

Viewpoint

Russell Research

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AUGUST 2011

Volatility-responsive asset allocation

A stronger link between asset allocation policy and the market environment

Market volatility is itself volatile; markets can be relatively stable at some points in time and explosively volatile at others. This means that the risk associated with a traditional (fixed-weight) strategic asset allocation policy can be highly variable over time. This paper explores the possibility of a dynamic asset allocation policy that varies as market volatility changes. We find that a volatility-responsive asset allocation policy can lead to a more consistent outcome and a better trade-off between risk and return.

Context: Strategic asset allocation is becoming more dynamic

An institutional investor's strategic asset allocation is generally set by an investment committee or another high-level decision-making body. As a result, it is typically reviewed infrequently: no more than once a year. This contrasts with the very dynamic approach that is taken to implementing the investment program once the strategic policy has been set, with full-time specialists (either investment staff or external money managers) continually reviewing and adjusting their parts of the portfolio in response to a constantly changing world.

In recent years, however, strategic asset allocation practices have evolved. The decision remains a high-level decision, but the policy is no longer necessarily a set of fixed weights that are held constant until the next review. Rather, it can be designed to respond to changes in the investor's experience or to changes in market valuations. Examples of such strategies are described in recent Russell Research papers such as "Liability-Responsive Asset Allocation" and "Dynamic LDI with a View", and in other work such as Bill Sharpe's "Adaptive Asset Allocation Policies". Brief summaries of these three papers are provided in Appendix 1.

In this paper, we explore the case for making the strategic asset allocation policy responsive to another sort of change: variations in market volatility.

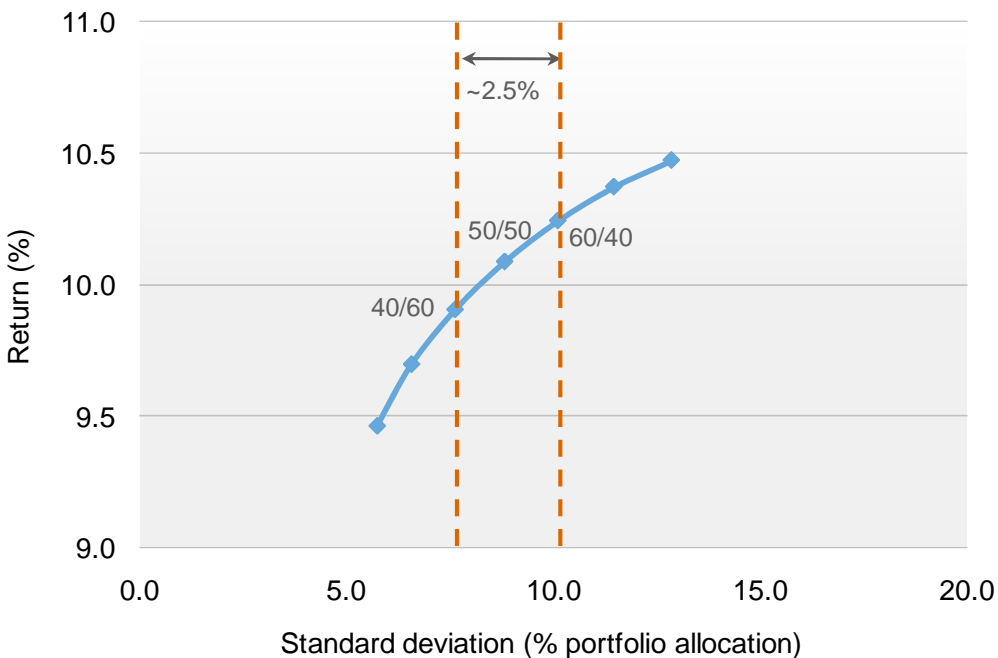
Policy is no longer necessarily a set of fixed weights that are held constant until the next review.

Volatility is itself volatile

The foundation of the strategic asset allocation decision is a trade-off between risk and reward. Reward is often expressed in terms of expected return and risk as the volatility of that around that expected return. Where a different measure of reward is used,¹ volatility remains either the primary measure of risk or a key contributing factor. To manage volatility, therefore, is to manage risk.

Chart 1 shows a typical presentation of this trade-off between equity and fixed income, in this case based on the returns experienced by the Russell 3000® Index and the Barclays Capital U.S. Aggregate Bond Index over the 30 years 1981–2010. The portfolios represented range from 20% to 80% equity.

Chart 1: A 20% reduction in equity allocation reduces risk by about 2.5%
Risk/return frontier (30 years ended 12/31/10)



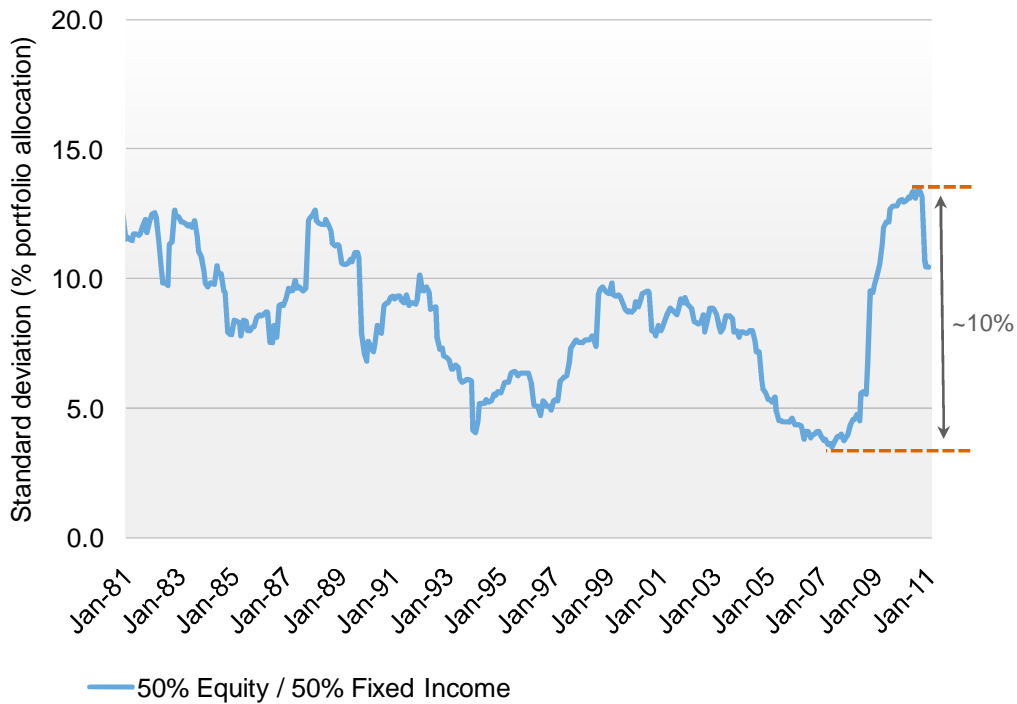
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Note that the difference in risk between candidate portfolios is relatively small. Reducing the equity allocation by 20% reduces the standard deviation of returns by about 2.5%. For example, the difference in standard deviation between a 40/60 portfolio and a 60/40 portfolio is 7.6% compared to 10.1%.

In Chart 2 we see quite another picture when we look at how one of these candidate portfolios – a 50/50 portfolio – behaves over time.

¹ Perhaps based on a pension plan's projected funded status or an endowment's ability to support a targeted level of spending, for example.

Chart 2: The risk experienced by a static 50/50 portfolio varies by almost 10% Annualized standard deviation (rolling 24-month period)



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This illustrates that volatility is itself volatile. While on average the standard deviation has been close to the 8.4% implied by Chart 1, it has varied considerably over time: over 13% at its high and below 4% at other times.² So the variation in the risk of this portfolio is several times greater than the difference between two portfolios whose equity allocations differ by 20% – two portfolios that are quite different from each other. Is it reasonable to expect fiduciaries to stick with a policy portfolio when it starts behaving like a portfolio they rejected in the strategic planning process?

These variations in volatility are extremely important. We find that the most impactful events in a portfolio occur at the extremes – 10 years of well-behaved markets can have less impact on the ultimate success or failure of your portfolio than can a couple of outlier months of extreme returns. And these extremes tend to be marked by high volatility.

Therefore, when volatility is high, the stakes are high. Even if the volatility of volatility is built into the modeling of market behavior,³ a fixed mix will take on a different nature in different market environments. As shown on Chart 2, there are times when a 50/50 portfolio behaves how we would expect a 90/10 portfolio to behave, and at other times it behaves how we'd expect a 100% bond portfolio to. Like the proverbial actuary with his feet in the oven and his head in the fridge (“on average, I’m just right”), fixed weights that deliver the right level of risk on average may be alternately undershooting and overshooting their intended position. This is why it is worth exploring the possibility of using changes in market volatility as the basis for a dynamic strategic asset allocation policy.

Is it reasonable to expect fiduciaries to stick with a policy portfolio when it starts behaving like a portfolio they rejected in the strategic planning process?

² The volatility that is experienced from the portfolio should be expected to vary somewhat just from random fluctuations, even if there is no change in the underlying market environment. The extent of the variation that is observed here is greater than would be expected from random fluctuations alone.

³ This is a feature, for example, of Russell’s strategic forecasting assumptions.

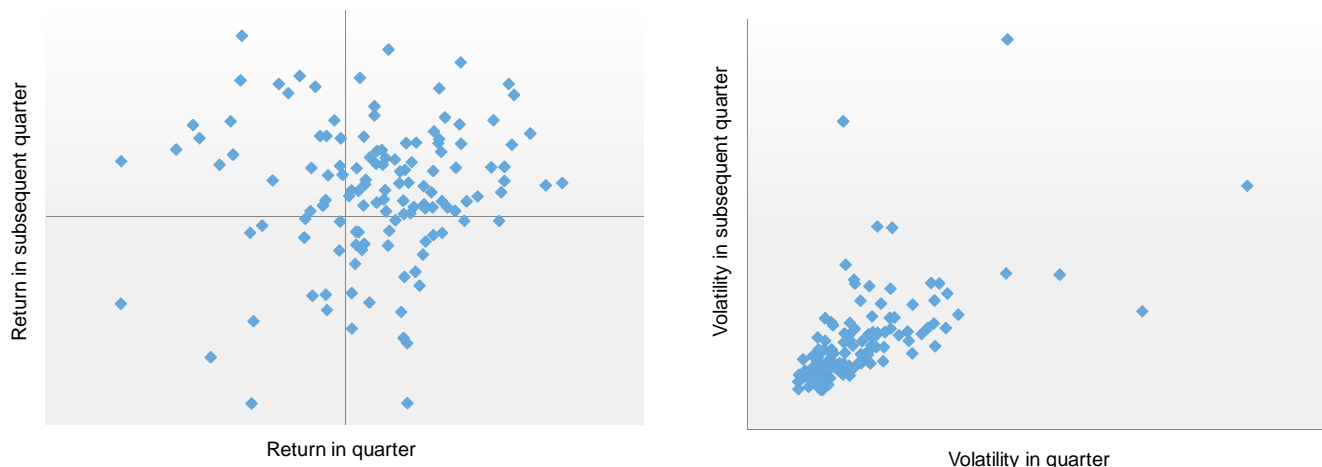
We would note, however, the danger of a policy that is driven by emotional reactions. The reason why volatility of volatility is so problematic is that, all too often, fiduciaries respond to extreme volatility with *ad hoc* changes to their investment strategy. This can mean selling near market bottoms. So a volatility-responsive approach needs to be as systematic and disciplined as any other strategic policy.

Sources of insight into the volatility environment

Volatility is an appealing foundation for a dynamic strategy because, unlike the outlook for returns (which are notoriously difficult to forecast), we can be relatively confident in our assessment of the volatility environment.

One reason for this confidence is that changes in volatility are more persistent than changes in returns. We can see this persistence in volatility (and the absence of persistence in return patterns) in Charts 3 and 4 below.

Charts 3 & 4: Returns in one quarter are no guide to the next... but volatility is



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On the left we see a comparison of returns on the Russell 1000[®] Index in each quarter to those in the following quarter, from the start of 1979 through June 2011. The R^2 of the two data series is just .007, implying that what we have just experienced provides essentially zero information about upcoming returns. On the right, we plot a comparison of the volatility of the daily returns experienced in each quarter with the volatility in the following quarter. Here, we can observe a stronger relationship. In this case, the R^2 is .348, which implies some degree of explanatory power. Additional charts, based on monthly rather than quarterly experience, are included in the appendix⁴.

So even a simple look at recent returns gives us useful insight about the immediate volatility environment. That is not the only source of information. For example, the Chicago Board Options Exchange Market Volatility Index, better known as the VIX, is a measure of the market volatility that is implied by the price of 30-day options to buy or sell the S&P 500 Index.⁵ A comparison of the level of the VIX at the start of each quarter with subsequent volatility implies that the VIX has explanatory power similar to trailing volatility. Being a market-based indicator, it responds instantly to changes in the outlook caused by a shock to

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⁴ The R^2 values for returns and volatility are .005 and .448 for monthly data.

⁵ The VIX is not, strictly speaking, a direct forecast of volatility, but rather a number derived from the demand for (and willingness to supply) options contracts that offer protection against changes in market levels. One feature of the options market is that the implied volatility tends to be higher than that which is actually experienced.

the system. As such it is a useful complementary source of information about the volatility environment, especially if a volatility-responsive asset allocation program were to be based on a daily analysis of the volatility environment, rather than on the monthly approach we describe here.

Likewise, further data on market volatility is available by looking at other markets: bond markets, international markets and so on.⁶ All of these can add to a more complete picture of the market environment. For the purposes of this paper, however, we will keep things simple by using the trailing volatility of the U.S. equity market as the indicator of general market volatility.

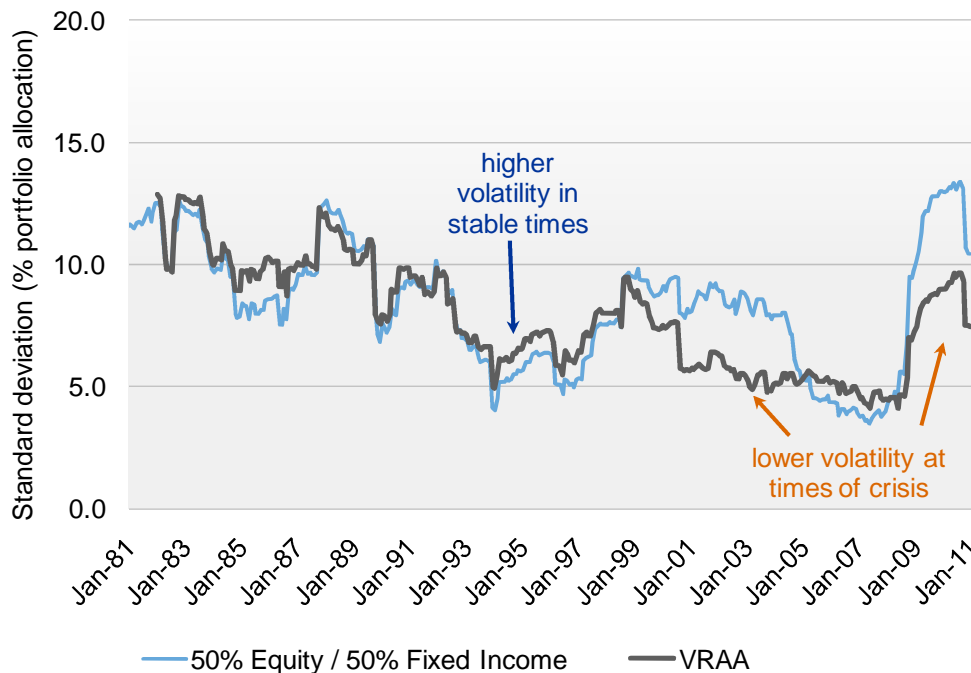
Reducing volatility and improving the risk/return trade-off

The principle that underpins volatility-responsive asset allocation is to reduce exposure to risky assets when volatility is high, and to increase that exposure when volatility is low. This might result in a portfolio that averages, say, 50% exposure to the equity market, but which has more than that at times of market stability and less during volatile markets. Even though the average allocation to the equity market is 50%, the resulting pattern of returns would be different. As we see below, this volatility-responsive portfolio would have been less volatile, on average, than the fixed 50% mix. The portfolio's volatility would also have been more stable.

The principle that underpins volatility-responsive asset allocation is to reduce exposure to risky assets when volatility is high, and to increase that exposure when volatility is low.

Chart 5: The risk experienced by a volatility-responsive portfolio is lower and more stable than that of a fixed-weight portfolio

Annualized standard deviation (rolling 24-month period)



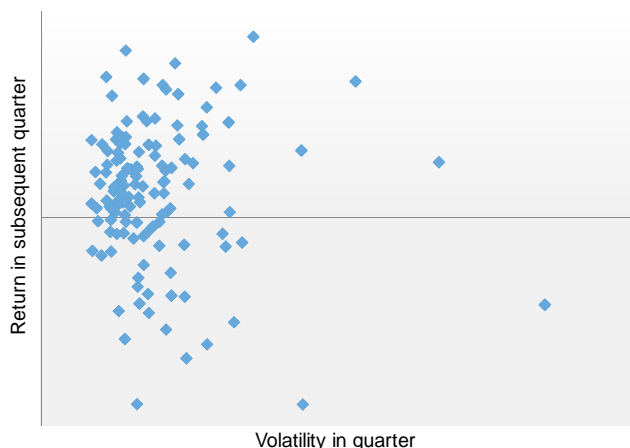
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⁶ The Merrill Lynch Option Volatility Estimate (MOVE) index is a measure of the market volatility that is implied by the price of 30 day options to buy or sell Treasury securities. There are also volatility indices (similar to the VIX) on a number of international markets, although most of these are fairly recent in origin. Clearly, if trailing volatility is being used to gauge the environment, then this is easy to calculate for any significant market.

Chart 5 repeats the analysis in Chart 2, and adds a second strategy. This strategy is a deliberately simplified example of a dynamic approach, one that is invested 30/70 a third of the time, 50/50 a third of the time and 70/30 a third of the time. Which of these three allocations is chosen depends on the trailing 60-day volatility at the start of each month: following high trailing volatility, we adopt the 30/70 allocation; following moderate volatility, the 50/50 allocation; and following low volatility, the 70/30 allocation. We observe that this would have led to a reduction, on average, in volatility (in this case a reduction of about 6%) and, equally important, to a more stable pattern: volatility is no longer as volatile as it was before.

However, this is only half of the story. Asset allocation is not about risk alone, but about the trade-off between risk and expected return. If the rewards for taking risk are highest at the times of high market volatility, then the reduction in volatility shown above would come at too high a price: a drop in returns that more than wipes out the risk benefit. So we need to consider also the relationship between market volatility and expected returns.

Chart 6: Volatility is not a guide to subsequent returns



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In Chart 6, we show analysis similar to that in Charts 3 and 4 earlier, this time comparing volatility in one quarter to returns in the next. There is no obvious connection (R^2 is just .002.)

The simple volatility-responsive strategy described above also points to no obvious return penalty: indeed, it would have delivered a higher return than the fixed 50/50 strategy over the period in question (roughly 17 basis points a year higher).

This question of the risk/return trade-off is, however, critical. The relationship between risk and return is subtle and complex, and we will explore this question in more depth in the next section. We will also look more closely at how a volatility-responsive asset allocation strategy might, in practice, be implemented.

Volatility-responsive asset allocation

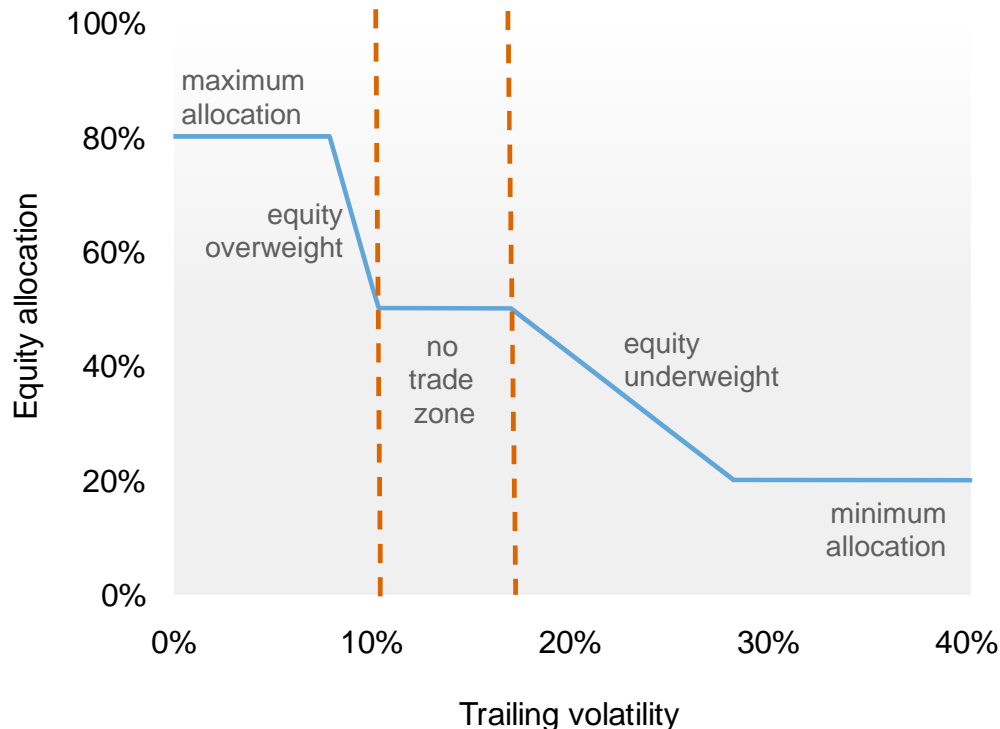
The analysis that follows is based on two assets only: U.S. equity and U.S. fixed income, as represented by the Russell 3000[®] Index and the Barclays Capital U.S. Aggregate Bond Index. It covers the period April 1979–June 2011, the period for which data on the Russell 3000 is available (the data starts at January 1979, and the strategy starts once 60 days' return data is available from which to calculate trailing volatility.)

The simple volatility-responsive strategy described above also points to no obvious return penalty: indeed, it would have delivered a higher return than the fixed 50/50 strategy over the period in question.

At the start of each month, the volatility of the daily equity market returns for the previous 60 trading days is calculated. If that volatility lies in the range 10.3%–16.9%,⁷ then a no-trade zone applies; this level of volatility is not regarded as being unusual enough to merit a deviation from the default asset allocation of 50% equity/50% fixed income. (This range was chosen so that the no-trade zone applies half of the time.)

As volatility rises beyond 16.9%, the allocation to risky assets is decreased. Conversely, as volatility falls below 10.3%, the allocation to risky assets is increased. Graphically, this trading rule is illustrated below.

Chart 7: Allocation to equity at varying levels of market volatility



Note that the size of the no-trade zone, the minimum and maximum allocations to risky assets and the rate at which those minimum and maximum positions are achieved are parameters that can be customized to the specific situation.⁸

The resulting mix between equity and fixed income is shown in Chart 8 below, along with the trailing volatility on which it is based.

⁷ Notwithstanding our argument that volatility varies over time, for presentation purposes here, and in keeping with convention, we have annualized the 60-day volatility by multiplying by SQRT(252).

⁸ For the analysis shown in this paper, the rule applied was, in full:

If trailing volatility is higher than 16.9%, then the equity allocation is reduced according to the formula:

Allocation = 50% - (TrailVol - TrailVol75) / (TrailVol95 - TrailVol75) x 30% (with a minimum allocation of 20%).

If trailing volatility is lower than 10.3%, then the equity allocation is increased according to the formula:

Allocation = 50% + (TrailVol25 - TrailVol) / (TrailVol25 - TrailVol5) x 30% (with a maximum allocation of 80%).

Where:

TrailVol is the 60-day trailing volatility on the Russell 3000 index.

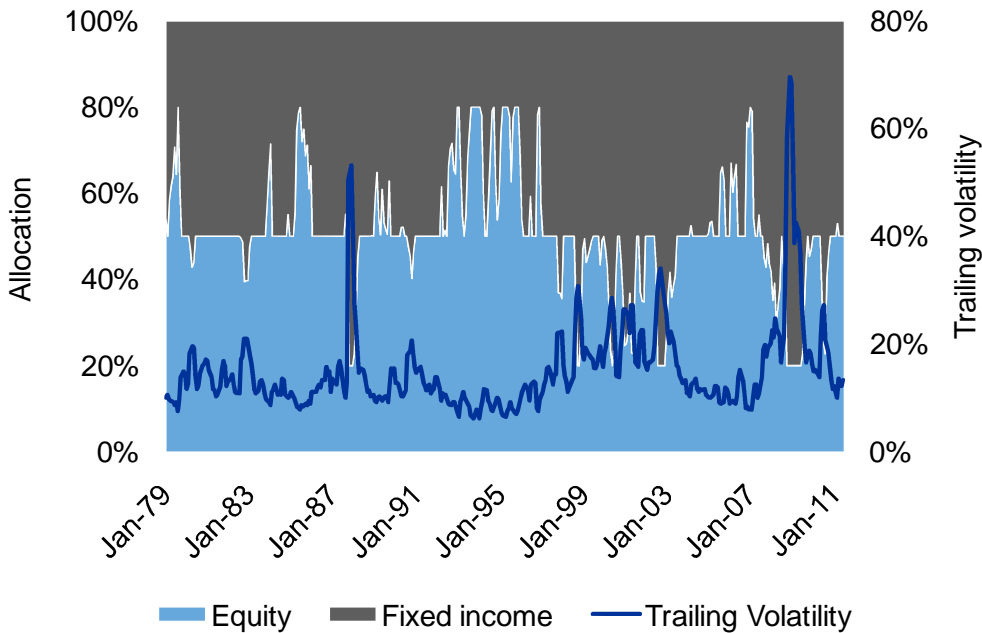
TrailVol95 is the 95th percentile of TrailVol for the historical period and is equal to 28.1%.

TrailVol75 is the 75th percentile of TrailVol for the historical period and is equal to 16.9%.

TrailVol25 is the 25th percentile of TrailVol for the historical period and is equal to 10.3%.

TrailVol5 is the 5th percentile of TrailVol for the historical period and is equal to 7.8%.

Chart 8: Equity/bond allocation under the VRAA strategy
 VRAA when volatility outside range of 25th percentile and 75th percentile



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Just as in the simpler simulation above, the volatility-responsive strategy described here produces lower volatility than the fixed mix, and its volatility is more stable and predictable. And, once again, there was no return penalty over the period analyzed; the volatility-responsive strategy delivered an average 40 basis points higher return after accounting for trading costs.⁹

The results are summarized in the table below, which compares the return pattern of the volatility-responsive strategy to that of a fixed 50/50 mix.

⁹ Assumptions regarding trading costs were based on the average cost of trading and rolling futures contracts and had the effect of reducing the return for the volatility-responsive strategy by an additional 0.6 bps per year compared to the fixed-mix strategy (1.8 basis points versus 1.2 basis points)

Table 1: Summary statistics of volatility-responsive strategy, April 1979– June 2011

	Fixed mix (50% equity)	Volatility-responsive strategy
Annualized return	10.28%	10.68%
Annualized standard deviation	8.99%	8.43%
5%ile monthly return	-3.41%	-3.05%
Worst monthly return	-10.05%	-9.44%
Worst three-month return	-16.86%	-12.16%
Biggest drawdown	-27.25%	-14.48%
Longest drawdown	38 months	33 months
Average equity allocation	50%	50.35%

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Let us consider each of these statistics in turn.

Annualized return: Even allowing for the cost of trading, the volatility-responsive strategy delivered a return over the full period that not only matched but beat that of the fixed mix. We will see below, however, that this can be episodic: there are periods of reduced return as well as periods of enhanced return.

Annualized standard deviation: For the reasons described earlier in this paper, we would expect the volatility-responsive strategy to deliver a more stable return stream than the fixed mix, and this was indeed the case. Note that not only is the standard deviation of returns over the full period lower, but the variability of the standard deviation over short periods is also materially lower, as shown in Chart 10 below.

5%ile monthly return: Roughly one in 20 of the monthly returns were -3.05% or worse under the volatility-responsive strategy, while roughly one in 30 were -3.41% or worse under the fixed mix. Thus, using this as a definition of a bad-case scenario, the volatility-responsive strategy fares slightly better, mitigating downside risk.

Worst monthly return: A more extreme bad-case scenario is provided by a look at the lowest monthly return. For the volatility-responsive strategy, this would have occurred in October 1987, when the portfolio value fell by 9.44%. (As a point of comparison, in that month the fixed-mix value fell by 9.43%.) The worst month for the fixed mix was October 2008, when it fell by 10.05% (By comparison, the volatility-responsive strategy fell by 5.44% that month.)

Worst three-month return: For the volatility-responsive strategy, this was a September through November 1987 decline of 12.16%. (As a point of comparison, over that same period, the 50/50 fixed mix declined by 14.37%.) The worst three-month return for the fixed mix, a loss of 16.86%, occurred in September through November 2008 (By comparison, the volatility-responsive strategy would have declined by 8.77% over that three-month period.)

Biggest drawdown: The drawdown is the loss incurred by the portfolio compared to its previous high. The biggest drawdown for both strategies occurred in February 2009, with the 50/50 strategy posting a 27.25% drawdown and the volatility-responsive strategy posting a 14.48% drawdown. More detail on drawdowns is shown in Chart 9 below.

Longest drawdown (longest period below high water): This statistic measures the length of time from a high-water mark until the strategy regains that high value. The longest such period for the fixed 50/50 mix was September 2000 through October 2003, 38 months in all. In other words, the strategy did not show a positive return relative to a starting point of September 2000 until more than three years later. The longest period below high water for the volatility-responsive strategy was 5 months shorter, at 33 months (also beginning at September 2000.)

Chart 9: Shorter and less severe drawdowns under the volatility-responsive strategy

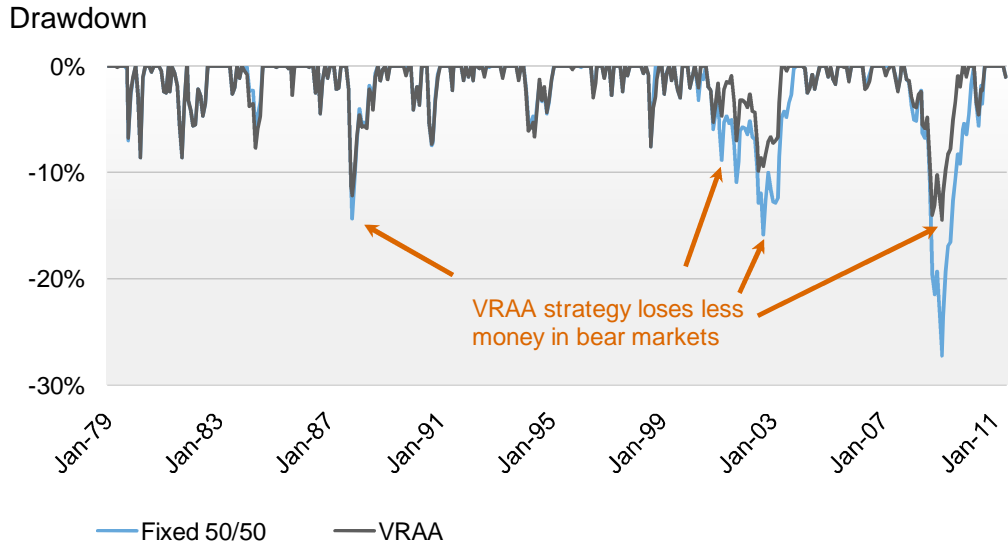
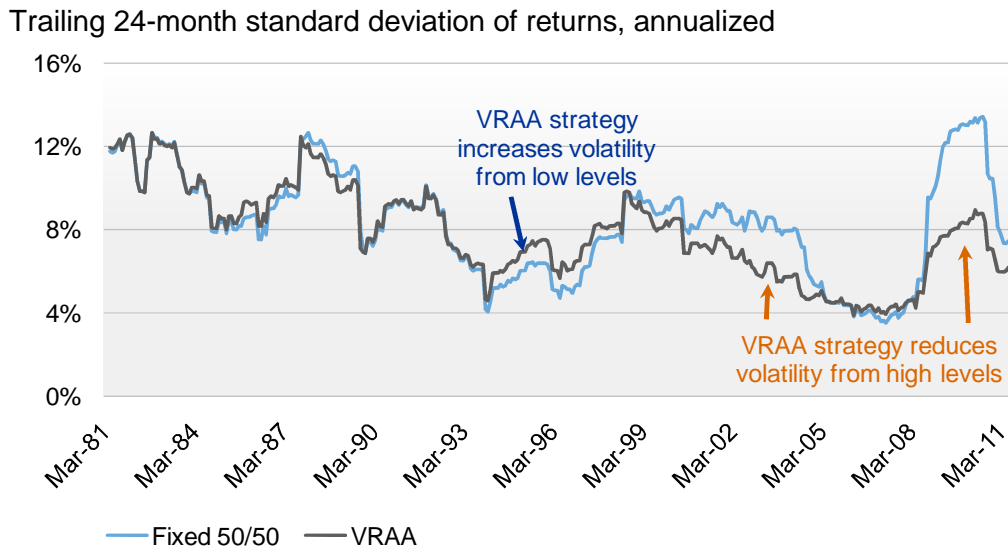


Chart 10: Volatility of returns is more stable under the volatility-responsive strategy



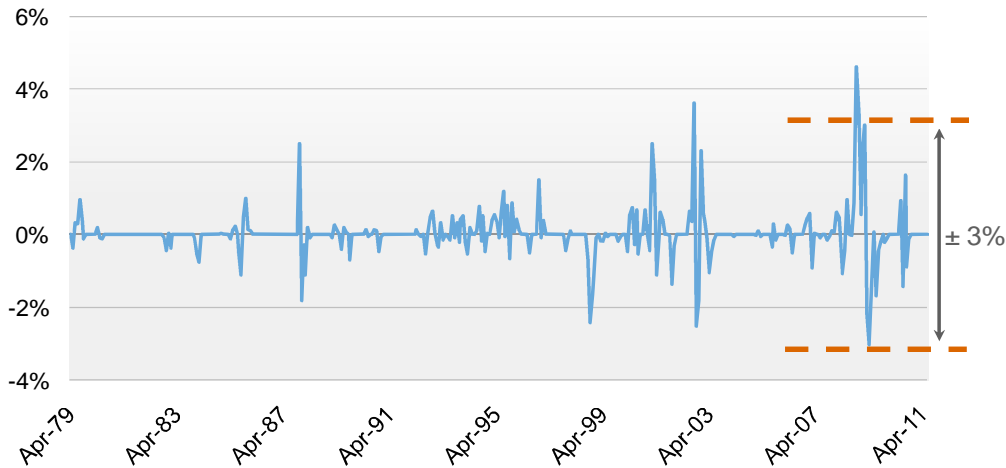
In summary, then, each of the measures points to the volatility-responsive strategy having been effective in reducing and stabilizing risk, without incurring any overall reduction in returns.

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In summary, then, each of the measures points to the volatility-responsive strategy having been effective in reducing and stabilizing risk, without incurring any overall reduction in returns.

As mentioned above, however, these benefits are somewhat episodic, especially with regard to the effect on returns. This can be seen in the chart below, which shows the month-by-month excess return of the volatility-responsive strategy relative to that of the fixed mix.

Chart 11: Difference in returns between volatility-responsive and fixed strategies
Excess of VRAA over fixed 50/50



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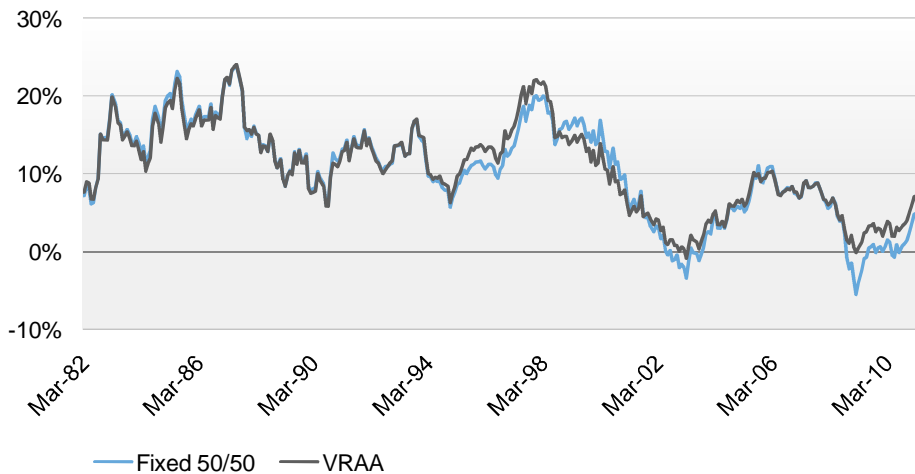
Thus, even though the volatility-responsive strategy would have delivered a better risk/return trade-off, it would also have created tracking error relative to the fixed mix. Thus, if it is judged only on the basis of its impact relative to the default strategy, there will be times when it underperforms. Now, it really makes no more sense to look at the tracking error of the volatility-responsive strategy compared to a fixed mix than it would be to move from, say, a fixed 60/40 mix to a fixed 50/50 mix and then judge the 50/50 mix on its tracking error relative to the higher-risk strategy. It is, however, a comparison that some will make, and it is sensible to be prepared in advance for what that comparison will show.

This highlights the difference between judging a strategy in terms of its absolute return (in which case the overall performance is used to assess risk) and judging it in terms of its relative return (in which case tracking error is used to assess risk.)

This difference in perspective is illustrated in Chart 12 and Chart 13 below.

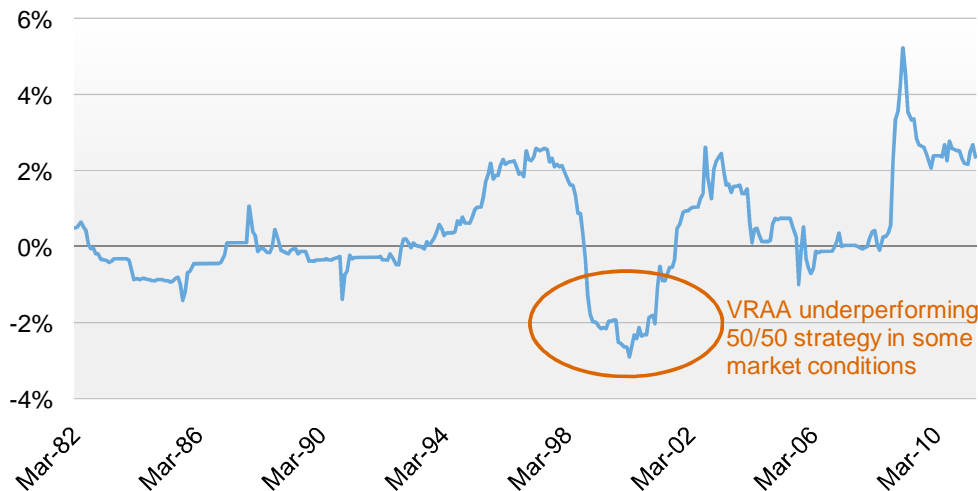
Even though the volatility-responsive strategy would have delivered a better risk/return trade-off, it would also have created tracking error relative to the fixed mix.

Chart 12: Attractive risk and return pattern when measured in absolute terms...
Trailing 36-month returns, annualized



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Chart 13: ...but periods of underperformance if judged in relative terms
Excess of VRAA over fixed 50/50, rolling 36-months, annualized



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Chart 12 shows the rolling three-year returns of the two strategies. It is during times of market decline – notably 2000-2003 and 2008 – that the volatility-responsive strategy would have offered the greatest benefit, with the three-year-average return at no point falling significantly below zero. The return pattern of the volatility-responsive strategy shown in Chart 12 is, for the reasons summarized above, very appealing compared to the fixed mix.

However, if we look only at the relative performance (Chart 13), there were multi-year periods during which the fixed mix did better. So, judged by this yardstick, there were periods when the strategy would have appeared to be ineffective – even though it achieved exactly what we hoped it would in terms of its effect on the overall return pattern. Therefore, those who follow a volatility-responsive strategy need to take care to create the right framework for monitoring its effect. This is, in turn, tied to the objectives and expectations that are set.

An improvement in the risk/return trade-off might mean increased return, it might mean reduced risk or it might mean some combination of the two.

Clear objectives should be set

There is, in fact, more than one way in which a volatility-responsive strategy could be structured. An improvement in the risk/return trade-off might mean increased return, it might mean reduced risk or it might mean some combination of the two. Different objectives can lead to different structures for a volatility-responsive asset allocation program and to different measures being emphasized in monitoring the results.

The analysis above is based on maintaining a similar overall allocation as a given fixed mix: 50/50 in this example. The objective is lower (and more stable) volatility of returns and, in particular, improved results during the worst markets – but with similar average returns over the long term. Against these objectives, monitoring would focus both on key risk measures (such as those shown in Table 1) and on returns.

It would, however, be possible to change the emphasis of the program from risk reduction to return enhancement. This would involve targeting a higher return, subject to similar levels of volatility and downside risk. For example, in the analysis above the volatility-responsive strategy had a standard deviation of returns similar to that of a 45/55 fixed mix. Compared to that mix, the volatility-responsive strategy is now aiming for higher returns at similar

levels of risk. The excess return of the strategy over the 45/55 fixed alternative would now become a more significant metric.¹⁰

Another possibility is to focus on the downside-protection aspect of the strategy. Here, the investor would want a reduced exposure to risky assets when the environment is unusually volatile, but would not target a higher exposure during unusually stable times. This would lead to a one-sided version of the strategy described earlier, with different return characteristics. In this case, the investor might be willing to accept a reduced return on average from the strategy – with downside protection being paid for, in effect, by a premium manifested in losses when markets are volatile but rising.¹¹ The results under this one-sided approach are shown in Appendix 3.

Conclusion

In summary, the use of fixed weights in strategic asset allocation policy does not result in a stable risk/return pattern over time, but rather leads to greater risk at times of high market volatility and to lower risk in unusually stable markets. For investors who are sensitive to volatility, a more consistent outcome can be achieved – both in terms of the volatility of returns and in terms of how volatile that volatility itself is – by adopting a dynamic, or volatility-responsive, approach.

An early version of the analysis of the effect of variations in volatility over time (under the working title “Ambient Risk Allocation”) was performed by Marco Diolosa. Significant contributions to the development of this idea were also made by Greg Nordquist.

¹⁰ The return on the 45/55 fixed mix over the period of analysis was 10.13%, which the volatility-responsive strategy beat by 0.55% a year on average. Annualized standard deviation was, by construction, similar between the two strategies. Against the other risk measures shown in Table 1, the volatility-responsive strategy was generally superior.

¹¹ We should note, however, that over the period tested the one-sided volatility-responsive strategy actually outperformed the 50/50 fixed mix by 15 basis points a year – slightly less than half of the outperformance shown by the two-sided strategy.

Appendix 1: Other examples of dynamic asset allocation policy

“Liability-Responsive Asset Allocation”

James Gannon and Bob Collie. *Russell Research*, April 2009.

Strategic asset allocation for defined benefit pension plans has evolved to focus increasingly on surplus management rather than on assets in isolation, and the asset allocation decision now depends more than ever on a plan's funded status. In this paper, the authors note that “if a pension plan decides to allocate 60% of its portfolio to return-seeking assets (such as equities) when its funded status is 70%, but knows that it would have only a 20% allocation if its funded status were 110%, then why would that plan not track its funded status and dynamically adjust the allocation accordingly?”

Liability-responsive asset allocation allows a plan to adopt an appropriate level of equity investment at a particular funded status, while also allowing for automatic adjustment of that strategy if funded status changes materially. The paper notes that the potential benefits of such a strategy are greatest for frozen plans and other plans with low rates of new benefit accruals.

“Adaptive Asset Allocation Policies”

William F. Sharpe. *Financial Analysts Journal*, Vol 66, No. 3, 2010.

Asset allocation policies that call for investing a fixed percentage of a portfolio in each of several asset classes are inherently contrarian in nature in that they require selling assets that have had relatively strong performance and buying others that have performed relatively poorly. As a result, it would be impossible for all investors to follow such policies.

This article proposes an asset allocation policy that adapts to market movements by taking into account changes in the outstanding market values of major asset classes. Under this approach, the asset allocation policy becomes responsive to changes in the investment opportunity set, i.e. the market value of available assets in each asset class.

“Dynamic LDI with a View: Market Timing Is Too Risky. Right?”

Mike Sylvanus. *Russell Research*, March 2011.

This paper examines the effect of a very simple dynamic asset allocation that responds to changes in interest-rate levels and to spreads between corporate bonds and Treasury bonds. It is based on the notion that liability hedging for defined benefit pension plans is more attractive and potentially more important when interest rates and spreads are high and expected to fall, and less important when rates and spreads are low and expected to rise.

While this strategy would have produced strong returns in recent years, probably the more remarkable finding is its impact on risk. When looked at in terms of the stability of the funded status, the dynamic strategy was found to *reduce* volatility. This challenges the commonly held view that market-timing strategies are necessarily risky.

All three of these papers describe asset allocation policies that are dynamic, in that they vary the asset mix in response to changes in some external variable. The variables to which they respond are, respectively: a pension plan's funded status; the market value of available assets; the level of interest rates. A variant on this theme – an asset allocation policy that is responsive to changes in market volatility – is described in the body of this paper.

Appendix 2: Relationship between return patterns from one month to the next

Charts 3a & 4a: Returns in one month are no guide to the next... but volatility is

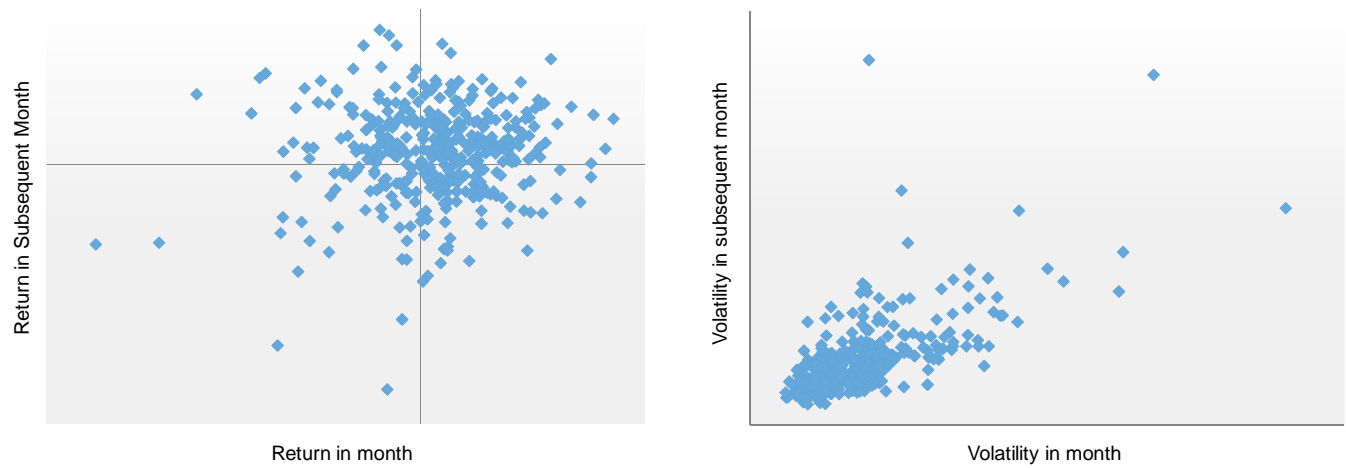
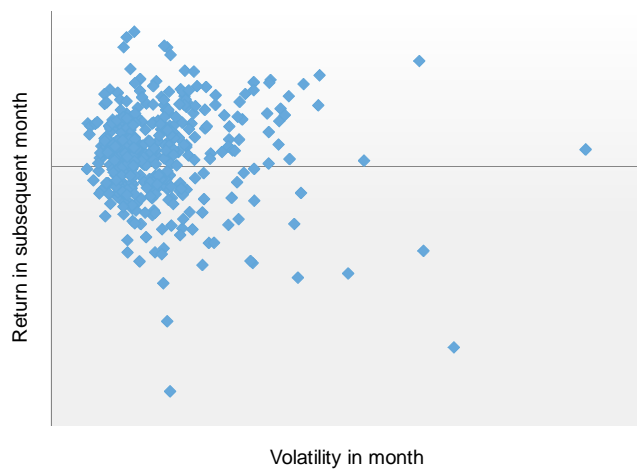


Chart 6a: Volatility is not a guide to subsequent returns



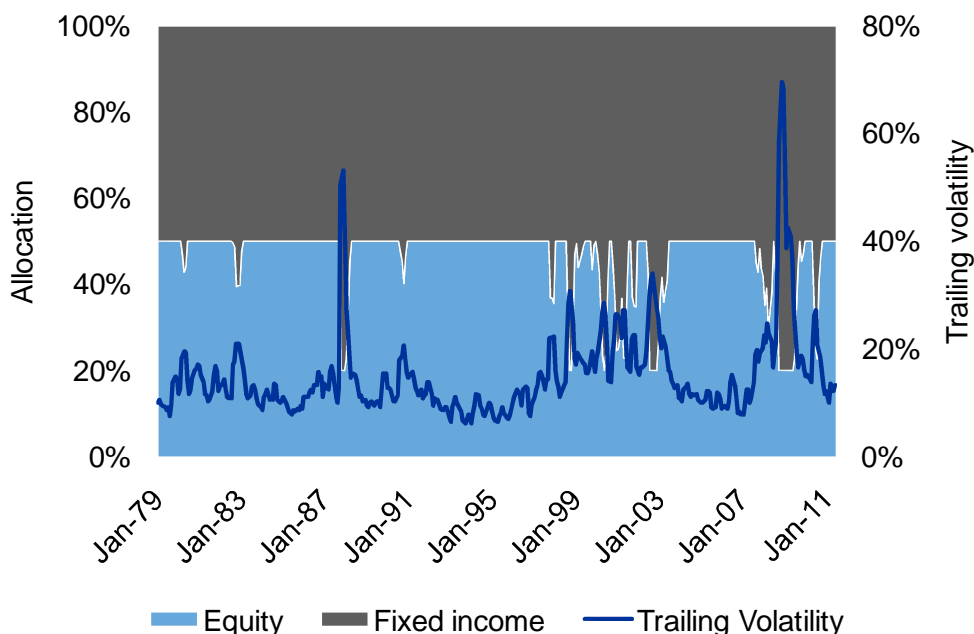
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Appendix 3: One-sided volatility-responsive asset allocation

The analysis below follows the same approach as that set out in the body of this paper, but does not make any adjustment away from the 50/50 fixed mix when trailing volatility is lower than average.

The resulting mix between equity and fixed income is shown in Chart 8a below, along with the trailing volatility on which it is based.

Chart 8a: Equity/bond allocation under the one-sided VRAA strategy
VRAA when volatility outside range of 25th percentile and 75th percentile



The results are summarized in the table below, which compares the return pattern of the volatility-responsive strategy to a fixed 50/50 mix. (Because in practice the volatility-responsive strategy resulted in an average 46% allocation to equity over this period, we also summarize, for completeness, the returns of a 46/54 fixed mix.)

Table 1a: Summary statistics of one-sided volatility-responsive strategy, April 1979–June 2011

	Fixed mix (50% equity)	One-sided volatility-responsive strategy	Fixed mix (46% equity)
Annualized return	10.28%	10.43%	10.16%
Annualized standard deviation	8.99%	8.23%	8.54%
5%ile monthly return	-3.41%	-2.92%	-3.28%
Worst monthly return	-10.05%	-9.44%	-9.47%
Worst three-month return	-16.86%	-12.16%	-15.68%
Biggest drawdown	-27.25%	-14.48%	-25.08%
Longest drawdown	38 months	33 months	37 months
Average equity allocation	50%	46.20%	46.20%

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Chart 9a: Shorter and less severe drawdowns under the volatility-responsive strategy
 Drawdown

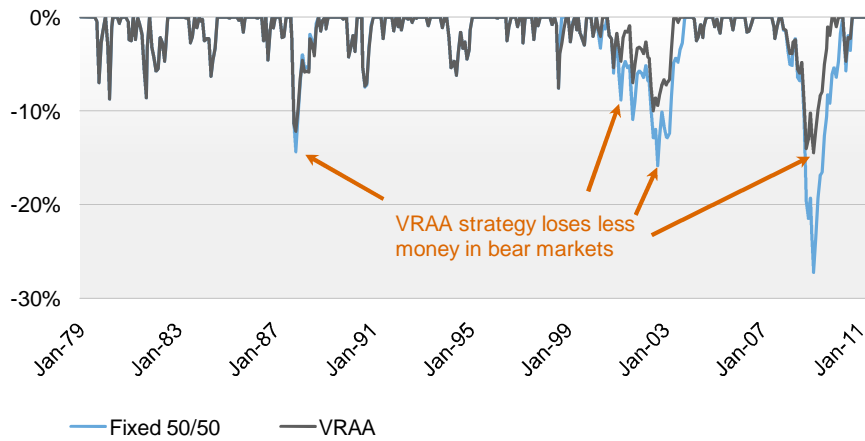


Chart 10a: Volatility of returns is more stable under the volatility-responsive strategy
 Trailing 24-month standard deviation of returns, annualized

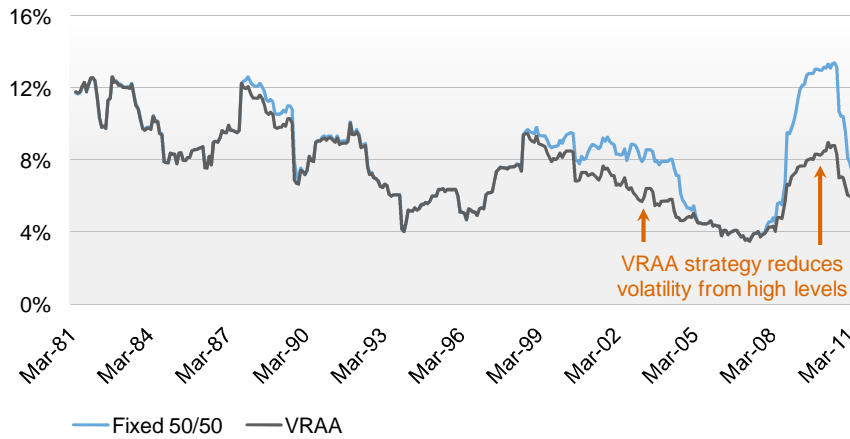
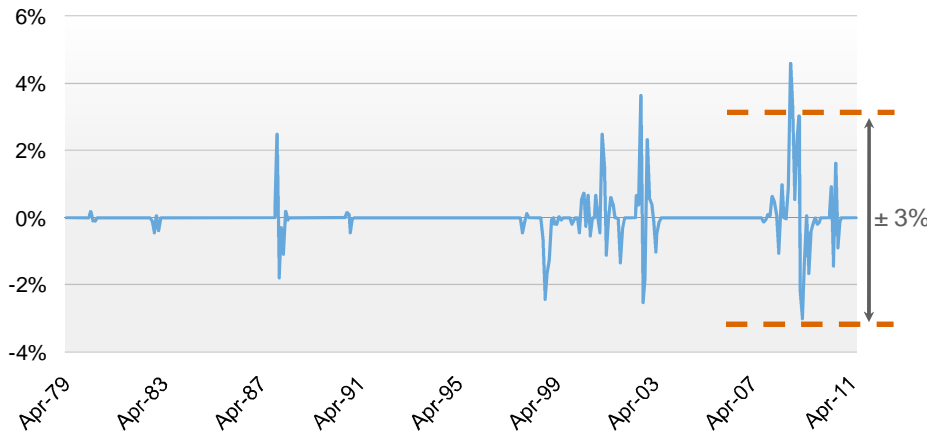


Chart 11a: Difference in returns between one-sided volatility-responsive and fixed strategies
 Excess of VRAA over fixed 50/50



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Chart 12a: Attractive risk and return pattern when measured in absolute terms...
Trailing 36-month returns, annualized

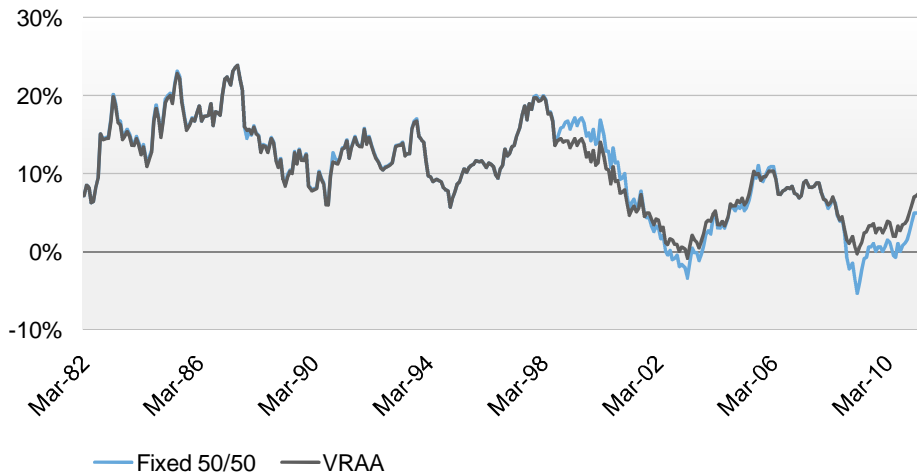
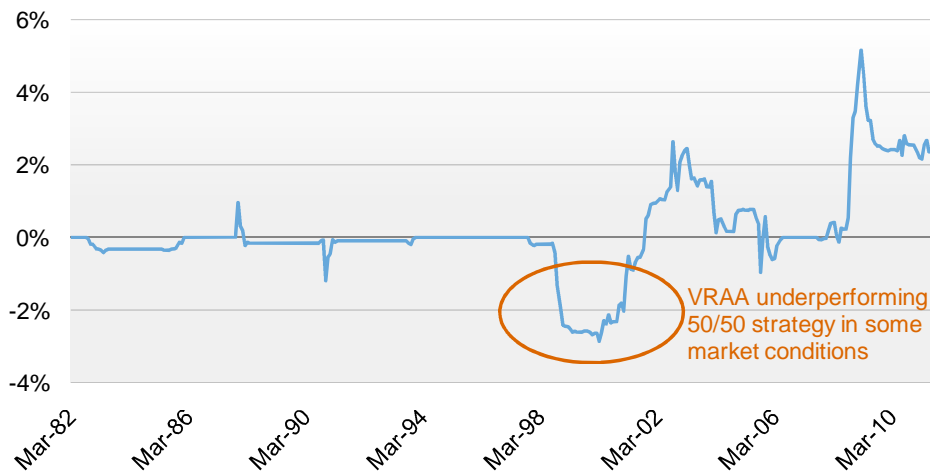


Chart 13a ...but periods of underperformance if judged in relative terms
Excess of VRAA over fixed 50/50, rolling 36-months, annualized



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First used: August 2011

USI-10680-08-13