

T H E J O U R N A L O F

# INVESTING

THEORY & PRACTICE FOR FUND MANAGERS

SPRING 2011 Volume 20 Number 1

## Risk Parity and Diversification

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**RISK** special  
section  
**PARITY**

# Risk Parity and Diversification

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It is often said that diversification is the only free lunch in investing. Is this cliché always true? What do we mean by diversification? What is a “free lunch” in investing? Is it lower risk, higher return, or possibly both?

The following simple example should dispel any doubt about diversification. Suppose we have at our disposal two investments. Investment A doubles in the first year and then promptly drops by half in value in the second year. In contrast, investment B moves in the opposite way: it goes down by 50% in year one and then recovers by 100% in year two. Both investments have gone nowhere individually, after two tumultuous years. However, a 50/50 portfolio with 50% of capital in each would yield a return of 25% in both year one and year two (rebalancing!) without annual return volatility.

While the example demonstrates the magic of diversification, which is in this case amplified by the perfect negative correlation, one should be careful not to conclude that a naïve 50/50 equal allocation is always a good choice. The 50/50 portfolio worked well because the two investments happen to have the identical risk–return profile. Under different circumstances, the results would be less spectacular. To continue with our example, suppose investment B is much less volatile; it only goes down 20% in year one and goes up by 25% in year two, leaving the cumulative

return still at zero. Now, the 50/50 portfolio would return 40% (average of 100% and –20%) in the first year but decline 12.5% (average of –50% and 25%) in the second year. Therefore, even though the naïve 50/50 diversification still leads to a positive cumulative return of 22.5%, it lost the consistency. In financial terms, its risk-adjusted return has worsened.

The key to improving upon capital diversification is risk diversification. Since investment A is much riskier than investment B, to diversify investment risk, one should invest less in A and more in B. For instance, if one invests one quarter of one’s capital in A and the remaining three-quarters in B, then investment risk is much more balanced. How does this 25/75 portfolio compare to the 50/50 portfolio? First, the good news—it offers a more consistently positive return pattern—the returns are 10% in the first year and 6.3% in the second year. The bad news is that its two-year cumulative return is about 17%, lower than that of a 50/50 portfolio.

This is apparently true—a more diversified portfolio loses out to a less diversified portfolio in terms of total return even though its risk-adjusted return is superior. However, a higher risk-adjusted return is not exactly a “free lunch”—investors want high returns and diversification itself does not pay the bills. But one wonders: Is it possible to achieve both superior diversification and higher total returns?

These are indeed the goals of risk parity portfolios. In this article, we first analyze the risk characteristics of traditional 60/40 portfolios and risk parity portfolios. We then highlight the diversification benefits of risk parity portfolios and show why a leveraged risk parity portfolio can achieve both a higher Sharpe ratio and a higher total return. Next, we explore explicitly the difference between the two portfolios. In addition, we show that one can extend the risk parity framework to incorporate active views regarding Sharpe ratios of different asset classes. Throughout the article, we use two asset class portfolios—stocks and bonds—to illustrate the concepts and insights. The analysis and portfolio construction naturally extend to portfolios with more asset classes and portfolios within asset classes. Finally, we summarize and offer some practical perspectives on risk parity.

## TRADITIONAL 60/40 PORTFOLIOS

It is time to bring out the real actors in the investment world. We replace investment A and B in our previous example with stocks and investment-grade bonds, respectively. In general, stocks have higher volatility and higher expected returns while bonds have lower volatility and lower expected returns. For exhibitory clarity, we assume

the annual volatility of stocks to be 15% and the annual volatility of bonds to be 5%. Over the long run, stocks get a positive boost from lower interest rates, resulting in a positive correlation between stocks and bonds, which we assume to be 0.2. A traditional 60/40 portfolio allocates 60% of its capital to stocks and 40% of its capital to bonds and has a total portfolio risk of 9.6%.<sup>1</sup>

From the outset, it should be clear that, based on our previous discussion, a 60/40 portfolio is *against* the spirit of risk diversification—it allocates a higher percentage to higher risk investments (stocks) and a lower percentage to lower risk investments (bonds). The question is why for a long time, many investors have invested and continue to invest this way. We already alluded to the answer in the previous section—the returns.

To bring return into focus, we make Sharpe ratio, or risk-adjusted return, assumptions for stocks and bonds. Over the long term, both asset classes have had positive risk premiums over the risk-free rate and their Sharpe ratios have been reasonably close. We assume both to be 0.35, implying excess returns of stocks and bonds to be 5.25% and 1.75%, respectively. If we assume a cash return of 1% over the next few years,<sup>2</sup> the expected total return for stocks and bonds will be 6.25% and 2.75%, respectively.

## EXHIBIT 1

### Traditional Risk–Return Frontier of Stock/Bond Portfolios

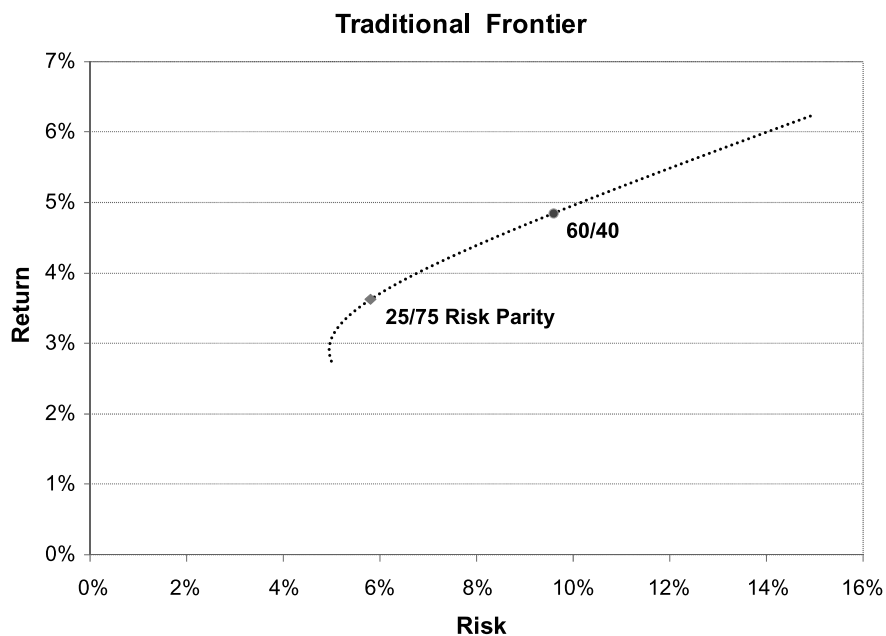


Exhibit 1 plots the traditional risk–return frontier of the two asset classes. The 60/40 portfolio, with annual volatility of 9.6%, has an expected return of 4.85%. While the number itself does not seem impressive, it is significantly higher than that of bonds. When the cash return was higher in a normal environment, a 60/40 portfolio could achieve the 7–8% return required by many pension plans. Therefore, from a return perspective, it is not hard to understand why pension plans have consistently adopted strategic asset allocations that resemble, in their core, a 60/40 portfolio. That is where the returns are. However, a 60/40 portfolio might appear balanced when compared to a 100% equity portfolio; but is it truly diversified?

Exhibit 2 shows the answer is no. Here, we plot Sharpe ratio of the traditional asset allocation versus risk. At both extremes of low and high risk, the Sharpe ratio is 0.35 due to non-diversification. The 60/40 has a Sharpe ratio of 0.40, which is better than the individual Sharpe ratio of stocks and bonds but lower than the optimal Sharpe ratio of 0.45, achieved by a 25/75 “conservative” portfolio. The 25/75 portfolio has lower risk (5.8%) and lower expected return (3.6%). It is in fact a *risk parity* portfolio.

## RISK PARITY PORTFOLIOS

To see why the 25/75 portfolio is risk parity, i.e., the risk contribution from both stocks and bonds are equal, we need to know how to attribute total portfolio risk to its individual components. The calculation could be mathematically complex, but fortunately, for a two-asset portfolio, the attribution is quite simple and intuitive in terms of deriving the percentage contribution to total variance (see Appendix). First, the total variance is composed of variances and twice the covariance. The risk contribution from an asset is equal to the ratio of the sum of its variance and covariance to the total variance.

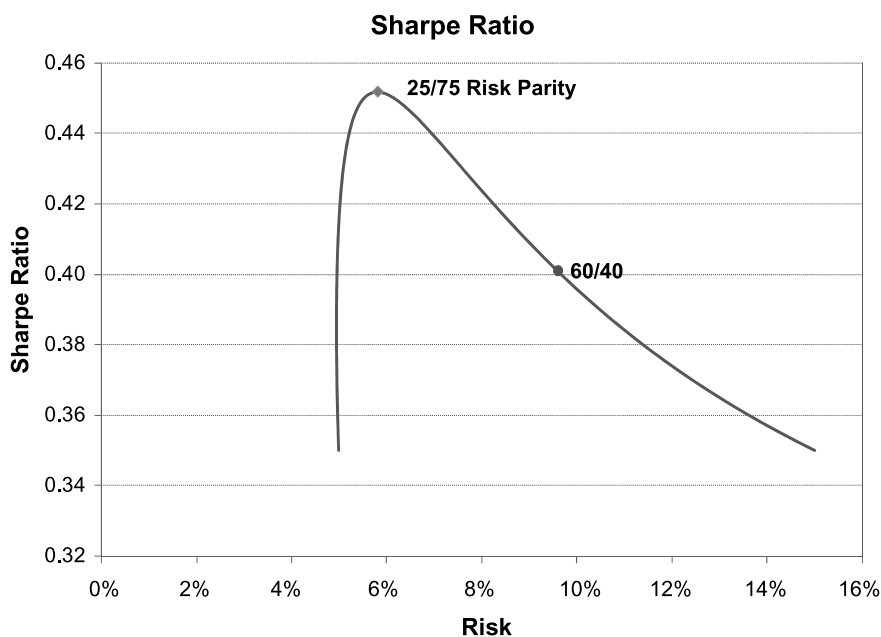
Take the 60/40 portfolio, the risk contribution from stocks is

$$\frac{0.6^2(15\%)^2 + 0.6 \cdot 0.4 \cdot 0.2 \cdot 15\% \cdot 5\%}{0.6^2(15\%)^2 + 0.4^2(5\%)^2 + 2 \cdot 0.6 \cdot 0.4 \cdot 0.2 \cdot 15\% \cdot 5\%} = 92\% \quad (1)$$

Since risk contributions add up to 100%, the remaining 8% of the risk is from bonds. So the 60/40 portfolio is a 92/8 portfolio in risk. On the other hand, the risk contribution from stocks of the 25/75 portfolio is exactly half, since

## EXHIBIT 2

### Sharpe Ratios of Stock/Bond Asset Allocation Portfolios



$$\frac{0.25^2(15\%)^2 + 0.25 \cdot 0.75 \cdot 0.2 \cdot 15\% \cdot 5\%}{0.25^2(15\%)^2 + 0.75^2(5\%)^2 + 2 \cdot 0.25 \cdot 0.75 \cdot 0.2 \cdot 15\% \cdot 5\%} = 50\% \quad (2)$$

In other words, the 25/75 portfolio is a 50/50 portfolio in risk—risk parity.

Inspecting the relative placement of the two portfolios in Exhibits 1 and 2 puts us in the same predicament: The 25/75 risk parity portfolio has the best Sharpe ratio but a lower return while the 60/40 portfolio has a lower Sharpe ratio but a higher return. How does one get the best of both worlds?

The solution is to leverage the *entire* 25/75 portfolio up along the “capital market line,” which passes through both the cash point and the 25/75 portfolio, as illustrated in Exhibit 3. Along this risk parity line, all portfolios are risk parity with the same Sharpe as the 25/75 portfolio. The only variations are the risk—return level and its associated leverage. For example, to achieve risk parity with 9.6% in total risk, the same as the 60/40 portfolio, we lever the 25/75 portfolio by a ratio of 165%<sup>3</sup> (=9.6/5.8). The resulting portfolio has the notional exposure of 41% in stocks and 124% in bonds. Its expected return would be higher than that of 60/40, thus offering both a higher risk-adjusted and a higher total return!

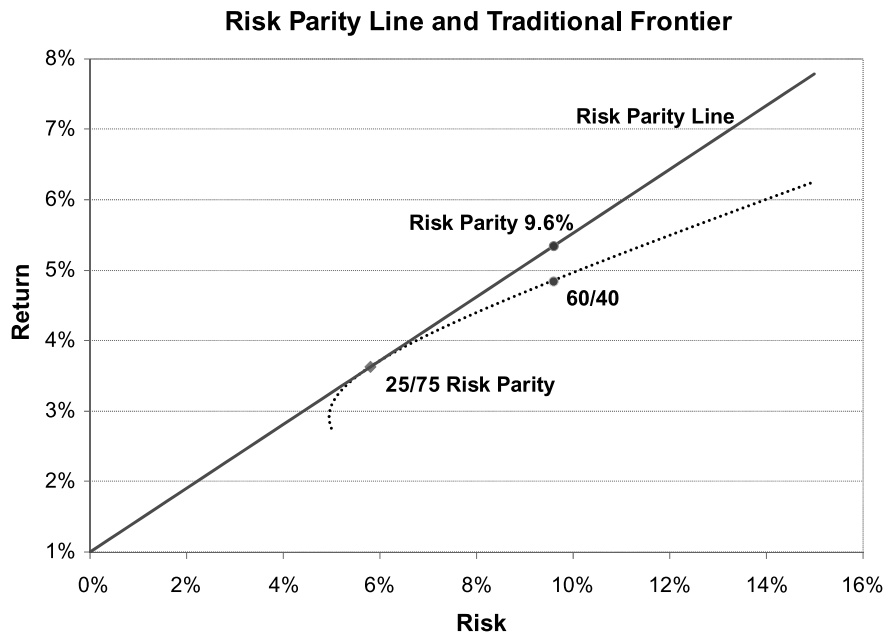
## RETURN ATTRIBUTIONS

The expected return of this particular risk parity portfolio is 5.3%. One can analyze the source of the return in three different ways, adding to our understanding of the portfolio structure.

The first is by using the Sharpe ratio and the cash return. We have  $5.3\% = 1\% + 0.45 \cdot 9.6\%$ , i.e., total return equals the risk-free rate plus the Sharpe ratio times risk. This gives a total portfolio perspective: The excess return is driven by the risk level and the Sharpe ratio of the entire portfolio. Second, we use expected *excess* returns and notional weights in stocks and bonds. We decompose the return into  $5.3\% = 1\% + 41\% \cdot 5.25\% + 124\% \cdot 1.75\%$ , i.e., total return equals the risk-free rate plus the sum of weight times excess return. This equation presents a clearer picture of the source of the excess return at the asset class level. Note that the return contributions from stocks and bonds are equal too—risk parity is return parity with equal Sharpe ratios. Third, we use expected *total* returns and notional weights in both risky assets and cash. We have  $5.3\% = 41\% \cdot 6.25\% + 124\% \cdot 2.75\% - 65\% \cdot 1\%$ , which makes the leverage cost explicit—65 basis points in this hypothetical case. We have effectively borrowed an additional 65% at the short-term risk-free rate and invested it in the 25/75

## EXHIBIT 3

### Risk Parity Portfolio Line and the Traditional Frontier



combination of risky assets. For example, if one uses exchange-traded futures to gain notional exposures, the return difference between futures and physicals would be the financing cost of the leverage. As the short-term rate varies over time, the cost of leverage will also change. In addition, the borrowing cost could also depend on the instruments used and counterparty risk if over-the-counter derivatives are involved.

The last two methods can both be used as frameworks for risk parity portfolio return attribution. The theoretically correct method is probably the second method using the risk-free rate and excess returns. Practically, from an accounting perspective, one might prefer the third method using total returns, in which case the borrowing costs and cash interests must be allocated equitably or proportionally across asset classes.

## DIVERSIFICATION BENEFITS OF RISK PARITY

From a return perspective, the benefit of diversification is simple: higher return with same amount of risk. Since risk parity portfolios are constructed with equal risk allocation, it is useful to analyze how this principle manifests itself in its portfolio characteristics.

The first measure is the return *correlations* of portfolios with stocks and bonds. Exhibit 4 displays the correlations of the 60/40 and the risk parity portfolios. The 60/40 has an extremely high correlation with stocks (0.98) and extremely low correlation with bonds (0.13). On the other hand, risk parity portfolios, regardless of their risk level, have equal correlation with both stocks

and bonds. Risk parity is diversified; it is not solely dependent on stock returns.

A second and closely related concept is portfolio exposure or *beta*<sup>4</sup> to underlying assets, which are displayed in Exhibit 5. At first glance, the 60/40's betas are more balanced while the risk parity's betas are tilted to bonds. However, this is a false sense of balance for the 60/40 portfolio. Recall stocks are much more volatile than bonds, hence a truly diversified portfolio must have lower beta to higher risk assets and higher beta to lower risk assets. This is exactly what risk parity has managed to achieve. Since stocks are three times more volatile than bonds in terms of standard deviation, its beta is one-third of the bonds' beta.

The last, and perhaps most important, measure is *loss contribution*. Downside risk is of practical importance to all investors. When significant losses occur or are expected to occur, we must analyze the loss contribution from underlying assets. It is proven theoretically (Qian [2006]) and empirically for a 60/40 portfolio (Qian [2005]) that loss contribution equals risk contribution. Thus, for the 60/40 portfolio, stocks contribute roughly 92% of its losses;<sup>5</sup> while for risk parity portfolios, stocks contribute only half of the losses. Therefore, in order to provide downside protection for the overall portfolio against significant losses of underlying assets, whether it is stocks or bonds, it is preferable to own a risk parity portfolio.<sup>6</sup>

## FROM 60/40 TO RISK PARITY

Even though the 60/40 and risk parity portfolios have the same total risk, the portfolio construction

### EXHIBIT 4

Correlations of 60/40 and Risk Parity Portfolios with Stocks and Bonds

	Stocks	Bonds
<b>60/40</b>	0.98	0.13
<b>Risk Parity</b>	0.77	0.77

### EXHIBIT 5

Beta Exposure of 60/40 and Risk Parity Portfolios to Stocks and Bonds

	Stocks	Bonds
<b>60/40</b>	0.63	0.76
<b>Risk Parity</b>	0.30	0.90

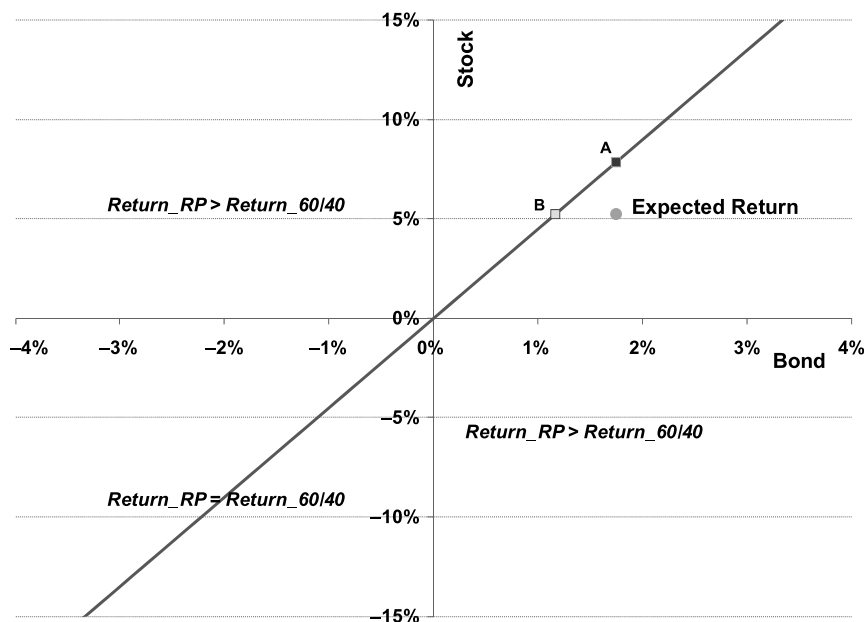
processes are different, leading to very different asset allocations. When considering a shift from the former to the latter, an analysis of the portfolio differences can be useful in balancing the short-term risk and long-term benefit. In this section, we carry out this analysis for the two portfolios under consideration.

First, the correlation between the two portfolios is quite high, at 0.89, because both portfolios use the same ingredients. The tracking error, or annual volatility of return differences, is 4.5%. The fact that this volatility is much higher than the incremental expected return makes it quite clear that the choice between risk parity and the traditional 60/40 is a strategic decision, based on Sharpe ratios, rather than a tactical one, often based on information ratios.

Second, we study explicitly the return difference between the two portfolios. Compared to the 60/40 portfolio, the risk parity portfolio, targeting similar risk, overweights bonds by 84% and underweights stocks by 19%. As a result, the return difference can be expressed in terms of the excess return of bonds and stocks as follows

$$\Delta r = r_{RP} - r_{60/40} = 84\% \cdot r_{bond} - 19\% \cdot r_{stock} \quad (3)$$

## EXHIBIT 6 Regions of Relative Return between 60/40 and Risk Parity Portfolios



Whether this difference is positive or negative depends on the relative performance of stocks and bonds. For instance, if  $84\% \cdot r_{bond} = 19\% \cdot r_{stock}$ , or  $r_{stock} = 4.42 \cdot r_{bond}$ , i.e., stock's excess return is 4.42 times bond's excess return, the two portfolios would have identical performance. Exhibit 6 plots the line of equal performance with respect to stock and bond excess returns. Below the line, the risk parity portfolio would outperform, and above the line, the 60/40 portfolio would outperform. Note the point representing the long-term expected excess returns of stocks (5.25%) and bonds (1.75%) sits in the area below the line, where risk parity is expected to generate a higher return than the 60/40 portfolio.

Scenario analysis can provide further understanding of the relative performance. In scenario A, we fix the bond expected excess return at 1.75% and seek the level of expected excess return for stocks that would make us indifferent to the performance of the two portfolios. The answer is 7.74% ( $4.42 \cdot 1.75$ ), denoted by point A in Exhibit 6. The Sharpe ratio for stocks would increase from 0.35 to 0.52. This implies a return premium of stocks over bonds by over 6%. Similarly, in scenario B, we fix the expected excess return of stocks at 5.25%. If the excess return of bonds drops to 1.19% ( $5.25/4.42$ )

at point B, the two portfolios would have equal return. In this scenario, the Sharpe ratio of bonds would drop from 0.35 to 0.24. In this case, the implied premium of stocks over bonds is over 4%. Hence, it does appear that in the short-term, the possibility of 60/40 portfolio outperforming risk parity is higher in a low return environment.

## DYNAMIC RISK PARITY PORTFOLIOS

While equal Sharpe ratios and equal risk allocation hold both practical and theoretical appeal in terms of long-term diversification, it is possible and often desirable to construct portfolios of assets with different Sharpe ratios based on a dynamic forecasting process. In this section, we outline an optimization process that maximizes the Sharpe ratio of an asset allocation portfolio.

Assume Sharpe ratios  $S_1$  and  $S_2$  for stocks and bonds, respectively. Denote the volatilities by  $\sigma_1$  and  $\sigma_2$  and correlation by  $\rho$ . The optimal weights for an unlevered portfolio are (see Appendix)

$$w_1 = \frac{\left(\frac{S_1}{\sigma_1}\right) - \rho\left(\frac{S_2}{\sigma_1}\right)}{\left(\frac{S_1}{\sigma_1}\right) - \rho\left(\frac{S_2}{\sigma_1}\right) + \left(\frac{S_2}{\sigma_2}\right) - \rho\left(\frac{S_1}{\sigma_2}\right)}, \quad w_2 = 1 - w_1 \quad (4)$$

The weights are simplified in two special cases. The first case is when the two Sharpe ratios are equal, i.e.,  $S_1 = S_2$ . Then the weights depend only on volatilities:

$$w_1 = \frac{\left(\frac{1}{\sigma_1}\right)}{\left(\frac{1}{\sigma_1}\right) + \left(\frac{1}{\sigma_2}\right)}, \quad w_2 = 1 - w_1 \quad (5)$$

They are inversely proportional to volatility. Therefore, when the stock and bond volatilities are 15% and 5%, respectively, the stock and bond weights are 25% and 75%, as we have shown previously.

The second special case is when the correlation is zero. Then we have

$$w_1 = \frac{\left(\frac{S_1}{\sigma_1}\right)}{\left(\frac{S_1}{\sigma_1}\right) + \left(\frac{S_2}{\sigma_2}\right)}, \quad w_2 = 1 - w_1 \quad (6)$$

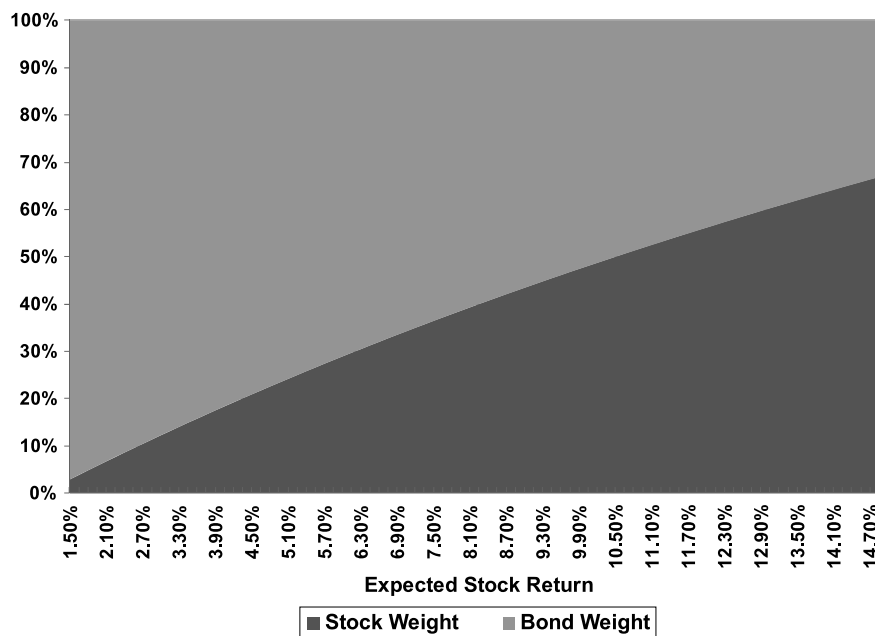
The weight is proportional to the ratio of Sharpe ratio to volatility.

We can explore the full solution by varying Sharpe ratios while keeping volatilities and correlation constant. Using the previous example, we fix the Sharpe ratio of bonds at 0.35 (excess return at 1.75%), vary the Sharpe ratio of stocks from 0.1 to 1, and calculate the optimal weights of stocks and bonds. Exhibit 7 plots the optimal weights versus the implied expected return of stocks. Consistent with earlier results, when the expected return of stocks is 5.25%, the optimal portfolio is the 25/75 portfolio. The graph helps answer the question: When is the 60/40 portfolio optimal? The answer is when the expected return for stocks exceeds 13%. This exceptional level of risk premium, while possible in the short term, is highly unlikely in the long term. In other words, 60/40 with its extreme concentration in equity risk is an optimal strategic allocation only if the equity risk premium is extremely high. Even when the expected return of stocks is near 10%, a levered 50/50 portfolio is still preferable to the 60/40 portfolio.

Conversely, we fix the expected return of stocks at 5.25% and vary the Sharpe ratio of bonds from 0.1 to 1. The expected return of bonds then ranges from 0.5% to 5%. The optimal weights of stocks and bonds are plotted

## EXHIBIT 7

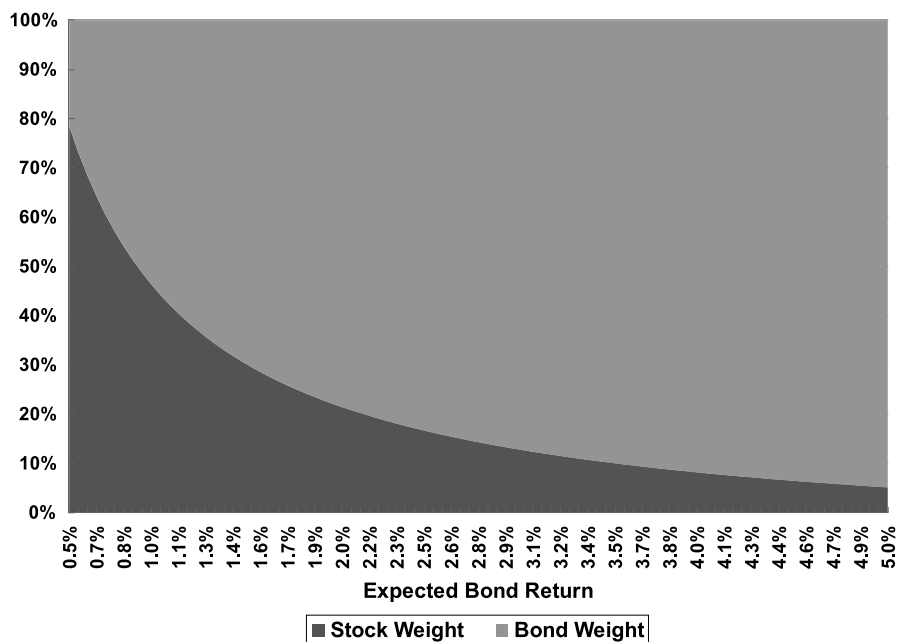
Optimal Weights with Varying Expected Return of Stocks (bond excess return fixed at 1.75%)





## EXHIBIT 8

### Optimal Weights with Varying Expected Return of Bonds (stock excess return fixed at 5.25%)



in Exhibit 8. When the bonds' expected return is 0.5%, the optimal portfolio is roughly 80/20. Pessimistic bond return expectations lead to overly concentrated risk in stocks. On the other hand, when the bonds' expected return is 5%, the optimal weight of bonds reaches 95%. Exuberant bond return expectations lead to risk overly concentrated in bonds.

Even though we have demonstrated that risk parity can be enhanced to actively allocate risk, using views on the risk-adjusted returns of underlying asset classes, we caution that one should make this adjustment a measured one, based on two grounds. First, long-term asset return forecasting is tenuous at best. Second, large adjustments to risk allocations can drive a portfolio to become unbalanced, defeating the original purpose of risk parity based strategies.

### SUMMARY

This article presents theoretical arguments for risk parity portfolios, which are constructed based on risk measures. The first measure is the risk parity allocation to underlying asset classes, resulting in true diversification or higher risk-adjusted returns. The second is risk targeting at the total portfolio level to achieve higher total

returns, with the use of appropriate financial leverage if necessary. This is possible because the risk-return target is scalable while the Sharpe ratio remains unchanged along the risk parity line. Traditional asset allocation portfolios lack risk control on both dimensions. Not only are they under-diversified but investors also have no control of the total risk embedded in these portfolios. Risk parity portfolios allow investors to achieve both risk composition as well as a total portfolio risk target.

How should one actually construct a risk parity portfolio with multiple asset classes and multiple objectives is a topic beyond the scope of the present article. There are at least two ways to use risk parity in strategic asset allocation. The first is to use it as a part of allocation to alternative investments. The second is to apply risk parity on the total portfolio level, as the basis of strategic asset allocation. Although both approaches are gaining acceptance, one nagging concern regarding risk parity among some investors seems to be whether it is the result of look-back bias. In particular, it has been noted that over the last decade, risk parity portfolios have performed far better than 60/40 portfolios. Will this still be the case over the next decade?

Of course, one can never be 100% certain. However, it is imperative to note that risk parity hinges on

diversification, not on the hindsight that bonds have been a better investment than stocks. In hindsight, one would have allocated a majority of risk to bonds rather than follow risk parity. This too would go against the risk parity philosophy. Diversification is not a new concept suddenly brought to light with risk parity. It is the opposite—risk parity is an application of diversification. If one believes in the benefits of portfolio diversification, then one should believe in risk parity.

At the expense of diversification some wonder, will traditional 60/40 portfolios perform better in the future? It is possible. Still, that possibility does not alter the fact that it lacks proper diversification. In other words, allocating over 90% of risk to high-risk assets has been damaging to wealth creation over the last decade and there are few signs for a reversal of fortune in the future. Indeed, the risk of a reversal in stock prices and inflation could make some investors reluctant to diversify their portfolios away from traditional asset allocation approaches. While this reluctance is understandable, there are several ways to mitigate the short-term timing risk. The first method is dollar averaging, which is used by many investors when making investment shifts. The second way that specifically guards against rising inflation is to include significant allocation to real assets in the risk parity portfolio. Last, employing dynamic risk parity can also make allocations more adaptive to changes in the capital markets.

## APPENDIX

The risk contribution of the two-asset case is given by

$$RC_1 = \frac{w_1^2 \sigma_1^2 + \rho w_1 w_2 \sigma_1 \sigma_2}{w_1^2 \sigma_1^2 + 2\rho w_1 w_2 \sigma_1 \sigma_2 + w_2^2 \sigma_2^2}, \quad RC_2 = 1 - RC_1 \quad (\text{A-1})$$

Assuming an unlevered portfolio, i.e.,  $w_2 = 1 - w_1$ , the Sharpe ratio is expected excess return divided by volatility

$$SR = \frac{w_1 S_1 \sigma_1 + (1 - w_1) S_2 \sigma_2}{\sqrt{w_1^2 \sigma_1^2 + (1 - w_1)^2 \sigma_2^2 + 2\rho w_1 (1 - w_1) \sigma_1 \sigma_2}} \quad (\text{A-2})$$

Taking the derivative with respect to  $w_1$  and equating the resulting equation to zero leads to the optimal solution in Equation (4).

## ENDNOTES

The author thanks an anonymous referee for helpful comments.

<sup>1</sup>The total risk is

$$\sqrt{0.6^2 (15\%)^2 + 0.4^2 (5\%)^2 + 2 \cdot 0.6 \cdot 0.4 \cdot 0.2 \cdot 15\% \cdot 5\%} = 9.6\%$$

<sup>2</sup>At the current writing, the risk-free rate in the U.S. is between 0% and 0.25% and U.S. Treasury 10-year yield is near 3.5%.

<sup>3</sup>One common misconception regarding risk parity is that leverage is solely applied to bonds not to stocks. It only appears so if one compares the risk parity portfolio to the 60/40 portfolio. The correct way is to view the leverage applied on the entire portfolio in same proportion to both stocks and bonds.

<sup>4</sup>Beta equals correlation times the ratio of portfolio volatility to asset class volatility.

<sup>5</sup>In reality, stocks contribute more than 92% because of their negative tail risk, i.e., their return distribution and return distributions of many other risky assets are skewed to the left and have high kurtosis.

<sup>6</sup>This was the original insight that led the author to the creation of the risk parity investment strategy.

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