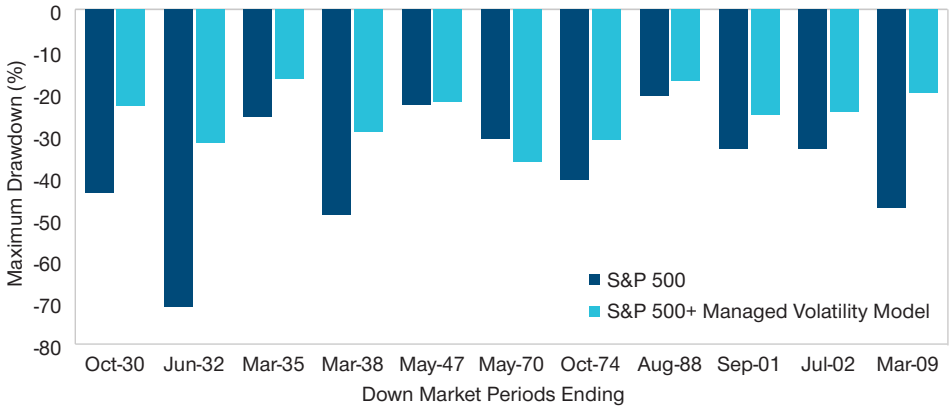
FIGURE 4: Maximum Drawdowns for the S&P 500 Index With and Without a Hypothetical Managed Volatility Model

February 5, 1928, Through June 30, 2018



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[4]For more details on our modeling methodology, please see the appendix.

We believe that managed volatility strategies also have the potential to mitigate tail risk. Typically, large portfolio drawdowns have been experienced during market dislocations and other periods of heightened volatility. Substantial increases in volatility typically have been accompanied by increases in the probability and potential magnitude of losses. Managed volatility strategies can be structured to react quickly in volatile environments by reducing expected risk in the portfolio during periods of market stress. While this potential downside protection may come at the cost of missing the initial market rebound, many investors may be willing to accept that outcome if the drawdowns they experience in volatile markets are not as severe.

CONCLUSIONS

Historically, the volatility of asset returns has been time-varying but forecastable. We believe that many investors—particularly those with heightened sensitivity to volatility and drawdowns—could benefit from including a managed volatility strategy in their portfolios. These strategies seek to stabilize volatility while minimizing any impact on long-term average performance and retaining the structural characteristics of the underlying actively managed portfolio. Managed volatility strategies can be customized along several dimensions and are just one example of how T. Rowe Price manages customizable strategies that seek to help investors achieve specific investment objectives within their constraints.

APPENDIX

MODELING METHODOLOGY

Managed Volatility Model Parameters

Dates	February 5, 1928, Through June 30, 2018
Net Notional Exposure	0%–150%
Equity Range	0%–150%
Target Volatility	13.5% (daily annualized)
Underlying Strategy Component	S&P 500 Index
Overlay Strategy Components	S&P 500 Index e-mini futures (as proxied by the excess return of the S&P 500 Index over the 30-day Treasury bill) and cash (30-day Treasury bill) for margin/collateral
Methodology	Strategy is managed to the applicable target volatility based on daily analysis of an exponentially weighted moving average covariance model with a one-month half-life.

Important Information—Model Results

The information presented herein is hypothetical in nature and is shown for illustrative, informational purposes only. This material is not intended to forecast or predict future events, but rather to demonstrate T. Rowe Price's capability to manage assets in this style. It does not reflect the actual returns of any portfolio/strategy and does not guarantee future results. Certain assumptions have been made for modeling purposes and are unlikely to be realized. No representation or warranty is made as to the reasonableness of the assumptions made or that all assumptions used in modeling analysis presented here have been stated or fully considered. Changes in the assumptions may have a material impact on the information presented. Data shown for the model portfolios are as of the dates shown and represents the manager's analysis of model portfolios as of that date and is subject to change over time. The model portfolios do not reflect the impact that material economic, market or other factors may have on weighting decisions. If the weightings change, results would be different. Management fees, transaction costs, taxes, potential expenses, and the effects of inflation are not considered and would reduce returns. Actual results experienced by clients may vary significantly from the hypothetical illustrations shown. The information is not intended as a recommendation to buy or sell any particular security, and there is no guarantee that results shown will be achieved.

The gross model performance results do not reflect the deduction of investment advisory fees. Returns shown would be lower when reduced by advisory fees and any other expenses incurred in the management of an investment advisory account. For example, an account with an assumed growth rate of 10% would realize a net of fees annualized return of 8.91% after three years, assuming a 1% management fee.

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