

Dynamic Volatility Targeting

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Volatility is a consideration at the center of most investment decisions. As a result, many tools have emerged to help protect against surges in volatility. Derivative overlay strategies are one approach; however, dampening volatility—and even stabilizing it—is also possible via asset allocation. Traditionally, asset allocation solutions rely on blending equity and fixed-income investments, and given the potential for future higher interest rates, reliance on fixed income has become a concern.

In this paper, we examine popular hedging strategies with derivatives and contrast these with passive and dynamic asset allocation approaches. In addition, we propose the use of low-volatility equities to substitute part of bond allocations in volatility targeting solutions.

Realized volatility on the S&P 500 Index reached 89% at the height of the global financial crisis in 2008. An investment in the S&P 500 Index started on 10 October 2007 would have experienced a 55% drawdown lasting 510 days from peak to trough and another 1,256 days to break even. Over the last five years, the price of the S&P 500 Index has experienced a daily move greater than five standard deviations on seven separate occasions. Statistical models assuming a normal distribution would predict each of these five-standard-deviation events to occur once every 13,417 years. Prior to the crisis, investors had leaned heavily on backward-looking correlation models (for portfolio construction) based upon periods of stable historical correlation data to assess their risk exposure, significantly underestimating portfolio risk. The inherent instability of market relationships was revealed as correlations among global equity markets increased dramatically, all but eliminating the diversification benefit at the precise time it was needed the most.

It is no surprise that the open interest on the Chicago Board Options Exchange (CBOE) VIX Index futures has increased five-fold over the past three years and investment strategies that bet on the incalculable probability of unforeseen events have begun to gain favor. Seeking protection against rising volatility has become commonplace in the wake of the global financial crisis as investors' desire to hedge tail (or outlier) risks has gained significant prominence without a true understanding of the likelihood of these tail events. In recent years, institutional investors with long-term investment horizons have responded to this aversion to volatility by considering a number of targeted volatility strategies. Those ranging from defined benefit plans to defined contribution investment only solutions to variable annuities offered at insurance companies must plan for long-standing liabilities. A targeted volatility approach provides a smoother path of asset returns and more closely aligns the performance of the institution's assets to the characteristics of its liabilities.

In this paper, we will evaluate the merits and drawbacks of different approaches to insuring a portfolio against rising volatility. On one side of the spectrum are strategies which rely on derivatives, and at the other end, are those that rely on static or dynamic asset allocation.

Hedging with Derivatives Overlay Strategies

The use of derivatives is a popular and effective approach to mitigating and/or targeting a specific level of volatility. Although some form of derivatives contracts has been widely used for millennia,¹ the CBOE's decision in 1983 to create options on stock indices made portfolio insurance more cost effective by allowing a single security to cover an entire stock market index. Options, futures, swaps, and inverse ETFs are among the most common hedging instruments in use today.

Options

The attractiveness and popularity of options as a hedging instrument revolves around their non-linear payoff structure. Options provide effective downside protection while preserving upside potential. For example, the value of put options rises as the price of the underlying asset falls, but more importantly, the rate of the increase in the price of puts increases as the price of the underlying asset falls. Conversely, the rate of the decrease in the price of puts decreases as the price of the underlying asset rises. This characteristic is unique to a long options position and is referred to as positive gamma.

This is in contrast to linear hedges like swaps, futures, and forwards where the degree of protection remains constant regardless of the price behavior of the underlying instrument. As a result, options are uniquely positioned to provide the most robust downside protection while at the same time allowing for the most upside capture in the event of large and unforeseen market moves to the upside or downside. This asymmetric payoff structure is priced-in to the premium of an options contract in the form of implied volatility. By their nature of becoming more valuable as the price of the underlying asset falls, put options are heavily used in the context of volatility protection for many portfolios. Hedging a portfolio using put options offers many advantages:

- Provides the ability to hedge against a loss if the price of the underlying asset falls below a certain level.
- Profits from rising levels of volatility in times of crisis.
- Enables the investor to adjust the degree of exposure without having to trade and adjust the composition of the long portfolio.
- Provides an asymmetric payoff structure with positive skewness—allowing for the reduction of downside risk while preserving upside potential, changing the shape of a portfolio's return distribution.
- Provides defense against market jump risk: a large and instantaneous market surprise.

However, the asymmetric payoff structure embedded in the option premium (option cost) exceeds the long-term benefit of this unique hedging characteristic over time. As a result, portfolio insurance using put options is not an effective long-term solution, in our view. For the reader's consideration, we discuss additional features in the sidebar "Option Costs Exceed the Long-Term Benefits."

Option Costs Exceed the Long-Term Benefits

Two Sources of Negative Expected Return

One source of negative expected return for put options is time decay (theta). Options are “wasting assets” whose value is eroded each day an option remains out of the money. The other component of negative expected return comes from the option’s delta (i.e., the ratio of the change in the price of the underlying asset to the change in the option’s price). Put options have negative deltas as they are profitable when the price of the underlying asset falls, and vice versa. A positive expected long-term return on equities becomes a negative expected long-term return on put options, as shown in Exhibit 1.

Realized versus Implied Volatility

The sensitivity of an option’s price to volatility is technically known as vega—and is positive for all long options positions. As a result, investors can profit from long options positions when realized volatility rises above the level implied by the option price.

Over the 23-year period, since the inception of the VIX Index, there have been 764 days (12.4% of the time) when realized volatility was higher than implied volatility (the VIX) had predicted.² An investor could have hypothetically timed the market to profit from holding long options during these periods, but in the remaining 87.4% of the time the sellers of insurance profited, as investors were unable to recoup the cost of protection.

Time Diversification

In probability theory, the law of large numbers states that the average result from a large number of trials of a random variable should approximate its expected value. This relationship holds with market returns if one maintains the assumption of a long-term positive expected value of returns. Over the short term, the instability of market returns can result in significant losses. However, over the long term, investments converge toward their positive expected value. Exhibit 2 illustrates this for the MSCI All Country World Index (ACWI).

The worst annualized loss for the MSCI ACWI goes from -47.9% to -14.4% as the investment horizon increases from one year to two years, and approaches zero as the time horizon nears ten years. As such, options become less necessary and more onerous as the investment horizon increases, as shown in Exhibit 2.

Positive expected returns are likely to generate more wealth over a longer period of time and thus more assets at risk (Samuelson 1963).³ Assuming that greater wealth leads to greater risk tolerance, the magnitude of potential losses which accompany greater wealth is offset by potentially higher risk tolerance—as negative returns over longer horizons are less likely.

Not Immune to Market Timing

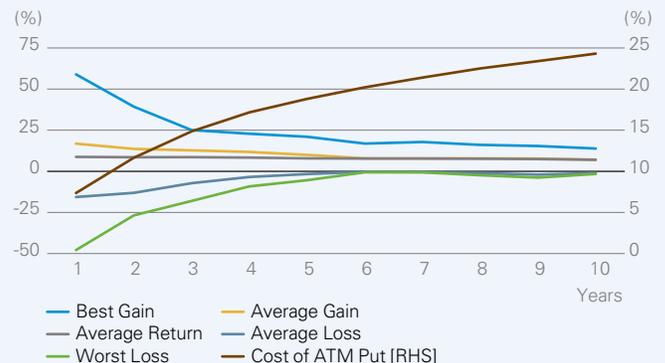
Market timing plays a prominent role when hedging a portfolio using options, as exposures can change rapidly. Put options with high levels of gamma (i.e., the sensitivity of the delta to changes in the underlying asset) provide adequate protection when volatility spikes. However, these options also have large time decay cost and are relatively short in maturity. Maintaining a long-term position in options for hedging will pay off at the outset of a crisis, but an investor would be required to roll short-term options to remain protected leading to high costs.⁴

Exhibit 1
S&P 500 Index Performance versus Option-Hedged Performance



As of 2 May 2013
SPY is the SPDR S&P 500 ETF Trust
This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.
Source: Bloomberg, J.P. Morgan

Exhibit 2
Convergence toward Positive Expected Value and Long-Term Option Costs



As of 28 June 2013
The chart is based on 281 monthly return observations of the MSCI ACWI. We calculated the best and worst returns for each length of time—from one to ten years. We also calculated the average positive return (average gain), the average negative return (average loss), and the overall average return for each period. Option costs are based on the iShares MSCI ACWI US Equity ETF.
This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.
Source: Bloomberg

Hedging an Equity Allocation Using Linear Derivatives – Total Return Swaps, Futures, and Forwards

Total return swaps, futures, and forwards have very similar economic characteristics as hedging instruments. With linear hedges, the future value to be exchanged is certain (determined at contract initiation) so hedging is constant, maintaining a static level of exposure. Hedging using total return swaps, futures, or forwards all involve reducing equity risk exposure by effectively shorting an equity index. The investor seeking protection agrees to exchange the return on an equity index for a fixed payment. In general, linear derivatives are simpler hedging instruments with fewer external variables to consider. Basically, these instruments passively dampen the volatility of an equity exposure by removing a portion of the beta. As a result, this beta is replaced with a larger weight to an active manager's alpha. Hedging using linear derivatives is significantly cheaper than using put options because they do not provide the investor with an asymmetric payoff structure. As a result, linear swaps dampen as much of the upside as the downside. In contrast, the protection that put options provide increases as the value of the underlying asset falls and decreases as the value of the underlying asset rises. We summarize some of the key advantages and drawbacks of linear derivatives next.

Advantages

- Do not interfere with the long portfolio: can reduce volatility, adjust beta exposure, and hedge ratios without introducing turnover into the long portfolio and without sacrificing alpha
- Are inexpensive in normal interest rate and credit environments
- Reduce the odds of shortfall

Disadvantages

- Basis risk: the underlying asset is not the same as the long portfolio so linear derivatives are not a perfect hedge
- Negative expected long-term return except when negative market events occur. By hedging with linear derivatives, the investor is reducing the volatility of the equity allocation by lowering its expected return
- Volatility remains unstable. Implementing a constant linear hedge on an equity allocation will dampen the overall volatility, but will not stabilize it. The volatility of the overall hedged portfolio will still fluctuate along with the volatility of the equity market unless an asset allocation framework is put in place to adjust the hedge as volatility levels change

A Passive Balanced Approach Based on Asset Allocation

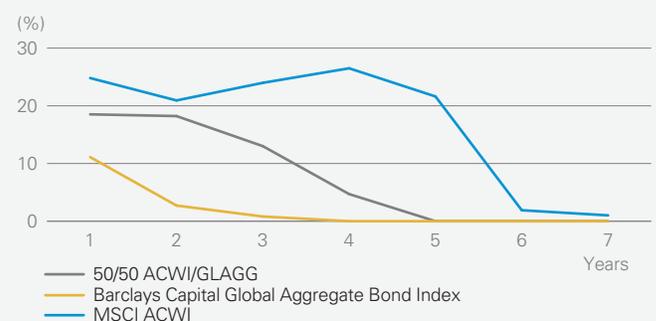
For an equity-only allocation, a passive balanced approach reduces the odds of a shortfall across time. A simple passive 50/50 equity and fixed income balanced allocation shortens the time horizon to achieve a minimal probability of shortfall. In Exhibit 3, we show that after four years the probability of shortfall from a 50/50 mix of the MSCI ACWI and the Barclays Capital Global Aggregate Bond Index is below 5%, compared to above 25% for an equity-only allocation. The inherent differences in the drivers of returns for bonds and equities

mean that blending these asset classes is, in our opinion, a straightforward way to mitigate volatility via the effects of diversification.

The steady income stream, capital preservation, and liquidity characteristics of bonds provide a degree of insulation from significant equity market corrections. The value of an equity allocation is dependent upon company profitability. The profitability of companies is, in turn, largely dependent upon the global economic cycle. In contrast, the value of fixed-income investments is dependent upon changes in interest rates and the market's view of a company's ability to repay debt (in the case of corporate debt). Bondholders have priority over equity holders as creditors in a company's capital structure; thereby cash flows to fixed income investments are less risky given this seniority. The fundamental differences between equity and bond investments are further highlighted by their volatility. The volatility of the MSCI ACWI exceeded 74% at the height of the financial crisis in November of 2008; in contrast, the maximum volatility of the Barclays Capital Global Aggregate Bond Index was 14.2% in the same period.

Due to the dependence of equity prices on cycles of global aggregate demand, equities tend to be impacted by similar factors across regions. This results in rising correlations and an erosion of diversification benefits from global equities in times of market turmoil. Correlations among major equity indices rose precipitously at the height of the crisis. In contrast, the correlation between the MSCI ACWI and the Barclays Capital Global Aggregate Bond Index also rose during the crisis, but remained in a range between -0.3 and 0.5 maintaining diversification properties. An additional diversification benefit between equities and bonds is in the low correlation of their implied volatility. Exhibit 4 shows the correlation between the VIX (implied volatility on the S&P 500 Index) and the MOVE Index (a yield-curve weighted index of implied volatility on Treasury options). Over the past two decades, the correlation has been 0.27, fluctuating between 0.71 and -0.27, illustrating that there are fundamentally different factors driving equity and interest rate volatility and enabling fixed income to provide a natural hedge to rising equity volatility.

Exhibit 3
Probability of a Negative Return



As of 28 June 2013

The allocations and investment characteristics presented herein reflect the hypothetical data for a product not managed by Lazard ("50/50 ACWI/GLAGG," which is a 50/50 blend of the MSCI ACWI and the Barclays Capital Global Aggregate Bond Index). Allocations and investment characteristics are shown for illustrative and comparative purposes only and are subject to change.

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.

Source: Bloomberg

Due to the persistence of the relatively low correlation between global equities and bonds in times of crisis, the diversification benefit has a larger impact on volatility reduction when it is needed the most. Exhibit 5 decomposes the volatility of a 50/50 allocation of MSCI ACWI and Barclays Capital Global Aggregate Bond Index. The global bond allocation is consistently the smallest contributor to overall volatility while the equity component is the biggest contributor. The diversification benefit at the bottom of the chart is the difference between the realized volatility of the 50/50 allocation and the weighted average volatility of the equity and bond components assuming a correlation of one (i.e., the hypothetical case of no diversification benefit).

As shown in Exhibit 5, the volatility of the MSCI ACWI peaked at 74.2% in 2008 while a passively rebalanced 50/50 allocation of the ACWI and Barclays Capital Global Aggregate Bond Index had volatility of 34.9% at the same time—adding 6.5% of diversification benefit to the volatility dampening effects of the asset mix which

assumes no diversification. These results illustrate that the volatility dampening effect of the fixed-income allocation is more pronounced in times of crisis.

We highlight the results of comparing the performance and volatility of a passive balanced approach and an option-hedged approach in Exhibit 6. For this analysis we used US-based data given the availability of options data in this market. While both solutions are successful at dampening volatility, what is striking is the favorable cumulative return of a balanced approach and the slightly negative performance obtained by using options. This underscores the different results from utilizing an asset with positive expected returns (bonds) or one with a negative expected return (options) for mitigating volatility of an equity allocation.

However, while a static allocation between equity and debt will dampen the volatility of the overall portfolio, it will not stabilize it. A stable level of volatility can only be achieved by actively allocating between different asset classes and hedging instruments as the volatility of these asset classes fluctuates.

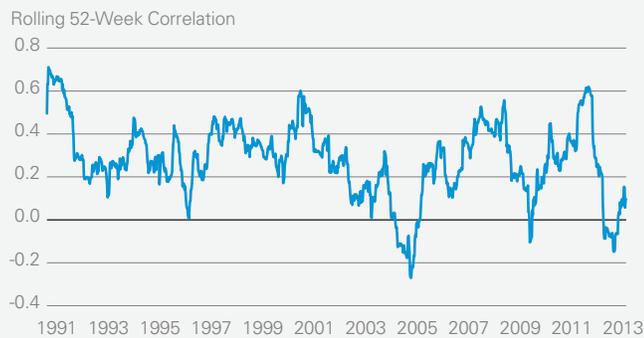
Volatility Targeting

A volatility targeting approach uses dynamic asset allocation to achieve a stable level of volatility in all market environments by taking advantage of the negative relationship between volatility and return as well as the persistence of volatility.

Volatility is negatively correlated with equity returns, as evidenced by Exhibit 7. As a result, a strategy which reduces volatility in periods when volatility is high and/or rising and which increases volatility in periods when volatility is low and/or falling is more likely to add value.

In addition, returns of assets are not independent across time as large returns tend to be followed by large returns and small returns tend to be followed by small returns. In other words, periods of high and low volatility tend to persist—clustering together for extended periods of time. This has been evidenced by the fact that the absolute value of market returns displays a positive and significant autocorrelation

Exhibit 4
Correlation between VIX and MOVE

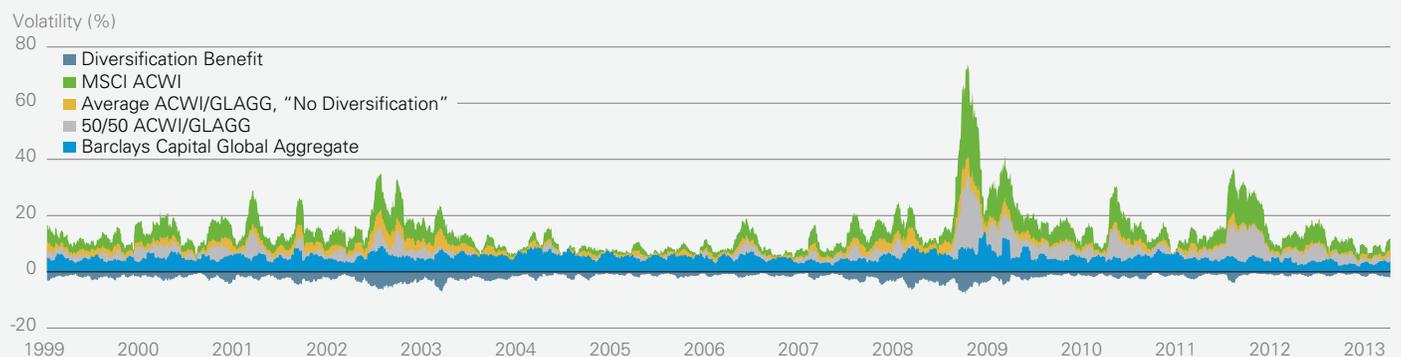


As of 3 July 2013

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.

Source: Bloomberg

Exhibit 5
Volatility Decomposition



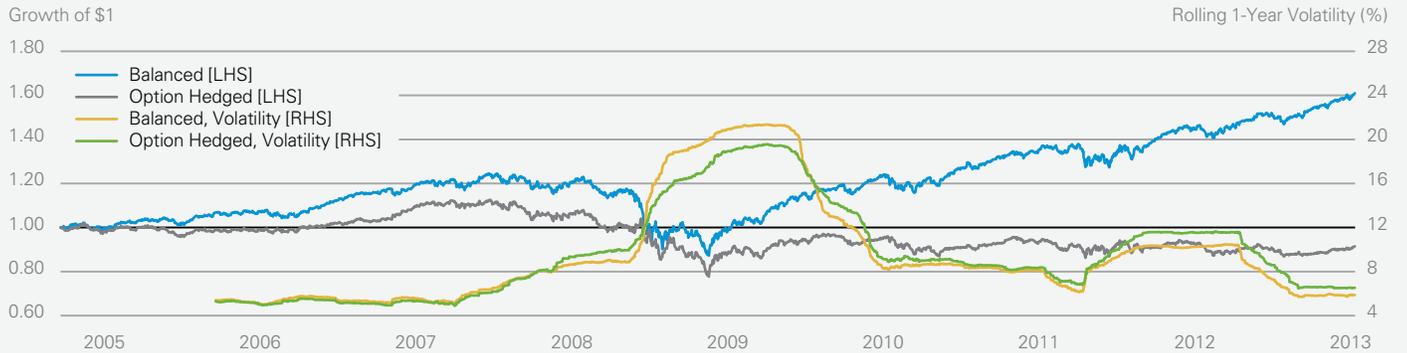
As of 30 April 2013

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.

The allocations and investment characteristics presented herein reflect the hypothetical data for a product not managed by Lazard ("50/50 ACWI/GLAGG" which is a 50/50 blend of the MSCI ACWI and the Barclays Capital Global Aggregate Bond Index). Allocations and investment characteristics are shown for illustrative and comparative purposes only and are subject to change.

Source: Bloomberg

Exhibit 6 A Passive Balanced Approach versus an Option-Hedged Approach

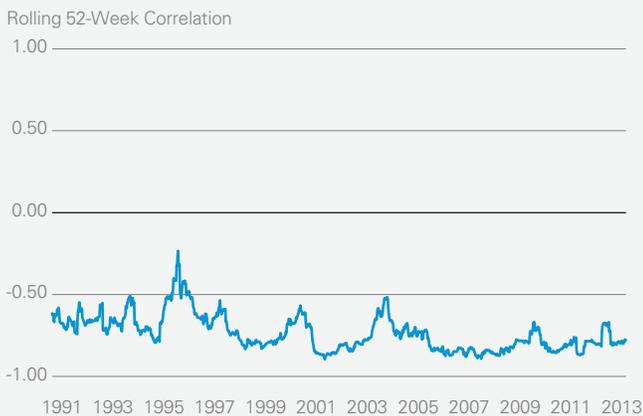


For the period January 2005 to April 2013

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results. Options data are based on the SPDR S&P 500 ETF Trust. The allocations and investment characteristics presented herein reflect the hypothetical data for a product not managed by Lazard ("Balanced," which is a 50/50 blend of the S&P 500 Index and the Barclays Capital US Aggregate Bond Index). Allocations and investment characteristics are shown for illustrative and comparative purposes only and are subject to change.

Source: Bloomberg, J.P. Morgan

Exhibit 7 VIX and S&P 500 Index Correlation

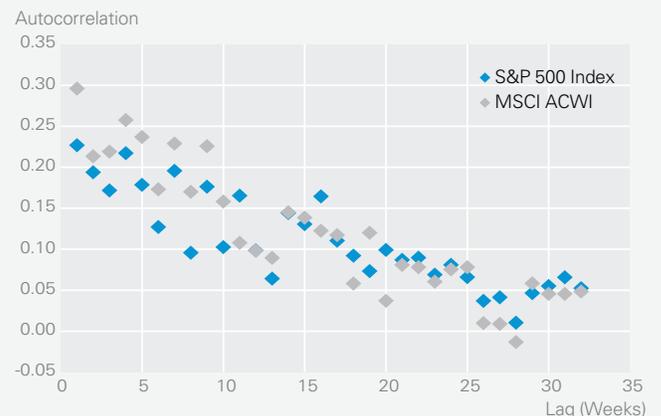


As of 17 July 2013

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.

Source: Bloomberg

Exhibit 8 Autocorrelation of S&P 500 Index and MSCI ACWI Returns



As of 17 July 2013

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.

Source: Bloomberg

which decays slowly over time, as shown in Exhibit 8. This illustrates that future returns are partially dependent upon past returns; and that this dependence becomes weaker over time.

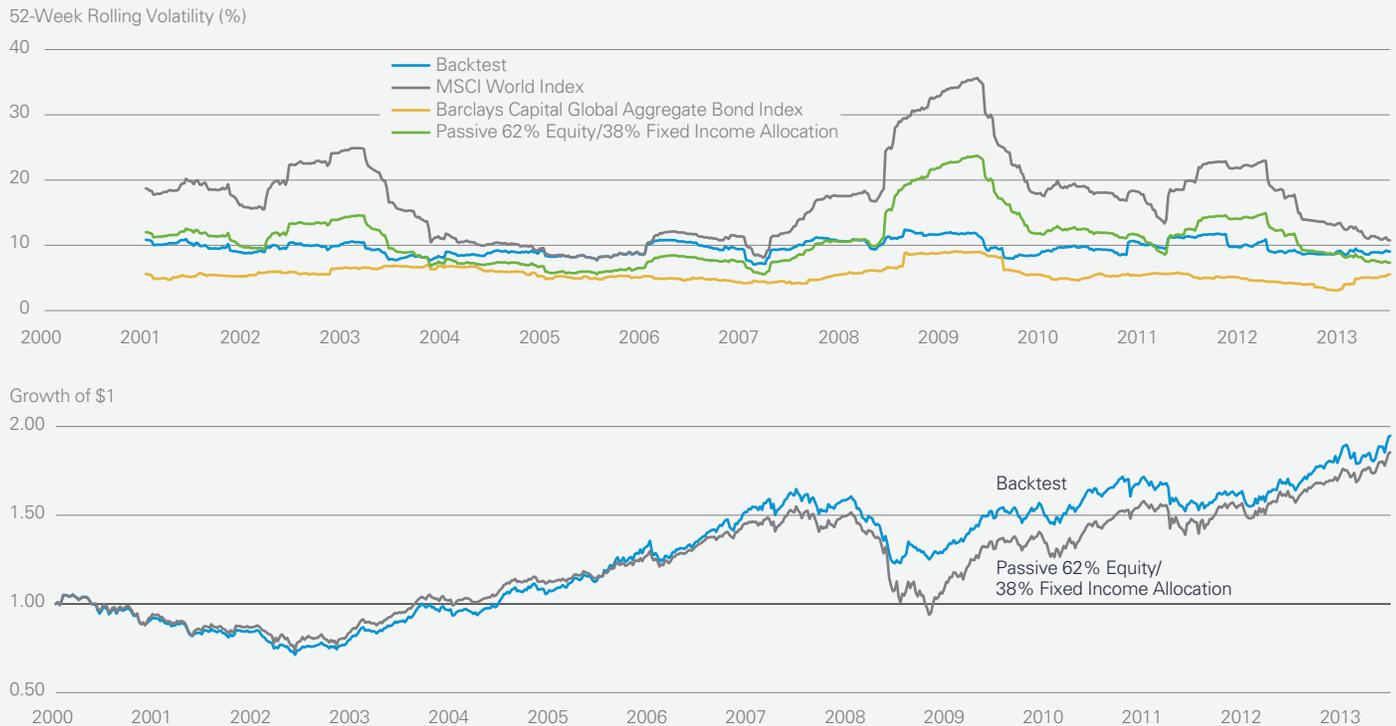
To take advantage of these relationships—the negative correlation between volatility and return as well as the persistence of periods of high and low volatility—volatility targeting has become a popular alternative to strategies which utilize a simple fixed allocation between equities and bonds. By selling equities while their risk-adjusted expected return is falling (while equity volatility is rising) and buying equities while their risk-adjusted expected return is rising (while equity volatility is falling), investors can increase risk-adjusted returns and smooth the overall volatility profile of the allocation.

Is It Possible to Target Volatility?

Absent a crystal ball to divine the future volatility of various asset classes, there is skepticism regarding investors' ability to target a particular level of volatility. However, it is the persistence of volatility which provides both a window into future volatility as well as the requisite time to adjust allocations to target volatility effectively over the long term.

We performed a simple backtest which uses an allocation to global, developed-market equity and bond indices to create a portfolio with a target of 10% annualized volatility. Two asset allocation optimizations are run in parallel. One is a longer-term optimization which uses weekly equity volatility observations and goes back six months

Exhibit 9 Optimized Volatility Targeting



As of 30 October 2013

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.

Please refer to the Important Information section for information regarding methodology for the backtested portfolio.

Source: Bloomberg

(26 weeks). The other is a shorter-term optimization which uses daily equity volatility observations and goes back one month (22 business days). The allocation is rebalanced weekly. Depending on the volatility environment, either the short-term optimization or the long-term optimization will suggest a larger allocation to fixed income. In order to provide protection in a rising volatility environment, the smaller allocation to the higher volatility asset class (in this case, developed-market equities represented by the MSCI World Index) of the two optimizations (short and long term) is used to increase or decrease the volatility objective as needed. Weekly rebalancing frequency allows for some drift in the realized volatility—between 8%–12% over the past ten years—while at the same time providing reliable protection in a rapidly rising volatility environment.

The results of this backtest are shown in Exhibit 9, and contrasted to those of the individual indices and a passive allocation. The passive allocation uses the average weights of equity and fixed income that result from the 10% targeted volatility optimization. This way, we are able to make a more meaningful comparison to the active approach. In addition, the bottom chart in the exhibit shows that the pattern of performance of an active volatility-targeting solution is able to defend favorably in times of crisis and also able to participate in rallies, as seen in the 2008–2009 period.

Utilization of Low Volatility/Low Beta Equities in Volatility Targeting

As the global economy recovers from the financial crisis and becomes less dependent upon central bank policies and a low interest rate environment, the long-term trajectory for interest rates is higher for the foreseeable future. This is likely to be a strong headwind for bonds and for a typical risk parity approach to asset allocation, as the declining interest rate environment of the past decades is not repeatable. This new dynamic naturally concerns asset allocators as they seek close substitutes to bond investments to provide the low-volatility characteristics needed for risk parity solutions.

In an asset allocation framework, low-volatility equities provide an alternative to bonds when interest rates are rising. A volatility targeting approach strives to balance the risk contribution of different asset classes within a multi-asset portfolio. This results in an outside weight to low-volatility asset classes like fixed income. This approach has gained favor due to its outperformance over more traditional methods of asset allocation over the past two decades. However, this time period has been marked by steadily falling interest rates, a strong tailwind for bonds—which a risk parity approach will perpetually overweight due to bonds' lower volatility profile.

Low-volatility equities are a tool that can be used in a volatility targeting portfolio to potentially replace part of fixed-income allocations. These stocks are primarily companies with more defensive balance sheets in more defensive sectors. With less debt in their capital structure, less volatile earnings, and higher dividend payout ratios, the risk profile of low-volatility equities resembles that of bonds while the returns exhibit less interest rate sensitivity.

Low-volatility or low-beta equities provide a relatively high level of risk-adjusted return, counterintuitively to traditional investment concepts such as higher risk equals higher returns. One of the reasons for this anomaly is that benchmark-oriented equity investors are judged upon their active return in relation to their active risk. As low-volatility stocks have relatively high tracking error relative to traditional benchmarks, traditional evaluation metrics have caused benchmark-oriented investors to eschew investment in low risk stocks in favor of stocks with higher absolute risk but lower tracking error.⁵

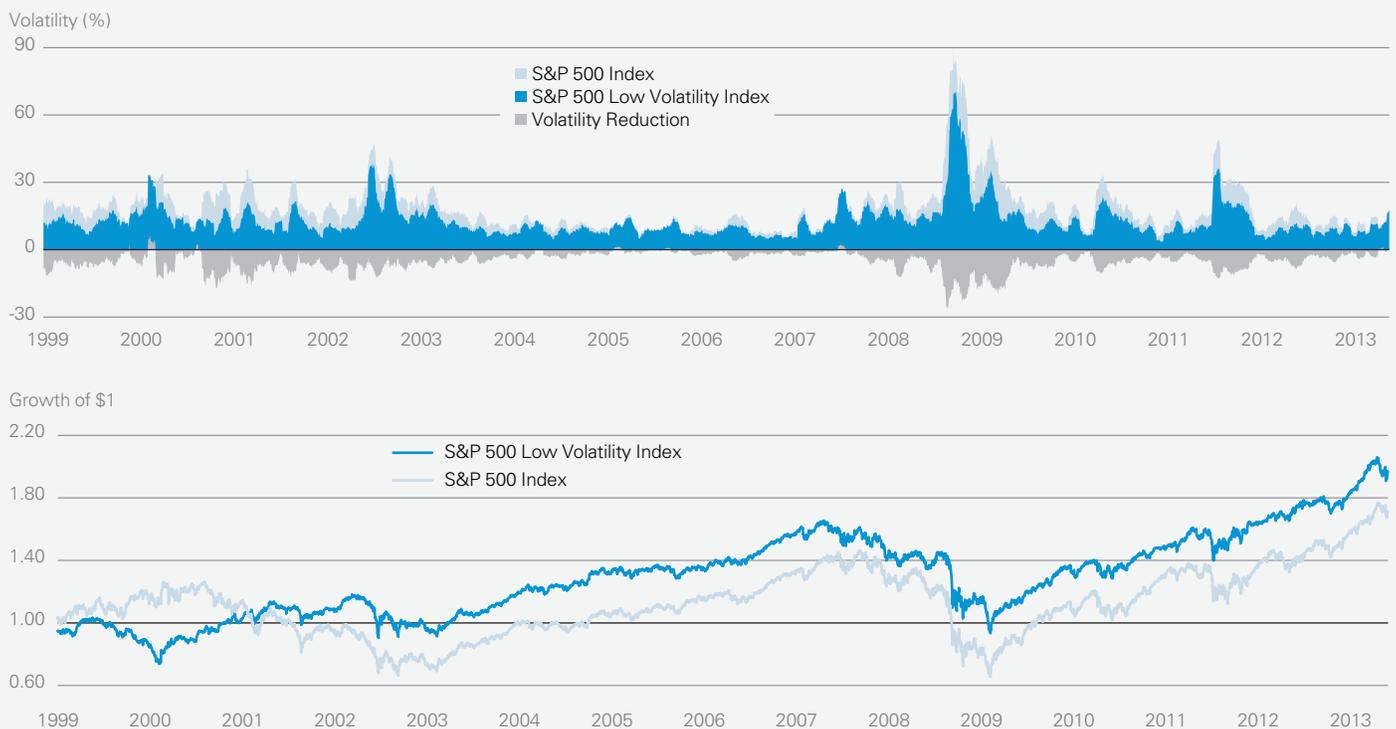
Empirical research suggests that the securities market line is not upward sloping. In other words, investors do not get compensated for investing in higher beta (higher risk) equities. At the same time, due to their bond-like characteristics—steady income streams, capital preservation and liquidity—low-beta equities have historically maintained a consistently lower volatility profile than the broader investment universe. This lower volatility profile is maintained even during periods of crisis. Low-volatility equities also take advantage of the market-cap

weighted nature of popular indices—which tilts toward a few large-cap names—to increase the diversification benefit further. Exhibit 10 illustrates how the S&P 500 Low Volatility Index has a favorable risk/return profile, obtaining returns commensurate with the S&P 500 Index and maintains more bond-like volatility features.

Conclusion

While there are myriad approaches to insuring a portfolio against rising volatility, empirical evidence suggests that over the long term, sellers of portfolio insurance (via derivatives) profit at the cost of buyers of portfolio insurance. Due to the negative expected return of put options as well as the persistent volatility premium—or positive spread between implied and realized volatility—investors that are long portfolio insurance are unable to make up that difference by monetizing rising volatility in times of crisis over the long term. Importantly, as an investor's time horizon increases, the aggregate cost of hedging increases and at the same time the need for a hedge decreases. The addition of linear hedges is a simpler and more cost-effective approach to mitigating volatility. However, linear hedges lack the asymmetric payoff structure of options as they serve to dampen as much of the upside as the downside risk. This results in more emphasis being placed upon an active manager's ability to generate alpha and less emphasis on beta.

Exhibit 10
Low-Volatility Equities Performance Characteristics



As of 28 June 2013

This information is for illustrative purposes only. Past performance is not a reliable indicator of future results.

Source: Bloomberg

It is our view that a dynamic allocation across the risk spectrum and across asset classes—which includes equities, bonds, as well as low-volatility equities—will accelerate the benefits of time diversification. Due to the persistence of volatility, it is possible to target a range of volatility by taking a dynamic approach and maintaining exposure to securities with positive expected long-term return without the use of portfolio insurance.

Due to the negative correlation between asset returns and volatility, systematically reducing an allocation to securities with lower expected risk-adjusted return in exchange for securities with a higher level of expected risk-adjusted return can enhance the overall return of a balanced portfolio while maintaining a stable range of long-term volatility.

Notes

- 1 Some examples of early use of derivatives include: bartering for perishable items harvested at different times of the year by ancient agricultural societies and shipping contracts in ancient Greece.
- 2 For the period 2 January 1990 to 16 April 2013. Source: Bloomberg.
- 3 Samuelson, Paul A. "Risk and uncertainty: A fallacy of large numbers." *Scientia* 98, no. 4-5 (1963): 108-113.
- 4 For example, the annualized cost on a 10% out-of-the-money put on the S&P 500 Index in November 2008 reached approximately 58% of the notional value, compared to an average of 5% evaluated for the period 10 January 2005 to 17 May 2013. Source: Bloomberg.
- 5 Baker, Malcolm, Brendan Bailey, and Jeffrey Wurgler. "Benchmarks as Limits to Arbitrage: Understanding the Low-Volatility Anomaly." *Financial Analysts Journal*, January/February 2011.

Important Information

Published on 14 September 2017.

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An investment in bonds carries risk. If interest rates rise, bond prices usually decline. The longer a bond's maturity, the greater the impact a change in interest rates can have on its price. If you do not hold a bond until maturity, you may experience a gain or loss when you sell. Bonds also carry the risk of default, which is the risk that the issuer is unable to make further income and principal payments. Other risks, including inflation risk, call risk, and pre-payment risk, also apply.

Structured products, derivatives, and other types of unregistered securities are generally not publicly traded. Non-publicly traded financial instruments are not readily disposable; in some cases, an account may be contractually prohibited from disposing of such financial instruments for a specified period of time. An account may be forced to sell its more liquid positions at a disadvantageous time, resulting in a greater percentage of the account consisting of illiquid securities. In addition, market prices, if such exist, for such illiquid financial instruments tend to be volatile, and an account may not be able to sell them when it desires to do so or to realize what it perceives to be fair value in the event of a sale. The sale of illiquid securities also often requires more time and results in higher brokerage charges or dealer discounts and other selling expenses than does the sale of securities eligible for trading on national securities exchanges or in the OTC markets. Furthermore, there may be limited information available about the assets of issuers of the financial instruments, which may make valuation of such financial instruments difficult or uncertain.

The portfolio data presented is that of a hypothetical portfolio and is not that of a portfolio managed by Lazard during the periods shown. The simulated performance presented herein is theoretical and is shown for illustrative purposes only and do not represent actual trading or the impact of material economic and market factors on Lazard's decision-making process for an actual Lazard client account. Simulated performance results were achieved by means of a retroactive application of a model designed with the benefit of hindsight.

BACKTESTED PERFORMANCE RESULTS HAVE MANY INHERENT LIMITATIONS. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. IN FACT, THERE MAY BE SHARP DIFFERENCES BETWEEN BACKTESTED PERFORMANCE RESULTS AND THE ACTUAL RESULTS SUBSEQUENTLY ACHIEVED BY ANY PARTICULAR INVESTMENT PROGRAM. ONE OF THE LIMITATIONS OF BACKTESTED PERFORMANCE RESULTS IS THAT THEY ARE PREPARED WITH THE BENEFIT OF HINDSIGHT. AS A RESULT, THE MODELS THEORETICALLY MAY BE CHANGED FROM TIME TO TIME TO OBTAIN MORE FAVORABLE PERFORMANCE RESULTS. THERE ARE OTHER FACTORS RELATED TO THE MARKETS IN GENERAL OR TO THE IMPLEMENTATION OF ANY SPECIFIC INVESTMENT PROGRAM WHICH CANNOT BE FULLY ACCOUNTED FOR IN THE PREPARATION OF BACKTESTED PERFORMANCE RESULTS AND ALL OF WHICH MAY ADVERSELY AFFECT ACTUAL TRADING RESULTS.

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