



**PRICE
POINT[®]**

October 2018

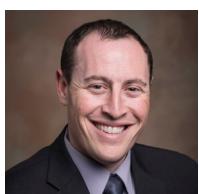
In-depth analysis and insights
to inform your decision-making.



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

¹Boudoukh, Jacob, Ronen Israel, and Mathew P. Richardson, 2018, "Long Horizon Predictability: A Cautionary Tale," working paper, available at SSRN: <https://ssrn.com/abstract=3142575>.

²For 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>.

³Engle, 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.

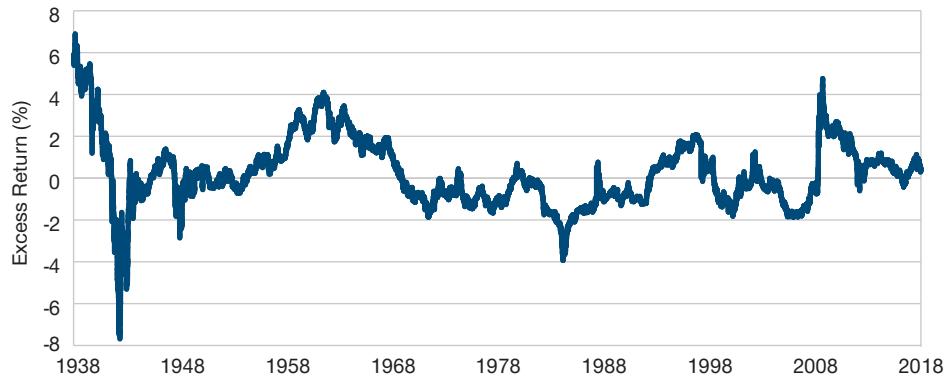
COMPONENTS OF A MANAGED VOLATILITY STRATEGY

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

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.

Sources: Haver Analytics, S&P, Bloomberg Index Services, Ltd. S&P 500 data include proxy returns prior to formal index inception in 1957 and are sourced directly from Bloomberg Index Services, Ltd. All data analysis by T. Rowe Price. Bloomberg Index Services Ltd. Copyright © 2018, Bloomberg Index Services Ltd. Used with permission.

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%

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

Sources: Haver Analytics, S&P, Bloomberg Index Services, Ltd. S&P 500 data include proxy returns prior to formal index inception in 1957 and are sourced directly from Bloomberg Index Services, Ltd. All data analysis by T. Rowe Price. Bloomberg Index Services Ltd. Copyright © 2018, Bloomberg Index Services Ltd. Used with permission.

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

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

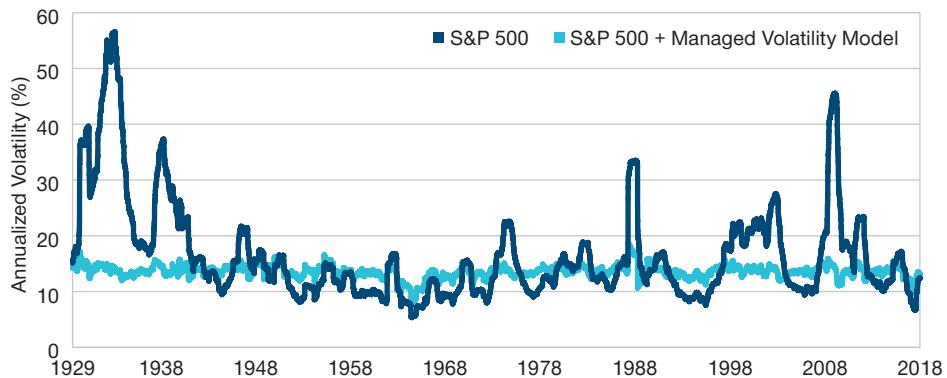
One potential benefit of a managed volatility strategy is the absence of a structural performance drag. An investor concerned about downside risk could systematically purchase put options to protect his or her portfolio, but the drag on portfolio returns imposed by the option costs could create a structural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

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

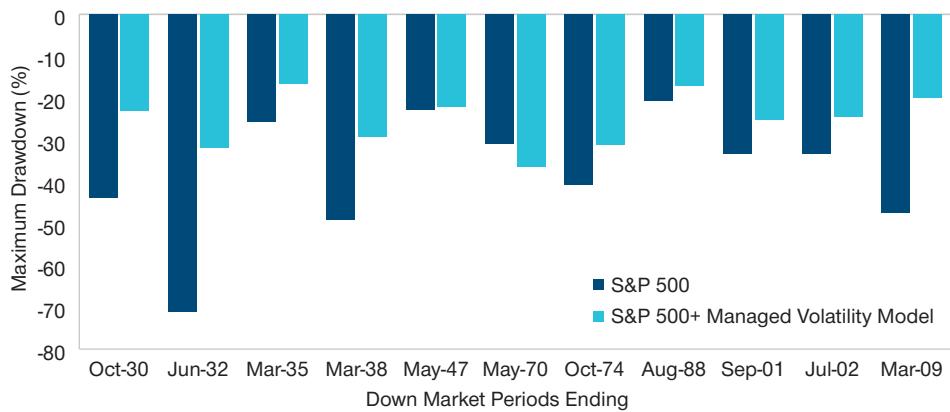


Contains hypothetical model results. See page 4 for important information regarding model portfolios and for modeling methodology.

Sources: Haver Analytics, S&P, Bloomberg Index Services, Ltd. S&P 500 data include proxy returns prior to formal index inception in 1957 and are sourced directly from Bloomberg Index Services, Ltd. All data analysis by T. Rowe Price. Bloomberg Index Services Ltd. Copyright © 2018, Bloomberg Index Services Ltd. Used with permission.

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



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

Sources: Haver Analytics, S&P, Bloomberg Index Services, Ltd. S&P 500 data include proxy returns prior to formal index inception in 1957 and are sourced directly from Bloomberg Index Services, Ltd. All data analysis by T. Rowe Price. Bloomberg Index Services Ltd. Copyright © 2018, Bloomberg Index Services Ltd. Used with permission.

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.

⁴For 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.

INVEST WITH CONFIDENCE®

T. Rowe Price focuses on delivering investment management excellence that investors can rely on—now and over the long term.

To learn more, please visit troweprice.com.

Important Information

This material is being furnished for general informational purposes only. The material does not constitute or undertake to give advice of any nature, including fiduciary investment advice, and prospective investors are recommended to seek independent legal, financial and tax advice before making any investment decision. T. Rowe Price group of companies including T. Rowe Price Associates, Inc. and/or its affiliates receive revenue from T. Rowe Price investment products and services. **Past performance is not a reliable indicator of future performance.** The value of an investment and any income from it can go down as well as up. Investors may get back less than the amount invested.

The material does not constitute a distribution, an offer, an invitation, a personal or general recommendation or solicitation to sell or buy any securities in any jurisdiction or to conduct any particular investment activity. The material has not been reviewed by any regulatory authority in any jurisdiction.

Information and opinions presented have been obtained or derived from sources believed to be reliable and current; however, we cannot guarantee the sources' accuracy or completeness. There is no guarantee that any forecasts made will come to pass. The views contained herein are as of the date written and are subject to change without notice; these views may differ from those of other T. Rowe Price group companies and/or associates. Under no circumstances should the material, in whole or in part, be copied or redistributed without consent from T. Rowe Price.

The material is not intended for use by persons in jurisdictions which prohibit or restrict the distribution of the material and in certain countries the material is provided upon specific request.

It is not intended for distribution to retail investors in any jurisdiction.

Bloomberg Index Services Ltd. Copyright © 2018, Bloomberg Index Services Ltd. Used with permission.

Copyright © 2018, S&P Global Market Intelligence (and its affiliates, as applicable). Reproduction of the S&P 500 Index in any form is prohibited except with the prior written permission of S&P Global Market Intelligence ("S&P"). None of S&P, its affiliates or their suppliers guarantee the accuracy, adequacy, completeness or availability of any information and is not responsible for any errors or omissions, regardless of the cause or for the results obtained from the use of such information. In no event shall S&P, its affiliates or any of their suppliers be liable for any damages, costs, expenses, legal fees, or losses (including lost income or lost profit and opportunity costs) in connection with any use of S&P information.

Australia—Issued in Australia by T. Rowe Price Australia Limited (ABN: 13 620 668 895 and AFSL: 503741), Level 50, Governor Phillip Tower, 1 Farrer Place, Suite 50B, Sydney, NSW 2000, Australia. For Wholesale Clients only.

Canada—Issued in Canada by T. Rowe Price (Canada), Inc. T. Rowe Price (Canada), Inc.'s investment management services are only available to Accredited Investors as defined under National Instrument 45-106. T. Rowe Price (Canada), Inc. enters into written delegation agreements with affiliates to provide investment management services.

DIFC—Issued in the Dubai International Financial Centre by T. Rowe Price International Ltd. This material is communicated on behalf of T. Rowe Price International Ltd. by its representative office which is regulated by the Dubai Financial Services Authority. For Professional Clients only.

EEA—Issued in the European Economic Area by T. Rowe Price International Ltd, 60 Queen Victoria Street, London EC4N 4TZ which is authorised and regulated by the UK Financial Conduct Authority. For Professional Clients only.

Hong Kong—Issued in Hong Kong by T. Rowe Price Hong Kong Limited, 21/F, Jardine House, 1 Connaught Place, Central, Hong Kong. T. Rowe Price Hong Kong Limited is licensed and regulated by the Securities & Futures Commission. For Professional Investors only.

New Zealand—Issued in New Zealand by T. Rowe Price Australia Limited (ABN: 13 620 668 895 and AFSL: 503741), Level 50, Governor Phillip Tower, 1 Farrer Place, Suite 50B, Sydney, NSW 2000, Australia. No Interests are offered to the public. Accordingly, the Interests may not, directly or indirectly, be offered, sold or delivered in New Zealand, nor may any offering document or advertisement in relation to any offer of the Interests be distributed in New Zealand, other than in circumstances where there is no contravention of the Financial Markets Conduct Act 2013.

Singapore—Issued in Singapore by T. Rowe Price Singapore Private Ltd., No. 501 Orchard Rd, #10-02 Wheelock Place, Singapore 238880. T. Rowe Price Singapore Private Ltd. is licensed and regulated by the Monetary Authority of Singapore. For Institutional and Accredited Investors only.

Switzerland—Issued in Switzerland by T. Rowe Price (Switzerland) GmbH, Talstrasse 65, 6th Floor, 8001 Zurich, Switzerland. For Qualified Investors only.

USA—Issued in the USA by T. Rowe Price Associates, Inc., 100 East Pratt Street, Baltimore, MD, 21202, which is regulated by the U.S. Securities and Exchange Commission. For Institutional Investors only.

© 2018 T. Rowe Price. All rights reserved. T. ROWE PRICE, INVEST WITH CONFIDENCE, and the Bighorn Sheep design are, collectively and/or apart, trademarks of T. Rowe Price Group, Inc.