The Invesco White Paper Series

Seeking better investment outcomes by managing volatility

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Until recently, financial markets during the current business cycle have been characterized by historically low levels of volatility, thanks in large part to the monetary policies of central banks globally. The recent uptick in volatility, extending from the second half of 2015 through the beginning of 2016, has rattled market participants and refocused attention on volatility and its potential impact on investors.

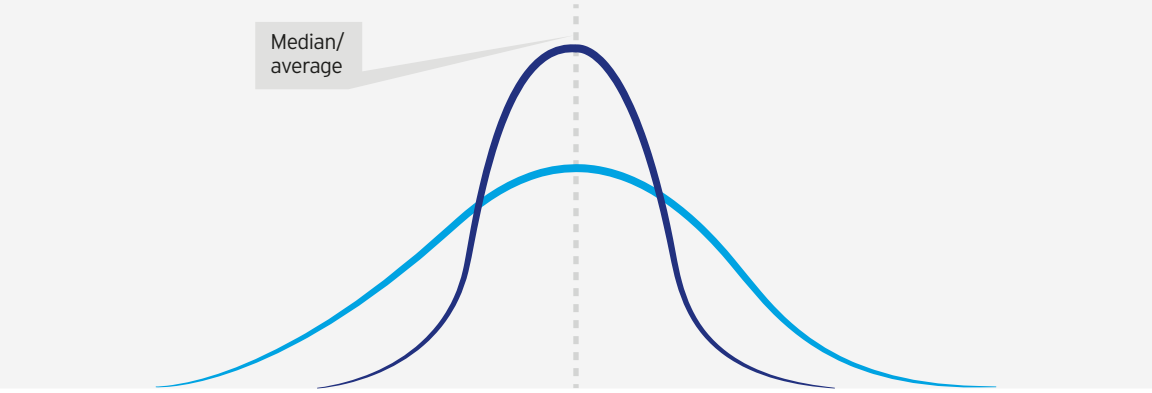
Volatility drag: What volatility means to returns

Volatility is a fundamental component of investing. It reflects uncertainty regarding investment returns, typically expressed as the amount of fluctuation in the returns of a financial instrument. Standard deviation is one commonly used statistical measure that expresses volatility by capturing the range of potential investment outcomes around the average investment return.

Given two potential distributions of investment returns with the same mean (or average) expected return (Figure 1), with the bulk of possible returns clustered around the middle, the higher the volatility, the fatter the "tails" of the distribution, which represent a higher chance of experiencing higher- or lower-than-expected returns at any point in time.

Figure 1: Higher volatility investments have a higher tendency to surprise investors on the upside and the downside

Two distributions with the same central tendency but differing in variability



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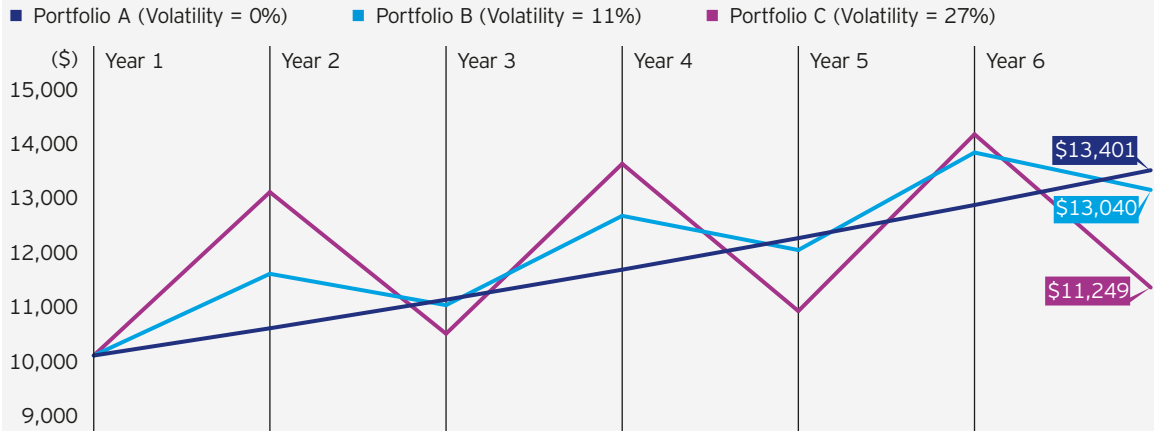
But while volatility can produce higher-than-expected returns during a moment in time, it's important to note that greater portfolio volatility lowers the potential return on the portfolio over time due to the effect of compounding. Let's look at three hypothetical portfolios, each with a beginning balance of $10,000 and average returns of 5%, but with varying degrees of volatility: 0%, 11% and 27%, respectively (Figure 2).

Figure 2: Volatility drag hinders portfolios' ability to grow wealth over time



These are not actual portfolios but are mathematical examples and are for illustrative purposes only.

While the average rate of return is the same, at the end of Year 6 the ending values of the portfolios are different due to the large negative effect of volatility on portfolio performance, or compounding. In other words, positive returns are made on less money, therefore you lose more money with each bout of volatility. This difference between the average rate of return (also known as arithmetic mean) and the ending portfolio values (which reflect the impact of the geometric return) is commonly referred to as "volatility drag." It implies that compound returns are "dragged down" by high levels of volatility because of the cumulative impact of negative returns when you remain invested. That difference also approximates as:

Volatility drag ~ 0.5 × Volatility^2

Using the portfolio examples in Figure 2 above, the annualized return drag associated with the 11% volatility of Portfolio B was 0.6%, while Portfolio C – with 27% volatility – would have experienced a 3.6% drag on returns annually. Assuming an environment with moderate to low returns, the implication of this is that high levels of volatility could have a large role in driving compound returns. We'll explore the implication of this in the context of the current market environment later on in this paper.

Avoiding large losses or even lower-than-expected returns is therefore critical to wealth accumulation and preservation, especially for long-term, buy-and-hold investors. Because of volatility drag, losses can have a disproportional impact on an investor's returns compared to gains.[1]

As a portfolio loses value, the returns needed to make up the losses grow substantially. Regaining those losses could take several years even if stocks perform well, making those nearing retirement and especially those in retirement more sensitive to the impact of volatility. Consequently, some particularly volatility-sensitive investors might be tempted to stay out of the market altogether, but this too would be detrimental to meeting long-term financial goals, in our view. Because the market is upward trending over the long term, sitting on the sidelines in cash – uninvested – could mean investors would fail to meet their investment goals over the long term (Figure 3). For example, $1 sitting in cash over the past 88 years would have yielded a cumulative ending value of $19.33 relative to investing in the S&P 500 Index, which would have yielded $115.40.

1 Learn more about the disproportionate impact of losses on returns in Invesco's Rethinking Risk Strategies piece "The tale of 10 days."

Figure 3: Avoiding the market altogether could undermine long-term investment goals
Growth of $1 in the S&P 500 Index from Dec. 31, 1927, to Dec. 31, 2015

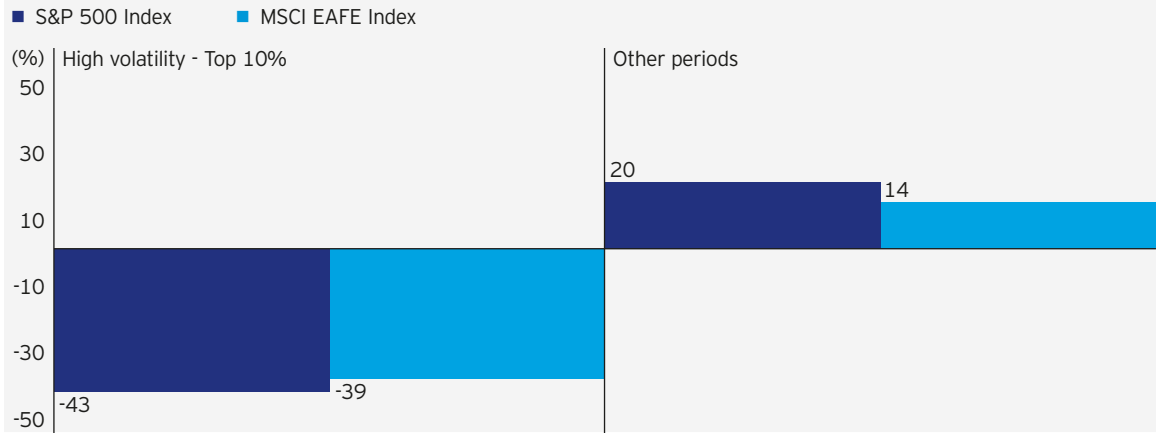
Days	Ending value ($)
Total cumulative return	115.40
Miss 10 best days	38.28
Miss 10 worst days	362.01
Miss 10 best and 10 worst days	121.09
Cash	19.33

Sources: Bloomberg L.P., Invesco, Morningstar, data as of Dec. 31, 2015. Past performance is no guarantee of future results.

The impact of volatility on loss is further compounded by investor behavior. While investors would like to believe they would "buy low and sell high," in practice we observe the opposite – that many investors respond to market volatility by selling equities and moving into cash, thereby locking in their losses. When they return to markets, it's generally after most of the recovery has taken place, which means they miss out on the gains. So as volatility increases, risk increases – investors begin to sell – and equity returns tend to decrease.

We can observe this relationship by looking at historical volatility and returns for the S&P 500 Index and the MSCI EAFE Index[2] dating back to 1990 (Figure 4). The top 10% most volatile periods (as defined by the VIX Index), corresponded to losses of more than 30%, while in all other periods, both markets were up on average 20% and 14%, respectively.[3]

Figure 4: High volatility has historically led to large market losses



Source: Bloomberg L.P., data as of Dec. 31, 2015. Data range from 1990-2015

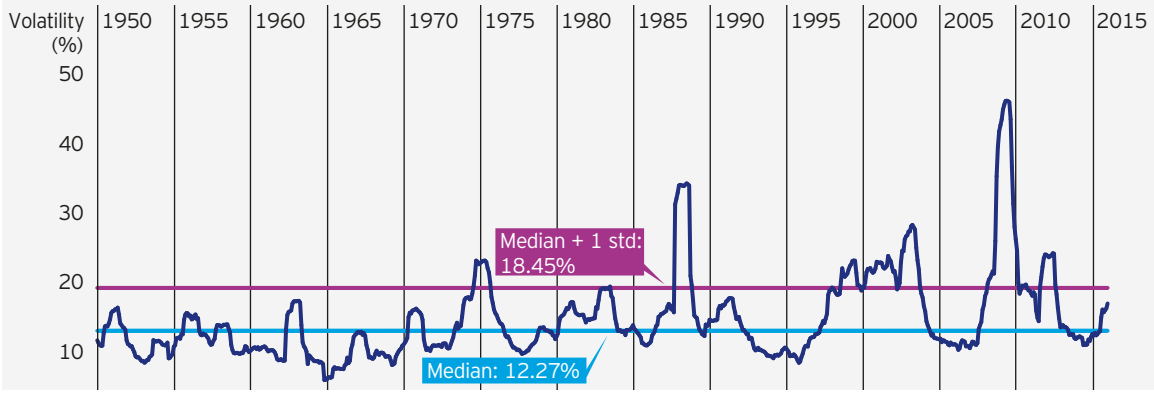
2 S&P 500 Index using daily data, MSCI EAFE Index using monthly data.
3 Annualized average return

Volatility is dynamic

Historically, volatility has always factored into investment decisions, for example, by allocating to a balanced portfolio of stocks and bonds to diversify risk. However, the global financial crisis forced investors to re-examine their understanding of volatility as well as their approach to accounting for it in their portfolios.

As volatility becomes more pronounced and more frequent, we believe the risk level investors actually experience over the short term will be unlikely to equal the risk tolerance level they expect to achieve over the long term. Since 1950, volatility, as measured by the standard deviation of rolling one-year S&P 500 Index returns, has averaged 12% (Figure 5).[4] And severe market swings, defined as volatility that exceeded one standard deviation above average volatility (18.4%), have occurred roughly once every six to seven years or so.

Figure 5: Post-war S&P 500 Index annualized rolling one-year volatility



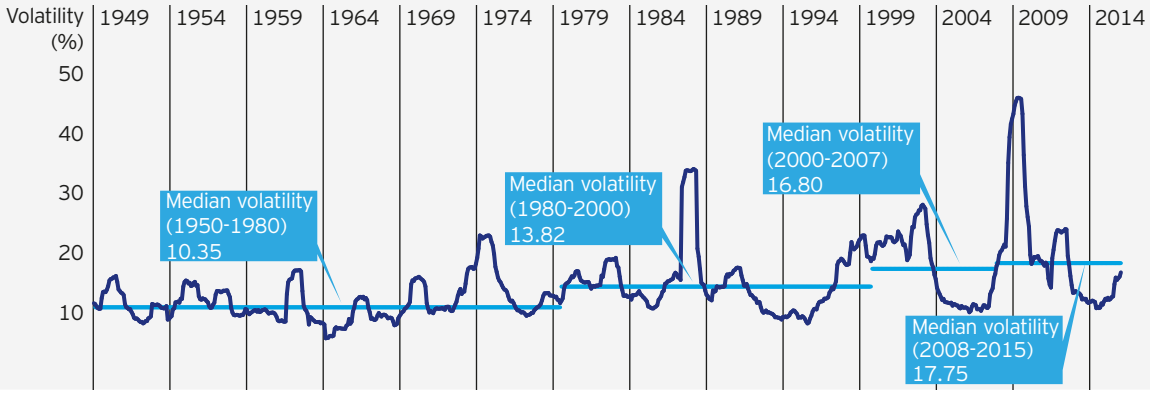
Sources: Bloomberg L.P. and Invesco, data as of Dec. 31, 2015. Data is represented by S&P 500 Index.

On the surface, this average level of volatility and frequency of high volatility events might be acceptable to most investors. However, underpinning investment decisions with the assumption that volatility is constant over time could undermine long-term financial goals, as the magnitude and frequency of volatility have increased over time.

Looking across the returns of the S&P 500 Index in the post-war period, we see that median volatility has increased (Figure 6) from 10.3% between 1950 and 1980 to 13.8% in the subsequent 20 years. Median volatility increased again in the period between 2000 and 2007 to 16.8%. In the years since the financial crisis, volatility averaged 17.7%. Thus, the average accumulator who began saving for retirement in the 1980s and 1990s would have incorporated incorrect assumptions regarding volatility – ones that were too low – in planning for retirement, with the potential to undermine financial goals.

4 Median volatility between 1950 and 2015 was used, as we feel it was a better representation and gave appropriate weights to extreme volatility events.

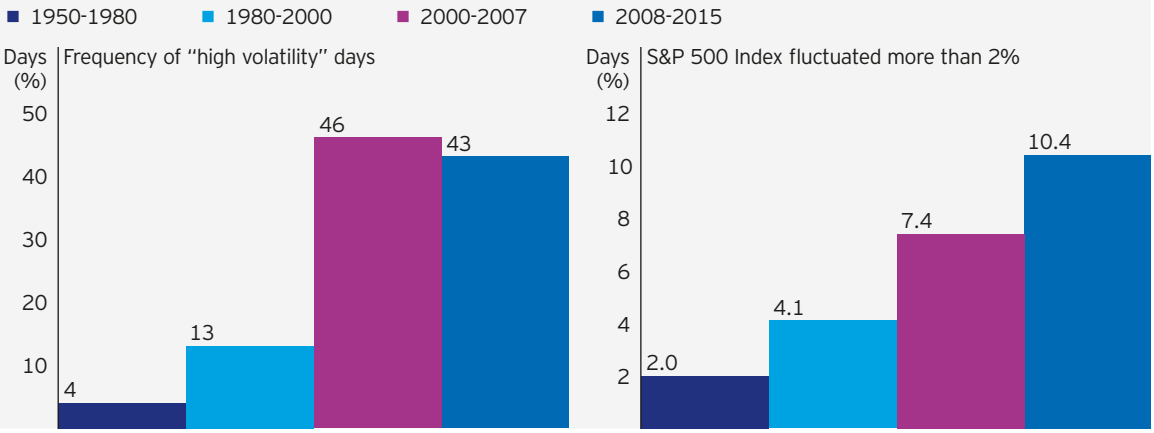
Figure 6: Magnitude of volatility has increased over time



Source: Bloomberg L.P., data as of Dec. 31, 2015. Data is represented by the S&P 500 Index.

In addition to magnitude, the frequency of high volatility episodes has also increased over the past 65 years (Figure 7). For example, the frequency of high volatility events (i.e., volatility higher than one standard deviation above the mean) has increased from 4% of the period between 1950 and 1980 to above 40% of the period since 2000. Another reflection of volatility involves short-term – daily – movements in market returns. The number of days during which the S&P 500 Index fluctuated more than 2% (up or down) has increased from 2% of the period between 1950 and 1980 to more than 10% of the period since 2008.

Figure 7: The frequency of volatility has increased over time



Source: Bloomberg L.P., data as of Dec. 31, 2015. Data is represented by the S&P 500 Index.

Traditionally, many investors target a level of volatility based on their tolerance of losses, and they have sought to manage volatility in their portfolios through a static allocation to assets they believed would move independently of each other – like a traditional balanced portfolio comprising 60% stocks and 40% bonds – thereby smoothing out portfolio returns. However, experience since 2000 shows that investing in a 60/40 portfolio does not always provide the diversification benefits investors seek, and moreover, that it does not account for the changing dynamics of stronger and more frequent volatility over time.

Caution: Volatility ahead

During the first five trading days of 2016, the S&P 500 Index declined 6% – the worst beginning of a year for stock markets since the beginning of the financial crisis in 2008. Is more volatility ahead?

In the years since the financial crisis, central bank stimulus in the form of very accommodative monetary policies has helped support financial markets by keeping interest rates low, and has cushioned the impact of the post-crisis deleveraging process as households and governments sought to unwind their high debt burdens. Consequently, however, as macroeconomic challenges begin to emerge, policymakers now have fewer tools to combat volatility. Market observers and economists have suggested that investors should expect market swings often in the short term amid a perfect storm of weakness in the global economy and concerns about the effectiveness of central bank monetary policy.

Against a market backdrop of modest returns and high volatility, and keeping in mind what we know about this type of environment magnifying the impact of volatility drag, what options are available to investors who are sensitive to the impact of higher volatility on the consistency of their portfolio returns?

Volatility management employs a "risk first" mentality, which typically contains some form of risk parity, low volatility, managed volatility (targets and ceilings), or tactical positioning. These strategies manage risk in absolute terms (i.e., total portfolio volatility or variance) rather than in relative terms (i.e., tracking error, R-squared, or beta), and can be implemented in various ways including holding less-risky stocks, selling options or futures, shifting asset allocation exposures, or holding excess cash. All of these approaches seek to achieve a similar goal – reducing total portfolio risk. Investors participating in these strategies are seeking a smoother stream of returns and better risk-adjusted returns at the expense of more active relative risk (or higher tracking error).

By limiting the amount of market risk, low or managed volatility strategies could outperform traditional equity investments during a market drawdown. By "not losing" – or losing less – in this environment, a low volatility investor seeks to achieve a similar level of return over an extended investment horizon, but with fewer significant drawdowns along the way.

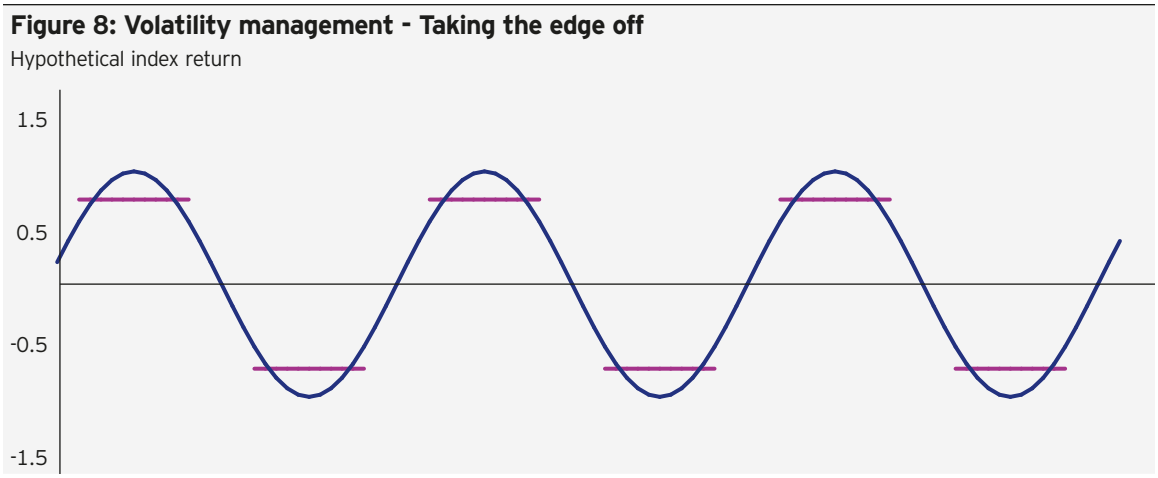
What is a managed volatility strategy?

One approach to managed volatility is to maintain portfolio volatility under a certain level (i.e., ceiling or cap). In seeking to reduce risk during extreme equity market declines, but allowing for some upside participation when markets rise, this type of strategy can increase the potential for higher risk-adjusted returns. This strategy addresses some of the math and psychology that compound the pitfalls of volatility we already discussed. Namely:

- It may be able to help make up losses more quickly when markets recover.
- It allows investors to stay in the game during periods of market stress and reduces the urge to lock in losses.
- It creates a closer link between expected and realized risk levels, seeking to meet investor expectations.

Managed volatility strategies typically keep volatility under a set ceiling by dynamically shifting the allocation of the portfolio across stocks and bonds as market conditions change. For example, if market volatility spikes, increasing above the portfolio's ceiling, the managed volatility strategy responds by reducing exposure to equity investments and increasing exposure to cash and cash equivalents. As market volatility returns to normal levels, exposure to equity investments will likely increase to allow the portfolio to participate in the market upside. Essentially, the approach seeks to "take the edge off" volatility (Figure 8), in that the investor is mitigating the impact of the lowest market troughs and the highest market peaks.

Figure 8: Volatility management - Taking the edge off

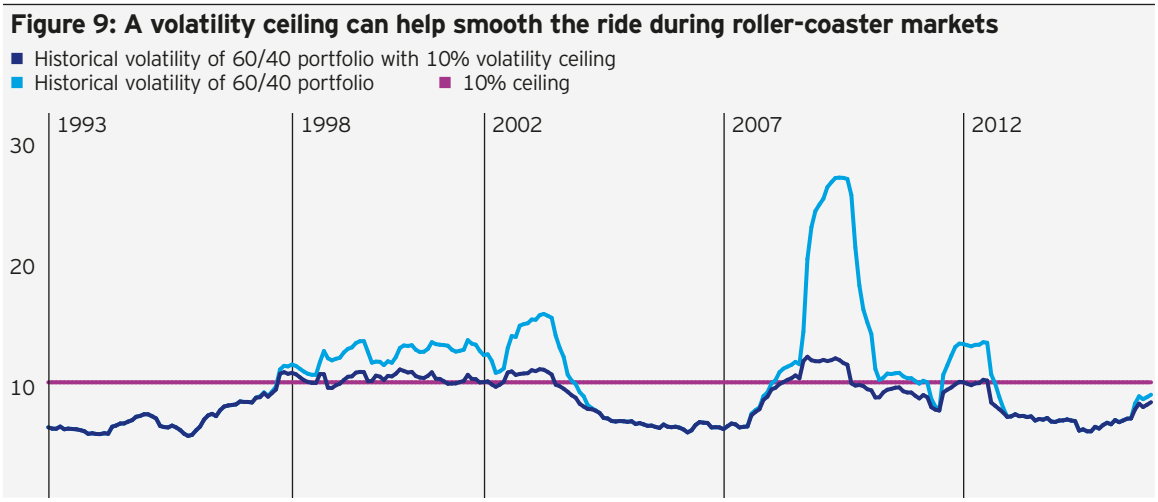


For illustrative purposes only

By introducing downside protection and limiting total volatility, managed volatility strategies seek to provide higher risk-adjusted returns, although managed volatility strategies tend to lag in highly volatile, sideways markets.

In short, managed volatility strategies may help create a smoother ride during the accumulation phase and a longer-lasting income stream during retirement (Figure 9).

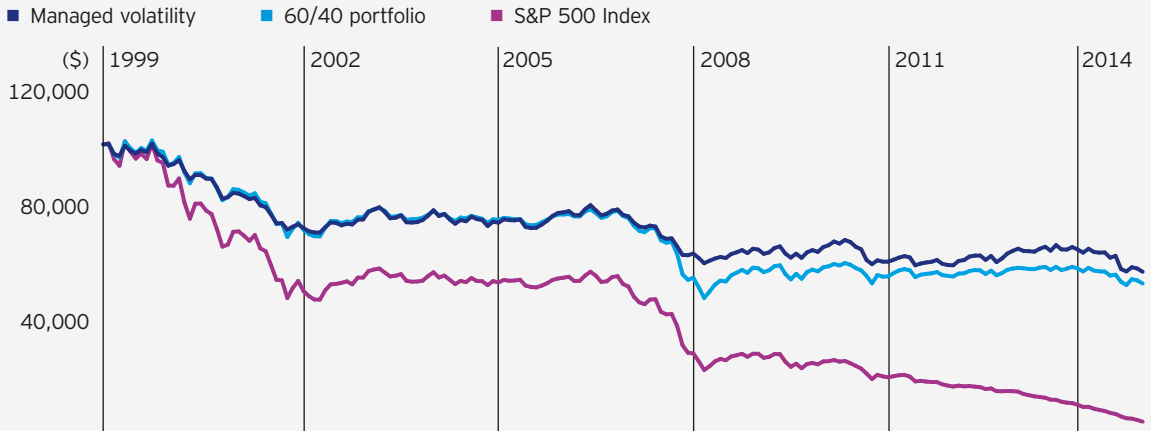
Figure 9: A volatility ceiling can help smooth the ride during roller-coaster markets



Source: Bloomberg L.P., data as of Dec. 31, 2015. The 60/40 portfolio is represented by a 60% allocation to the S&P 500 Index and a 40% allocation to the Barclays Aggregate Index.

Investors with a shorter investment horizon (e.g., retirees, pre-retirees), or who are risk-sensitive or risk-averse, could benefit from this type of approach. Retirees, particularly those who withdraw money from their accounts on a regular basis, could extend the life of their portfolio during this distribution phase. Withdrawing invested savings when markets are falling can make it more challenging to recover from potential losses and could accelerate the rate of depleting savings, which increases longevity risk – the risk of outliving your retirement savings. Volatility management may extend the stream of retirement income by as much as several years (Figure 10).

Figure 10: Managed volatility could extend the longevity of retirement savings



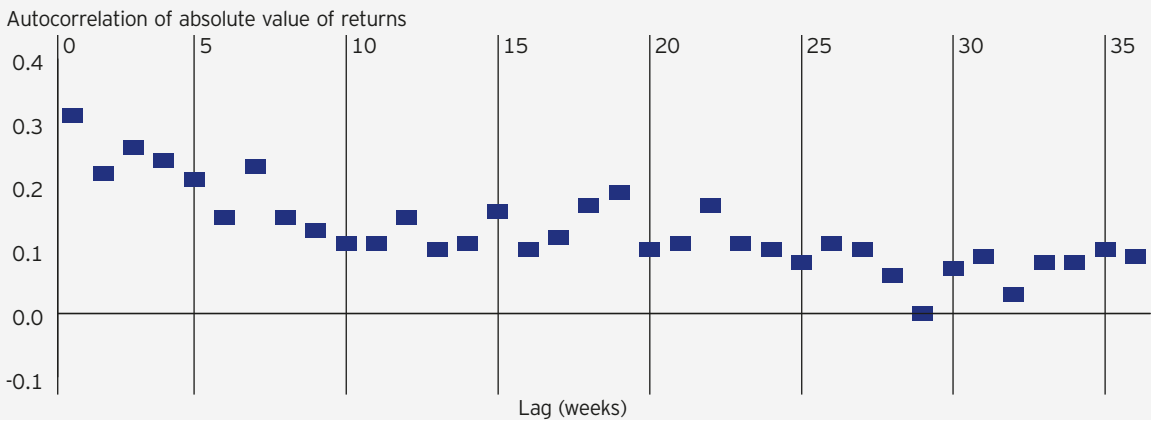
Decumulation of $100,000, with annual withdrawals of $6,000 distributed daily.
Source: Bloomberg L.P., data as of Dec. 31, 2015. The 60/40 portfolio is represented by a 60% allocation to the S&P 500 Index and a 40% allocation to the Barclays Aggregate Iindex.

Modeling volatility

In contrast to the stochastic or random nature of asset price returns, a robust body of academic research exists exploring the statistical properties – also known as stylized facts – of volatility. These properties lend themselves to the enhanced ability to model and forecast, and consequently manage, volatility:

- **Persistence.** Volatility clustering expresses the well-documented observation that periods of high volatility have historically been followed by subsequent periods of high volatility, and vice versa, with high correlation between current and past volatilities.[5] The implication of this "persistence" or "clustering" is that volatility shocks today will influence the expectation of volatility well into the future. This is also evidenced by the positive serial correlation in the absolute value of returns (Figure 11), which decreases over time.

Figure 11: Volatility shocks today will likely influence the expectation of volatility in the future

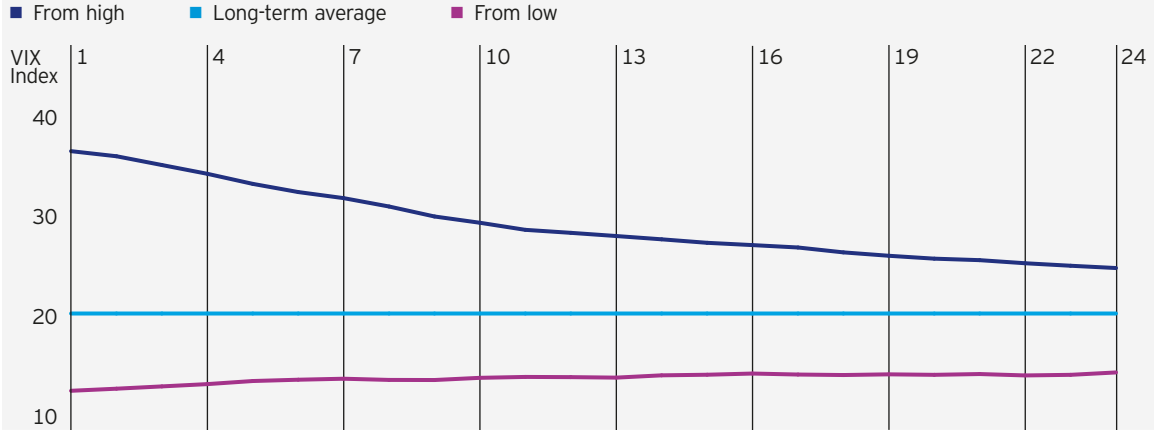


Source: Bloomberg L.P., data as of Dec. 31, 2015

- **Mean reversion** – While future volatility tends to be linked to prior volatility, there is a general decay in this relationship, meaning that volatility tends to revert to a long-term average or mean following a shock. In other words, what goes up, must come down. Research has also found that low levels of implied volatility (VIX Index) can persist and are more stable than elevated levels of implied volatility, which tend not to persist as long or as strongly (Figure 12).

5 Mandelbrot (1963), Fama (1965), Baillie et al. (1996), Chou (1988) and Schwert (1989).

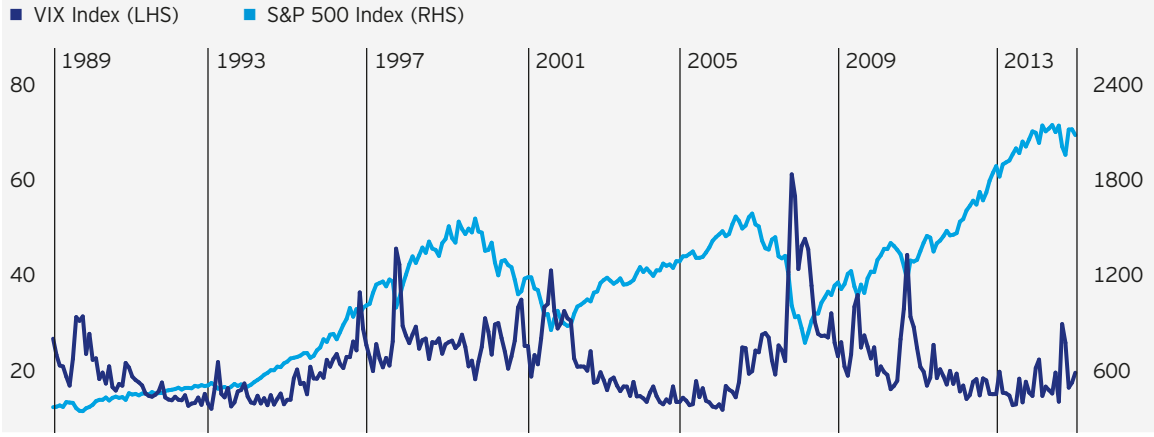
Figure 12: Volatility tends to revert to a long-term average following a shock



Source: Bloomberg L.P., data as of Dec. 31, 2015

- **Asymmetry** is a statistical property that underscores why it makes sense to model volatility. It expresses the empirical observation that a negative shock to returns tends to have a larger impact on volatility than a positive return shock (Figure 13), as higher correlations tend to correspond with down markets. In other words, we would expect a forecast of elevated volatility to signal a high probability of negative returns. In the academic literature, it is also referred to as the "leverage effect" or "risk premium effect." In the case of the former, as the price of a stock falls, its debt-to-equity ratio rises, increasing the volatility of returns to equity holders. In the case of the latter, news of increasing volatility reduces the demand for a stock because of risk aversion. The consequent decline in stock value is followed by the increased volatility as forecast by the news (Engle and Patton, 2001).

Figure 13: A negative shock tends to have a larger impact on volatility



Source: Bloomberg L.P., data as of Dec. 31, 2015

There are several approaches available to model the statistical properties of volatility:

- **Moving (or rolling) average** (e.g., rolling one-month or three-month). Models persistence and mean reversion of volatility, but does not capture asymmetry. All observations have an equal contribution to volatility, so near-term fluctuations are not given as much weight. This approach also assumes returns are independently and identically distributed.
- **Autoregressive Moving Average (ARMA).** Adds an autoregression component to the moving average approach. That is, it expresses a time series of returns as a linear function to past values, so it gives weight to the short-term persistence of volatility.

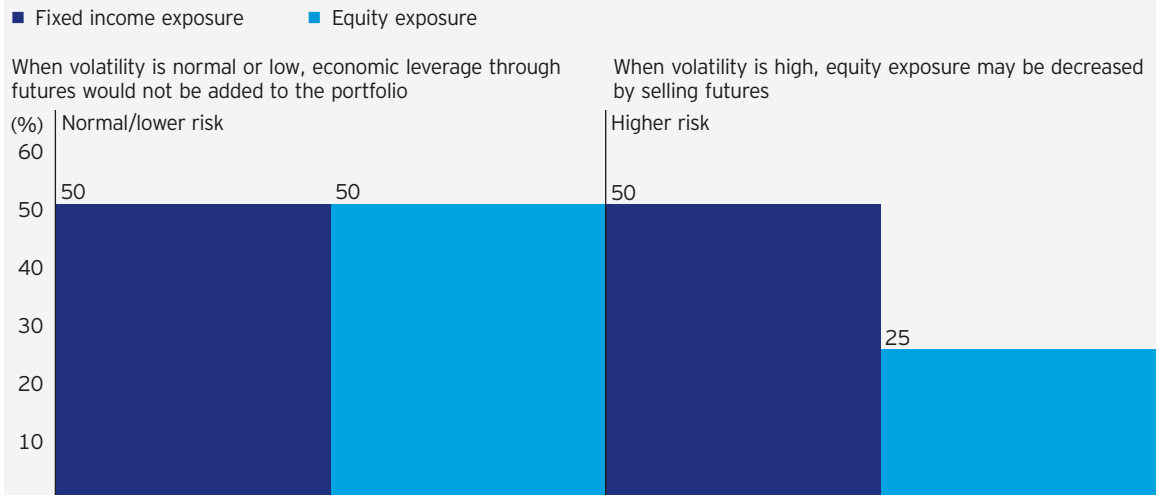
- **Autoregressive Conditional Heteroscedasticity (ARCH).** Because volatility clustering is nonlinear but predictable, it allows us to develop better-fitting volatility models. Conventional econometric models operate under the assumption of constant variance. Engel (1982) proposed a model called ARCH, which reflects the observation that volatility is not constant, that some periods in the market are risker than others, and that these periods are not randomly dispersed across time – past values can help forecast future values. In doing so, the model helps resolve the issue of heteroscedasticity (the volatility of one period is conditional on the volatility of the previous period), improves the accuracy of prediction, and can describe volatility clustering.
- **Generalized Autoregressive Conditional Heteroscedasticity (GARCH).** In 1986, Bollerslev proposed a more nuanced model called GARCH, which incorporates a more flexible lag structure to the conditional variance term. Another way of thinking about it is that it incorporates an ARMA model for the variance of the error term in ARCH. Further iterations of GARCH (e.g., EGARCH, asymmetric GARCH) help address the limitation of GARCH in capturing volatility asymmetry.

Invesco's approach to managed volatility

The Invesco Global Solutions Development and Implementation team has extensive experience in designing and implementing managed volatility strategies that can either be applied to existing portfolios or can serve as stand-alone products, with the aim of mitigating portfolio volatility by dynamically adjusting asset allocations in response to shifts in the market environment.

These strategies seek to manage portfolio volatility by using hedge assets such as equity index futures to keep overall volatility below a predetermined ceiling or cap. Specifically, the strategies approach seeks to maintain a higher exposure to equities in low volatility markets and to defend against portfolio losses by lowering exposures to equities or other risk assets during periods of extreme market volatility by selling equity market futures (Figure 14).

Figure 14: Equity exposure is managed to stay under the predetermined volatility cap



For illustrative purposes only

The team uses a GARCH-based algorithm to forecast portfolio volatility, and proprietary optimization software that seeks to create a portfolio that will meet the overall target level of risk with the smallest futures position possible. The team's unique approach to managing volatility is predicated on the following tenets:

- **Stability over noise.** While modeling has evolved toward capturing faster-moving signals, which we believe offers less stability from day to day, we have adopted an approach that incorporates a more stable signal. This affords us greater confidence in our simulations and more fluid transition from research to implementation.
- **Conservative modeling.** Our extensive experience in research and implementation has led to the development of models that seek to incorporate more realistic simulations of risk by reflecting realistic lags and frictions, rather than best-case scenarios.
- **Focus on risk reduction.** We focus our research and fit our simulations on results that seek to reliably control risk rather than produce the greatest total return.
- **Liquidity and hedging.** Because managed volatility strategies often require trading into a choppy, volatile and less liquid market, it's important to select instruments with ample excess liquidity, and to implement alternatives for hedging in the event that our primary instrument is not tradable at a given time.
- **Responsive rebalancing.** Using proprietary models, we hedge and rebalance the portfolio in response to volatility spikes as they occur, seeking to reduce trading costs and improve our hedging ability relative to competitors.

About risk

In general, stock values fluctuate, sometimes widely, in response to activities specific to the company as well as general market, economic and political conditions.

The Adviser may not be able to effectively manage the strategy's volatility or may be unable to trade certain derivatives effectively or in a timely manner. There can be no guarantee that the strategy will maintain its target volatility level, nor that maintenance of the target volatility level will ensure competitive returns. The risks of investing in securities of foreign issuers can include fluctuations in foreign currencies, political and economic instability, and foreign taxation issues.

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