ReSolve
ASSET MANAGEMENT

YES YOU CAN EAT SHARPE RATIOS

Adam Butler, CFA

Michael Philbrick

Rodrigo Gordillo

Pinocchio: *Am I a real boy?*
The Blue Fairy: *No, Pinocchio. To make Geppetto's wish come true will be entirely up to you.*
Pinocchio: *Up to me?*
The Blue Fairy: *Prove yourself brave, truthful and unselfish, and someday you *will* be a real boy.*

PROLOGUE

Let me be upfront: this paper is going to discuss the performance of ReSolve's strategies. Our Adaptive Asset Allocation and Risk Parity mandates, which we offer to private U.S. investors through our ReSolve Online Advisor, are off to a great start and we're going to bang the drum a bit.

However, in typical ReSolve fashion we are going to weave some points on performance into a broader lesson about how you should think about portfolio construction. Specifically, we are going to challenge the popular investment meme that "You can't eat Sharpe ratio."

WHAT IS THIS SHARPE RATIO YOU SPEAK OF?

The Sharpe ratio was first proposed by Nobel Laureate Bill Sharpe in 1962 in a paper about how to measure mutual fund performance. Sharpe pointed out that a mutual fund's performance should not be judged on total returns in isolation. Rather, investors should be concerned about returns in excess of what might have been earned without taking any risk, by investing in Treasury bills. In addition, Sharpe suggested that excess returns are only relevant in the context of how much risk the fund manager undertook to generate the returns. Consistent with these assertions, the ratio is calculated as the excess return of an investment above risk-free T-bill yields ($E(R) - R_f$) divided by the standard deviation of the excess returns (σ)

Sharpe's original paper was narrow in scope, but he generalized the concept in a 1964 paper entitled "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk". This paper is relevant because it also illustrated a fantastically useful concept; a financial alchemy that ReSolve uses today to turn Sharpe ratio into tangible wealth[1] .

$$SR = \frac{E(R) - R_f}{\sigma}$$

YOU CAN'T EAT SHARPE RATIO!

Consider a portfolio of uncorrelated assets, such as a basket of global equity and bond indexes, gold, commodities, and tradeable real-estate. The goal is to create a portfolio that maximizes available returns without exceeding an investor's tolerance for risk. Equities are expected to deliver higher returns than bonds, but at higher levels of volatility.

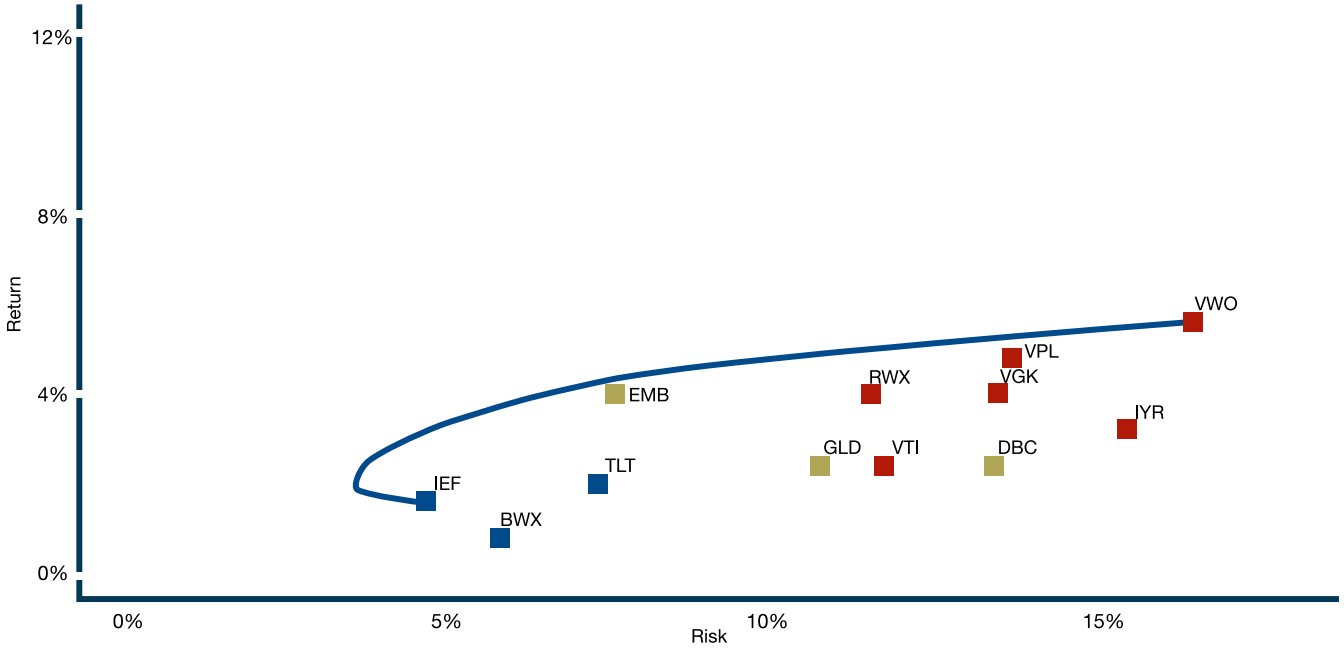
Harry Markowitz contributed the mathematical tools to determine the mix of assets that would be expected to produce the highest returns at each level of volatility, after accounting for the diversification properties of portfolios. When we plot this function it is called the Efficient Frontier.

1 Sharpe had a lot of help along the way from Harry Markowitz, James Tobin and others, but Sharpe put all the pieces together.

Each increment on the frontier is associated with a portfolio that maximizes the available return at that particular level of volatility. We plot an illustrative frontier in navy blue in Figure 1, with the expected risk-return character of individual assets plotted in light blue squares.

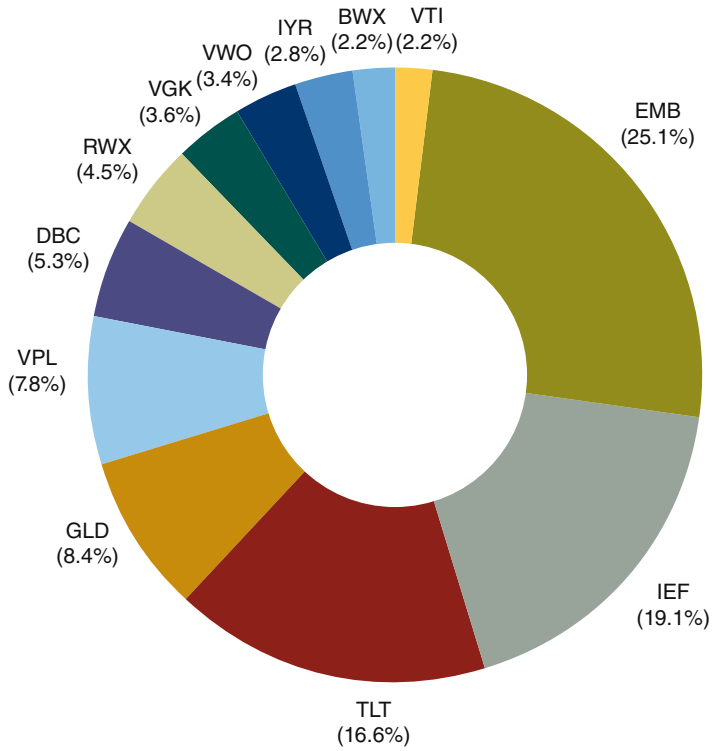
BWX - Int'l Treasury Bonds	DBC - Commodities	EMB – Emerging Bonds
GLD – Gold	IEF – Treasuries	IYR – US REITs
RWX – Int'l REITs	TLT – Long Treasuries	VGK – European Stocks
VPL – Asian Stocks	VTI – US Stocks	VWO – Emerging Stocks

Figure 1. Efficient frontier



Source: ReSolve Asset Management. For illustrative purposes only. See details in the Appendix.

Figure 2. Maximum Sharpe Ratio portfolio.



Source: ReSolve Asset Management. For illustrative purposes only. See details in the Appendix.

All things equal, investors will prefer to own the portfolio that is expected to produce the maximum "bang for their buck", which translates to maximum return for risk. In other words, they want to maximize their returns above safe cash with minimal extra volatility. The portfolio that maximizes this objective is the maximum Sharpe ratio portfolio. We highlight the holdings associated with this portfolio in a ring chart. The portfolio is dominated by 26% in emerging government bonds (EMB) and 35% in intermediate and long-term Treasury bonds. Many investors might find this portfolio to be strange and uncomfortable. They might also note that such a large allocation to bonds implies only modest returns. Nevertheless - all things equal - a portfolio with this constitution would be expected to produce the highest return per unit of risk.

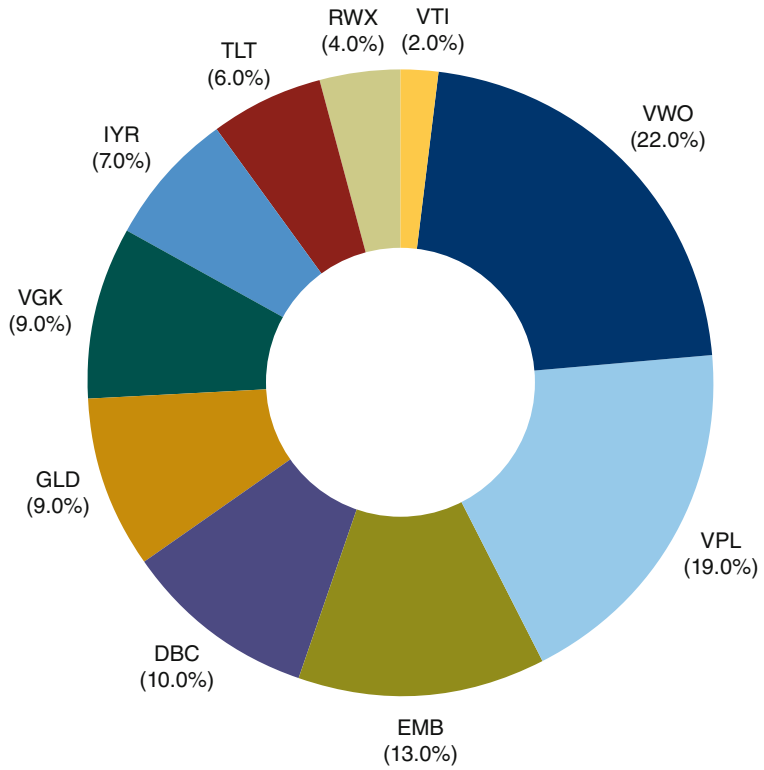
PORTFOLIO OPTIMIZATION IN PRACTICE: A CASE STUDY

But things are rarely "equal". More often, investors require a certain minimum return to achieve financial targets such as regular portfolio income in retirement, or sustainable distributions for pensions and other institutions. And this is where things get interesting.

Consider a foundation charged with 3% per year in annual distributions above inflation, where inflation is expected to be 2% per year. As such, the board of the foundation sets a target return of 5% per year. The investment committee analyzes the available investment options and generates forecasts of expected returns, volatilities, and correlations. They then proceed to create the efficient frontier in Figure 1. They discover that the most efficient – maximum Sharpe ratio – portfolio generates an expected nominal return of 3.8% at a volatility of 6.7%. However, they need to create a portfolio that generates a 5% nominal return to meet the obligations of the foundation. What should they do?

The investment committee has two fundamental options. Typically, the committee seeks out the portfolio on the efficient frontier that is expected to produce a minimum 5% return over the long-term, with minimal volatility. This portfolio is shown in Figure 3, created using the same assumptions we used in Figures 1 and 2. Note that this portfolio is expected to produce a 5% nominal return, but with 13.4% volatility. It contains 35% in emerging market stocks and bonds (VWO + EMB), 19% in Asia Pacific stocks, 19% in commodities and gold, and just 27% in a basket of other equity and bond markets. (Note: see Appendix for optimization details)

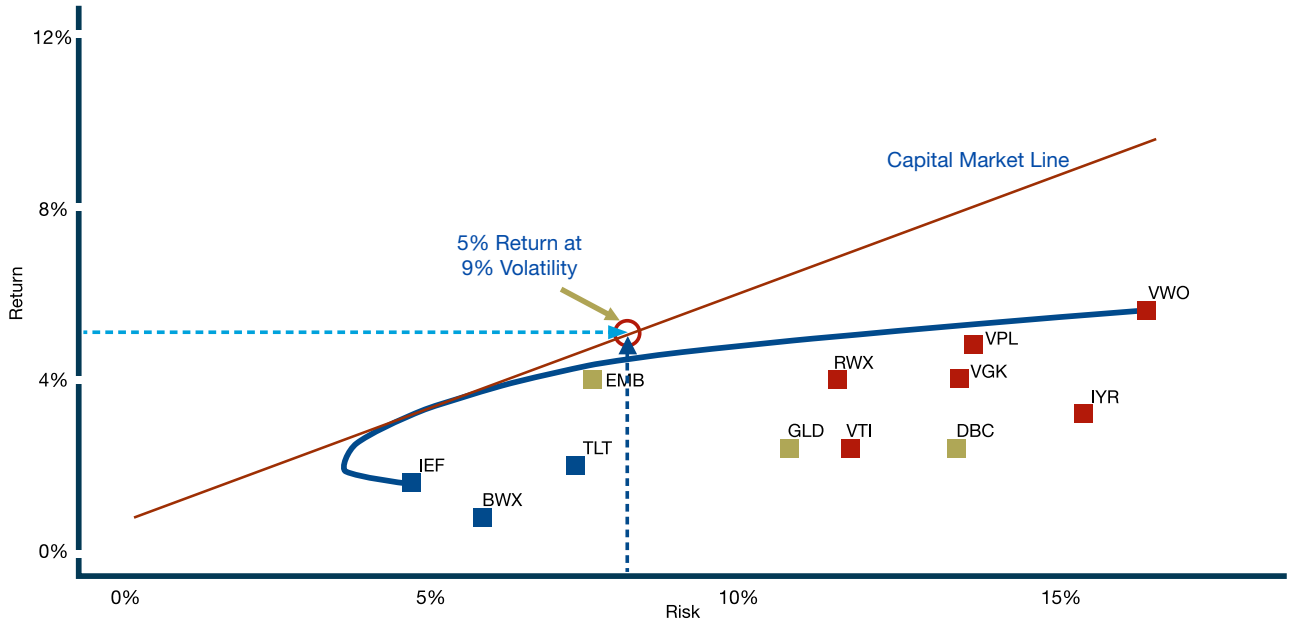
Figure 3. Most efficient portfolio given a minimum 5% nominal expected return.



Source: ReSolve Asset Management. For illustrative purposes only. See details in the Appendix.

However, the committee has another option, which takes advantage of the "fantastically useful concept" referenced above. Tobin and Sharpe discovered that, when an investor can invest in a risk-free asset like Treasury bills in addition to risky assets like stocks and bonds, the shape of the frontier collapses from a curve to a straight line. This is the concept of the Capital Market Line (CML). As illustrated in Figure 4, the CML connects the return available from the risk-free asset with zero volatility (a point on the y-axis of the chart) with the maximum Sharpe ratio portfolio on the efficient frontier. We assumed a 1% T-bill yield for this illustration.

Figure 4. Efficient frontier with Capital Market Line



Source: ReSolve Asset Management. For illustrative purposes only. See details in the Appendix.

The CML opens the door to a second option that the foundation can pursue to achieve its 5% target return. Now, the foundation can borrow and lend at the rate of the risk-free asset to scale exposure to the maximum Sharpe ratio portfolio along the CML to achieve any desired balance of risk and return. By borrowing 40% of the value of the portfolio at a risk-free rate of 1%, the foundation can invest 140% in the maximum Sharpe ratio portfolio to achieve the same 5% target return, but with just 9% volatility. In other words, this portfolio achieves the foundation's objectives with 35% less risk.

HITTING A MOVING VOLATILITY TARGET

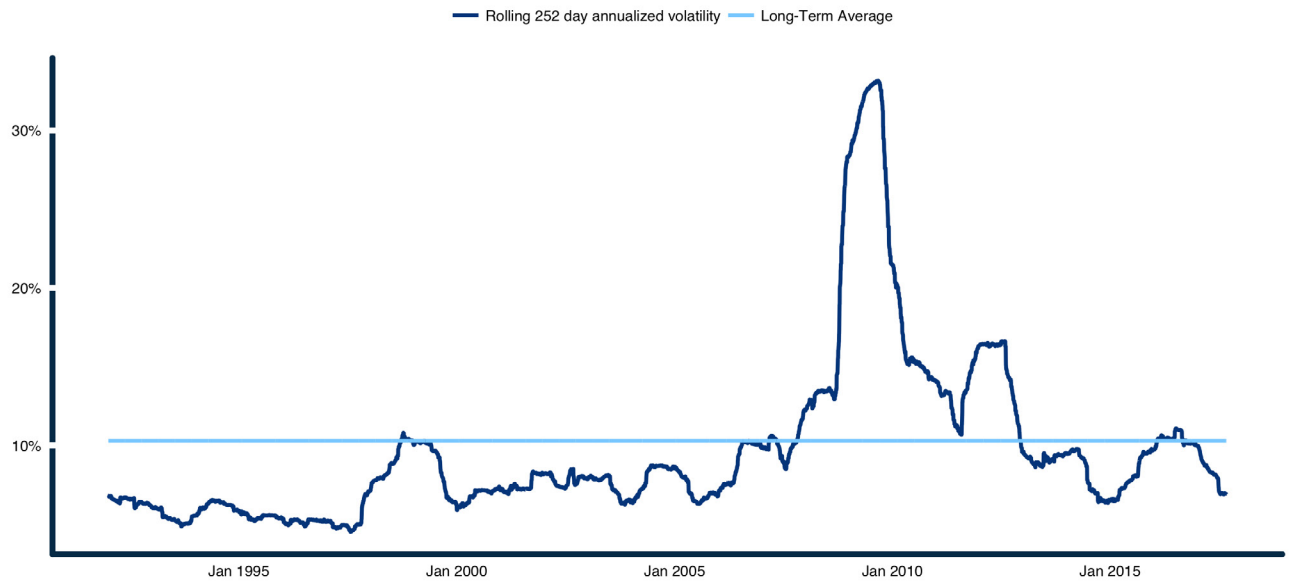
In the example above we discussed a foundation seeking to construct a policy portfolio allocation to meet their specific investment objectives. The idea was to set a strategic portfolio based on long-term average expected asset behaviour. Since this approach implies that the foundation will hold this specific allocation for the long-term, we can infer one of two basic assumptions:

1. Either the foundation assumes that assets always behave in ways that are consistent with their long-term average behaviour, or;

2. the foundation assumes it can't adapt over time in response to changes in asset class behaviour. In any case, the foundation has decided to set a fixed asset allocation and let risk happen.

It is worthwhile examining whether these assumptions are valid. To examine the first assumption, let's observe the behaviour of a representative portfolio through time. Specifically, Figure 5 shows the rolling 1-year daily volatility of a global balanced portfolio over the 26 years from 1991 – 2017. The long-term average annualized volatility of the portfolio is about 10% (light-blue line). However, the volatility experienced by investors in the portfolio ranged from 3% in 1996 to 33% in the depths of the 2008 financial crisis.

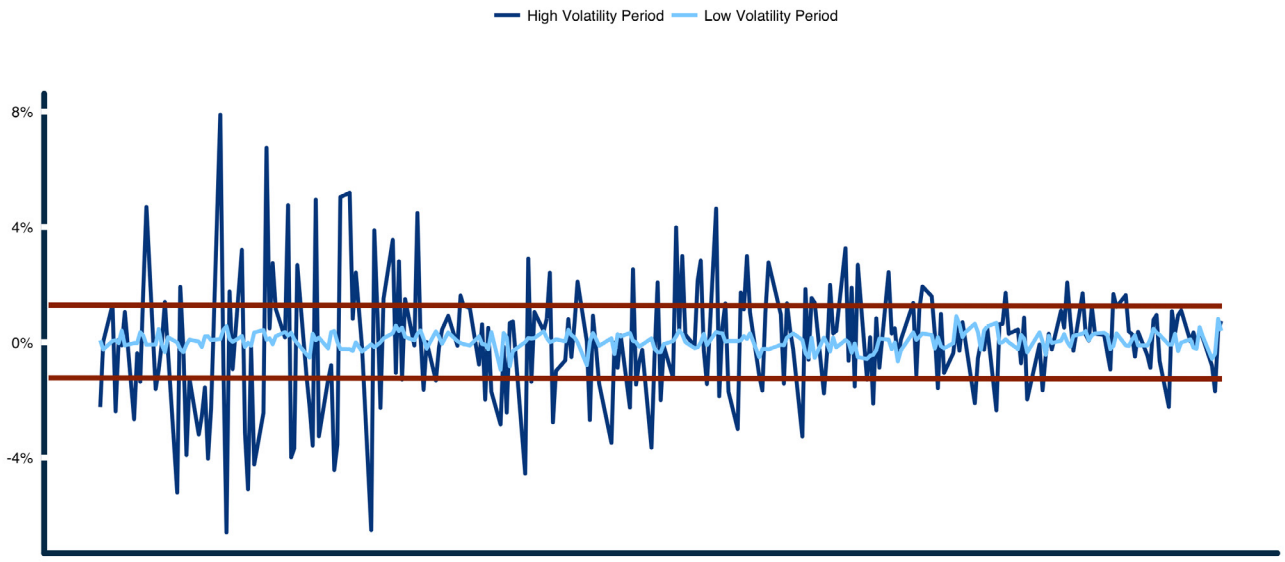
Figure 5. Rolling 252-day rolling annualized volatility of a global balanced portfolio, 1991 - 2017



Source: ReSolve Asset Management. For illustrative purposes only. See details in the Appendix.

An investor who signed up for a 10% volatility experience over the long-term is likely to be rather traumatized by 33% volatility experience. A portfolio with 10% volatility bounces up and down within a daily range of ±2% about 99% of the time. However, when a portfolio has a volatility of 33% it gyrates wildly, with a range of up to 6% per day! To get a sense for the difference, Figure 6 compares the daily returns of the portfolio during a low volatility period in 1996 to daily returns during the 2008-09 financial crisis.

Figure 6. High volatility vs low volatility daily portfolio returns. Expected 95% range based on 10% expected volatility bounded by red lines.

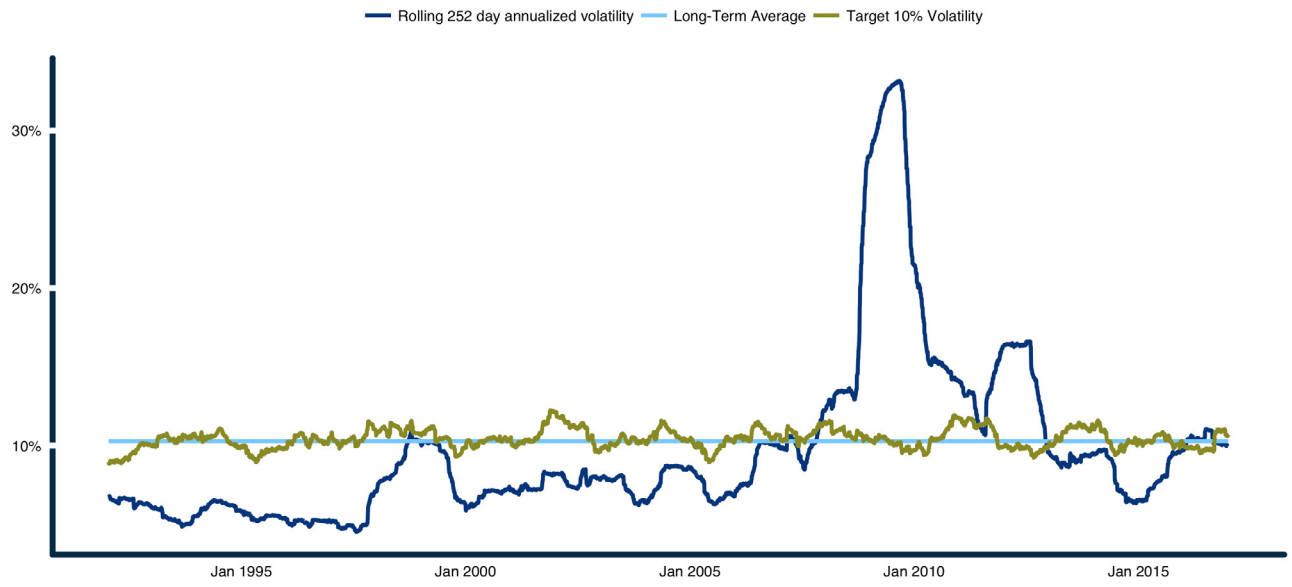


Source: ReSolve Asset Management. For illustrative purposes only. See details in the Appendix.

Recall that the foundation has chosen to deploy a strategic policy portfolio, which implies one of two assumptions about long-term asset behaviour. We can clearly reject the first possible explanation, that “assets always behave in ways that are consistent with their long-term average behaviour.” We now turn to the second potential reason for why our foundation is choosing to deploy a strategic policy portfolio. If the foundation acknowledges that asset often deviate materially from their long-term average behaviour, is it possible to measure asset class behaviour in real-time, and make regular adjustments to the portfolio so that it adapts to changing market conditions?

For consistency, we will continue with our examination of portfolio volatility. Specifically, we will use a well-documented method[2] to measure current portfolio volatility at the end of each month, and adjust exposure to the portfolio higher or lower in the next month to achieve our target volatility. If estimated portfolio volatility is higher than our target we will reduce exposure to the portfolio in the following month, with the balance in cash. If estimated volatility is lower than our target we will increase exposure to the portfolio in the following month with the use of leverage. Figure 7 describes the results.

Figure 7. Rolling 252-day rolling annualized volatility of a global balanced portfolio vs a target 10% volatility portfolio, 1991 - 2017



Source: ReSolve Asset Management. For illustrative purposes only. See details in the Appendix.

[2] An Exponentially-Weighted Moving Average of covariance with a lambda value of 0.94 consistent with the RiskMetrics 2006 Methodology outlined in this paper.

To interpret Figure 7 note that the navy-blue line tracks the rolling 252-day annualized volatility of the global balanced portfolio; the light-blue line shows the long-term average volatility of the portfolio, and; the gold line shows the rolling 252-day volatility of a strategy that adjusts exposure to the portfolio to maintain a 10% volatility based on a well-known approach. It's clear that the gold line maintains a narrow range around the target volatility at all times, even when markets are extremely volatile or calm.

The examples in Figures 5, 6 and 7 provide compelling evidence that the foundation's assumptions of stable or unpredictable asset class behaviour over time are false. Rather, asset classes exhibit a large range of behaviours from one year to the next, and it is eminently possible to measure changes in these behaviours and adapt portfolios to changing market conditions. These concepts are the fundamental building blocks of ReSolve's strategies.

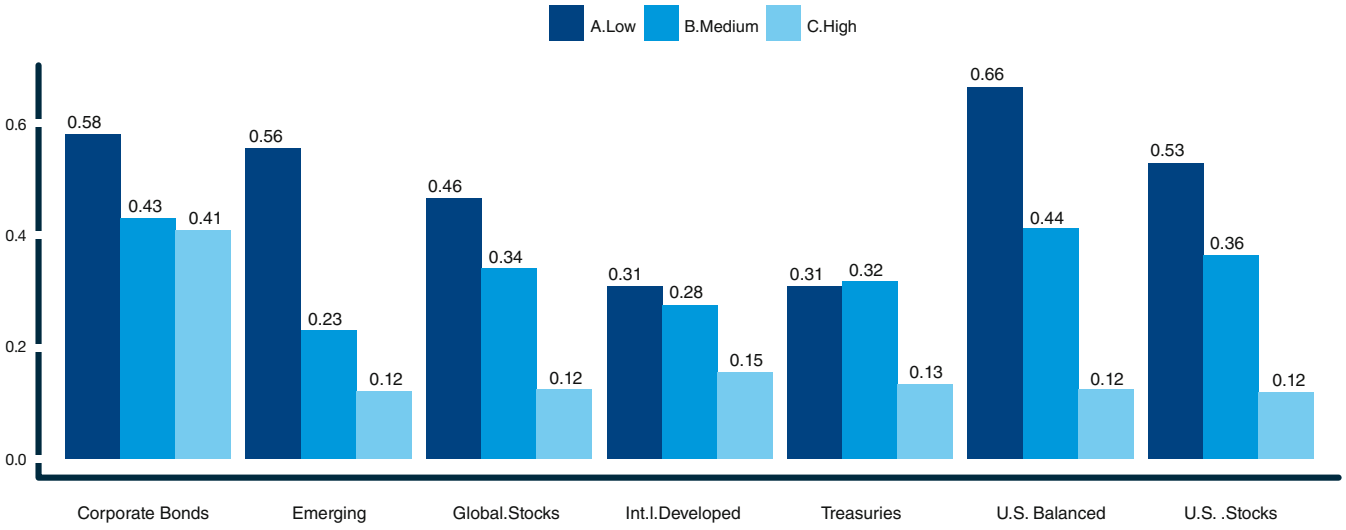
A LOW VOLATILITY BONUS

So far we've shown how to scale a portfolio of low risk assets along the Capital Market Line by employing a little leverage to achieve a range of reasonable return and risk targets. This option is almost always preferable to concentrating the portfolio in riskier assets to achieve the same objective, because it results in similar returns with less risk. We also discussed the idea that market behaviour can change dramatically through time. It's a relatively simple matter to measure and adapt portfolios as markets change to achieve a target portfolio volatility, or other objectives.

To achieve a constant portfolio volatility, you must reduce exposure when risk is high, and increase exposure when risk is low. If you can target volatility with reasonable precision as we saw above, and compound growth expectations are similar when risk is high or low, an investor can achieve superior performance by targeting volatility. But it turns out that the short-term relationship between risk and return is tilted even more in favour of volatility targeting. That's because, as seen

in Figure 8, asset classes produce their best performance when volatility is low, and their worst performance when volatility is high.

Figure 8. Average annualized Sharpe ratios observed in low-, medium- and high-volatility months across asset classes, 1991 - 2017



Source: ReSolve Asset Management. Data from CSI. Daily data is sorted into equal sized buckets of low, medium, and high volatility months. Daily Sharpe ratios represent daily excess returns divided by standard deviation of returns in the month, annualized.

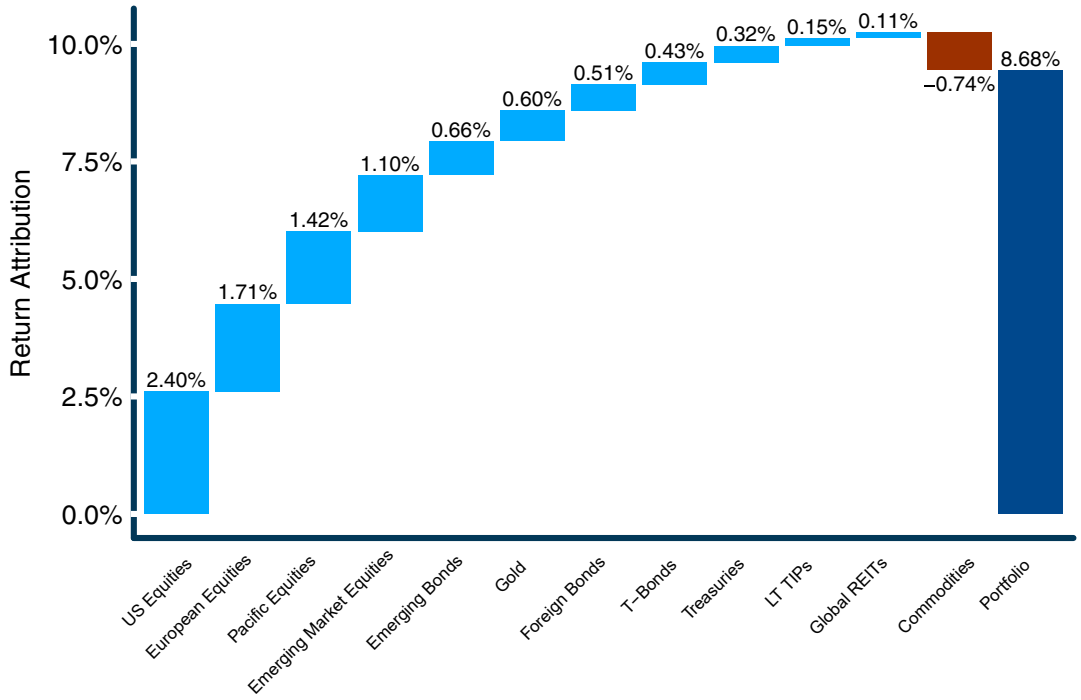
Let's revisit the options that are available to an investor that can tolerate a portfolio with an average long term volatility profile of 10%. He can go down the traditional path and invest in a static balanced portfolio, with the understanding that volatility will run wild at the least prospective times. Alternatively, he can implement a strategy that dynamically manages portfolio exposure to consistently target a 10% portfolio volatility . The strategy would use leverage to seek out high annualized excess returns in low volatility months, but scale back exposure during low returning high volatility months. You can see how this inverted relationship between risk and return presents an incredible opportunity to enhance returns while consistently enjoying the risk that the investor signed up for.

A CURRENT EXAMPLE

To review, we've examined the options available to investors who are seeking higher returns from their portfolio. We demonstrated that it is possible to generate higher returns with the same risk, or similar returns with less risk, by levering diversified portfolios rather than concentrating portfolios in higher returning equities. Leverage allows us to target a higher level of portfolio volatility, with commensurately higher expected returns. Let's examine how this theoretical construct works in real life using a current example.

The ReSolve Global Risk Parity Strategy is designed to create the most diversified portfolio possible from the world's major asset classes, including regional equity and government bond markets, and diversified commodities. It also benefits from a proprietary trend overlay that incrementally reduces risk exposure to assets in persistent negative trends. Figure 9 shows the assets held in the portfolio from January 1st through August 31 2017, and the total return that each asset has contributed to the portfolio. Note that the strategy held 13 different assets in the portfolio over this period, which collectively produced 8.68% cumulative growth.

Figure 9. Return attribution for ReSolve Global Risk Parity 6% USD Composite, January 1 – August 30 2017



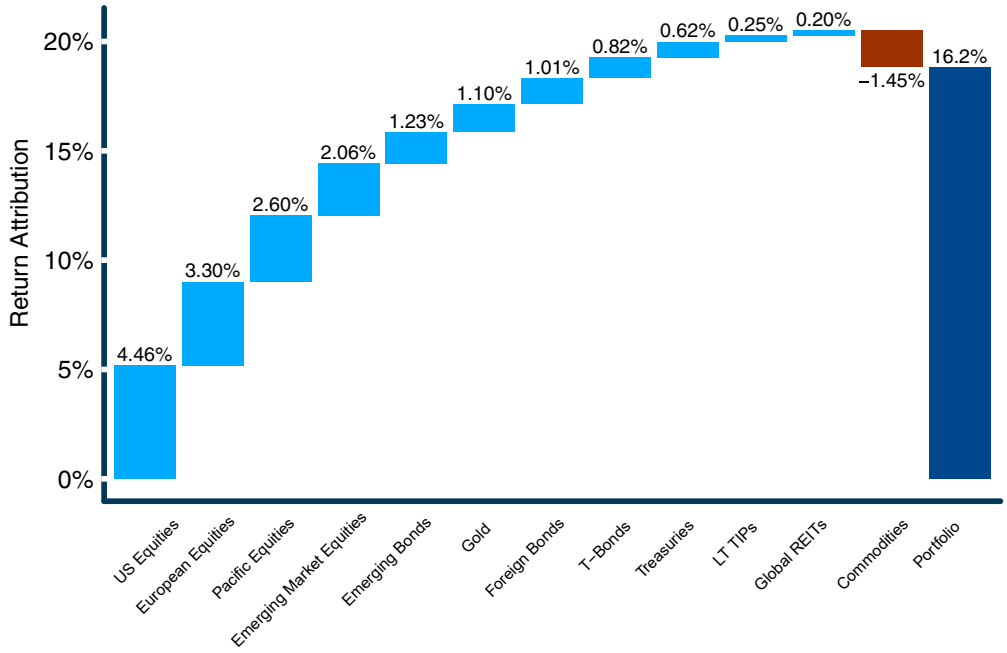
Source: The performance data above represents the performance composite of all ReSolve Global Risk Parity: 6% Volatility (USD) mandates managed by ReSolve Asset Management Inc. Indicated returns of one year or more are annualized. Past performance is not indicative of future performance.

This portfolio accrued most of its returns from holding a diversified basket of global equities. However, by also holding bonds and commodities, the portfolio is more diversified, which means it was positioned to benefit from a wider variety of outcomes, including ones that would not have been favourable for equities. It also had lower volatility than a pure equity portfolio.

Admittedly, this diversified portfolio did not achieve the same returns as a pure global equity portfolio, which gained 15.46%. But investors in the pure equity portfolio also accepted the risks of this portfolio. These risks include a maximum preak-to-trough loss of over 50% in the last decade, and a peak-to-trough loss of over 80% in the Great Depression. Moreover, it is possible for an investor in the diversified portfolio to achieve even better returns than the pure global equity portfolio by using the risk targeting techniques described in Figure 3. By simply borrowing funds to lever up

the portfolio to achieve a higher volatility target, investors in the ReSolve Global Risk Parity 12% Volatility Strategy achieved a 16.2% return.

Figure 10. Return attribution for ReSolve Global Risk Parity 12% USD Composite, January 1 – August 30 2017



Source: The performance data above represents the performance composite of all ReSolve Global Risk Parity: 12% Volatility (USD) mandates managed by ReSolve Asset Management Inc. Indicated returns of one year or more are annualized. Past performance is not indicative of future performance.

This same technique has resulted in even higher returns for some of ReSolves more aggressive and active Adaptive Asset Allocation mandates.

TAKEAWAYS

In summary, most investors seek higher returns by taking on concentrated risk in equities. But equities are fundamentally designed to perform only during periods of benign inflation, positive growth, and abundant liquidity conditions. When these conditions are absent, concentrated equity

investors have historically endured 50% or greater impairments to their wealth. A properly diversified portfolio holds diverse assets in balance such that it is much less vulnerable to unexpected shifts in economic dynamics. An investor who owns a diversified portfolio and uses moderate leverage to achieve a higher target risk has the opportunity to earn higher returns with less risk throughout the economic cycle.

To learn more about ReSolve strategies please visit investresolve.com or email Rodrigo at rodrigo.gordillo@investresolve.com

APPENDIX

Efficient frontiers used in the illustrations were formed by taking the average of 10,000 resampled frontiers. Resampling was based on historical data for covariance estimates, and the expected return values below.

Returns are reasonable guesstimates of 10-year returns based on current yields and valuations, and informed by published capital market expectations from J.P. Morgan, GMO, AQR, and Research Affiliates. ReSolve does not publish capital market expectations. These should not be considered official forecasts, and are for illustrative purposes only.

Expected returns for illustrative optimizations.

BWX	DBC	EMB	GLD	IEF	IYR	RWX	TLT	VGK	VPL	VTI	VWO
1%	3%	5%	3%	2%	4%	5%	2.5%	5%	6%	3%	7%