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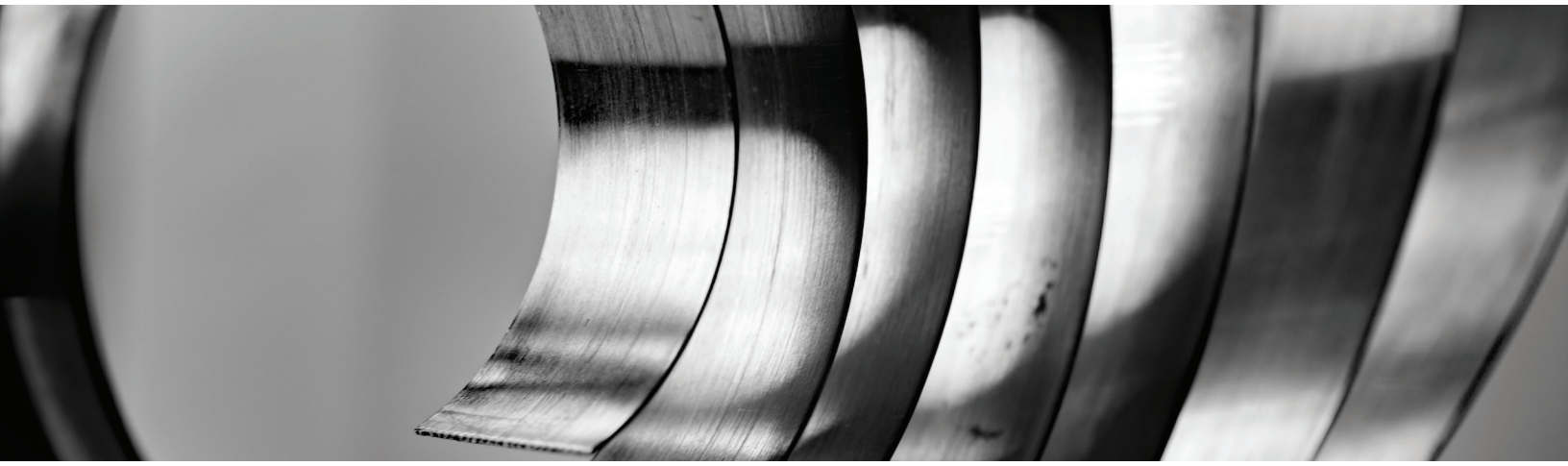

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Risk Parity: A Flexible Tool for DB Pension Plans

Risk parity strategies have a role to play for under-funded defined benefit pension plans that face the challenges of low bond yields and low expected returns from risk and growth assets. We show that adding risk parity can enhance risk-adjusted return, particularly downside risk-adjusted returns, relative to traditional asset allocations. Investors that are willing to give up some potential for funded status to meaningfully exceed 100% may be able to lower the probability of funded status falling below 80% using risk parity.

Moreover, while we seek to show that risk parity has what we view as a clear role for under-funded plans, we also argue that the flexibility of the strategy can give it a useful role to play regardless of current funded status.

Executive Summary

- Risk parity identifies the portfolio with the highest expected risk-adjusted return and applies leverage to achieve the desired level of return.
- Using risk parity, it has been possible to achieve the returns of a traditional 60/40 portfolio with lower volatility and lower drawdowns and left-tail losses.
  - As a pro-rata replacement for an equity-bond mix, risk parity can help a portfolio respond to pension plan liability movements and mitigate losses during the worst equity market sell-offs.
  - As a replacement for equities, risk parity makes a portfolio better matched with liabilities and a better mitigator of downside equity and credit risk.
- Within the analysis, we show the impact of adding risk parity to:
  - An 80%-funded pension plan
  - A 90%-funded plan
  - A 105%-funded plan
  - For the 90%- and 105%-funded plans, we also show 10-year Monte Carlo simulations comparing allocations with and without risk parity
- In general, adding risk parity means giving up some potential for funded status to meaningfully exceed 100% in order to lower the probability of funded status falling below 80%.
- While we seek to show that risk parity has what we view as a clear role for under-funded plans, we also argue that the flexibility of the strategy can give it a useful role to play regardless of current funded status; for example, an 80%-funded plan may choose to allocate 10 – 15% to risk parity taken pro-rata from its current asset allocation, whereas a 105%-funded plan may choose to allocate 5 – 10% taken mostly from equities.

Around the world, defined benefit pension plans face difficult choices. Notwithstanding a decade of strong equity returns leading up to the 2020 COVID-19 crisis, many are still substantially underfunded. Declining interest rates have pushed reported liabilities higher and higher, and as valuations have risen across virtually all financial markets, plans have been forced to revise their long-term expected return on assets lower and lower.

On top of all this, levies and premia paid to pensions insurance or "lifeboat" systems, such as the Pension Benefit Guaranty Corporation (PBGC) in the U.S. and the Pension Protection Fund (PPF) in the U.K., continue to increase—particularly so for poorly funded, at-risk plans.

Even well-funded plans have dilemmas to resolve, as low yields in bond markets make it more difficult to de-risk portfolios sustainably, while the risk profile associated with holding equities looks increasingly asymmetric: the downside could damage funding status; but there is little advantage to being over-funded should the upside be realized.

For many, the solution has been to move away from the traditional 60% equities and 40% bonds asset mix and embrace alternative investments, especially hedge funds and an expanded fixed income and credit universe. These are perceived to hold out the possibility of mitigating the equity risk of a portfolio without having to give up too much equity-like return potential or buy assets with unsustainably low yields.

These innovative allocations have a role to play, but investors should bear in mind that they can still be prone to cyclicality. They may create the illusion of diversification rather than the real thing, masking a high underlying sensitivity to equity market risk, particularly during the more extreme, so-called left-tail events that have proven so damaging to pension plans' funding in the past. For example, lower-rated corporate bonds added to the portfolio to help match the volatility of liabilities may be subject to large losses in an economic downturn that brings extensive re-rating and rising defaults.

We believe problems such as these can potentially be resolved with risk parity strategies.

What is a risk parity strategy?

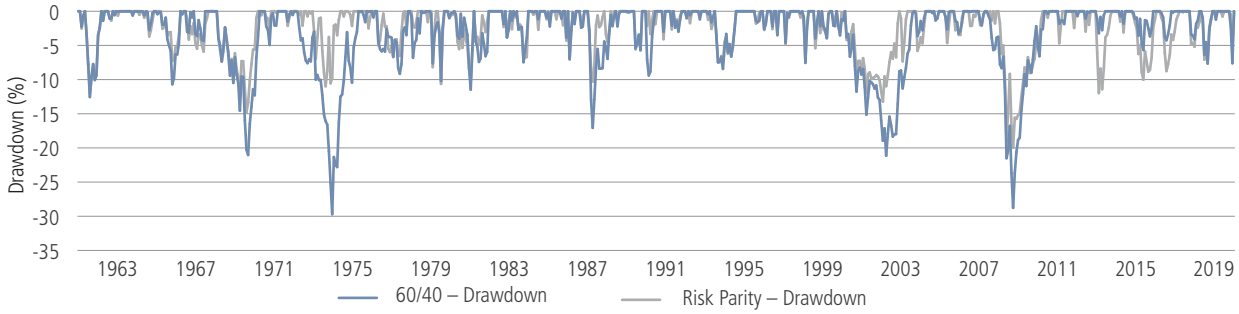
Rather than attempting to diversify by simply adding new asset classes, risk parity is an approach to portfolio construction that attempts to get the most possible benefit from the diversifying characteristics of different asset classes by weighting them so that their contribution to the risk of a portfolio is roughly equal. Since we believe that the Sharpe ratios, or risk-return ratios, of most asset classes are very similar over the long run, it follows that we believe that there is limited benefit from adding more and more of them to a portfolio and no benefit at all from allocating a bigger share of the risk to some over others. In this paper, our simple risk parity strategy contains only equities, bonds and commodities.

While Sharpe ratios are similar, expected returns can be very different. A risk parity strategy will tend to allocate around four times more capital to bonds than to equities in order to equalize their contributions to overall portfolio volatility. But that results in a portfolio whose expected return is much lower than that of a 60/40 portfolio. The risk parity solution is to leverage the resulting risk-balanced portfolio so that its overall exposure is greater than 100%.[1] In this paper, we leverage our equity, bond and commodity portfolio to target the volatility historically exhibited by the 60/40 portfolio, 10%, in order to make a direct comparison of the two investment approaches. Once the risk parity portfolio is constructed, however, it can be leveraged to any calibration of risk or return objective, and, as we will explain below, this ability to scale the risk or return target relatively easily is very useful when it comes to tailoring risk parity strategies for pension plans in different funding situations.

How does moving from 60/40 to risk parity affect a portfolio's vulnerability to the left-tail market events that cause the most damage to funding ratios?

We seek to show that in figure 1. Between 1962 and the present, while average annualized volatility was the same for both strategies, Conditional Value-at-Risk (CVaR), which measures the average loss incurred in the worst 5% of months, was 50 basis points lower for risk parity than for 60/40. Risk parity's maximum drawdown was almost 10 percentage points less than 60/40's, and risk parity's drawdowns were also shorter and took less time to be recovered. During the 10 occasions when 60/40 suffered a drawdown greater than 9%, risk parity always outperformed. On three occasions it posted positive returns.

FIGURE 1. COMPARING 60/40 TO RISK PARITY, 1962 – 2020 (HYPOTHETICAL BACKTEST)



	Return	Volatility	CVaR (95%,M)	Max DD	Sharpe Ratio	Return-ToCVaR	Avg Ddown Lgt (M)	Avg Recov Lgt (M)	Kurtosis	Alpha vs. 60/40	TrErr vs. 60/40	IR vs. 60/40
60/40	9.3	10.1	5.8	29.7	0.5	1.6	5.8	3	1.3			
Risk Parity	12.2	10.2	5.4	20	0.7	2.3	5.2	2.6	0.6	2.7	5.8	0.5

	RETURNS DURING PERIODS OF 60/40 DRAWDOWN									
	Nov 72 / Sep 74	Oct 07 / Feb 09	Aug 00 / Sep 02	Nov 68 / Jun 70	Aug 87 / Nov 87	Mar 62 / Jun 62	Nov 80 / Sep 81	Oct 65 / Aug 66	Aug 79 / Mar 80	Jul 90 / Sep 90
60/40	-29.7	-28.8	-21.2	-21	-17.1	-12.6	-11.5	-10.7	-10.2	-9.4
Risk Parity	23.1	-18.9	-11	-13.4	-9.9	-12	-10.4	-6	0.2	4.4

Source: Bloomberg, Neuberger Berman. Data as of April 30, 2020. The model risk parity strategy seeks to achieve its objective by investing in stocks, bonds and real assets across global markets. Stocks are represented by the S&P 500 Index and backfilled with the Ibbotson U.S. Large Cap Index; bonds are represented by the 10-Year Treasury Index and backfilled by the Ibbotson U.S. Intermediate-Term Government Bond Index; real assets are represented by the Bloomberg Commodity Index. At any point in time, a simple risk parity portfolio is created by first creating an unleveraged portfolio of assets that are weighted inversely on their rolling two-year volatilities; this portfolio is then leveraged up to the point where the portfolio volatility would have equaled 10% over the previous trailing two-year period. Please see important "Hypothetical Backtested Performance Disclosures" at the end of this material. **Past performance is no guarantee of future results.**

[1] See Hakan Kaya, "The Alpha Left on the Table" (October 2019) at https://www.nb.com/global/link?type=article&name=the-alpha-left-on-the-table.

In this paper we seek to show how these potential benefits translate into a defined benefit pension plan's total balance-sheet context—and how they have the potential to translate equally well for a plan that is poorly funded and one that is well funded. Indeed, we would argue that one of the strengths of risk parity is that it has the potential to play quite different roles depending on the funded status of the pension plan.

To show this in action, we created three hypothetical pension plans, one 80% funded, one 90% funded and one 105% funded, and looked at what happened when we changed their asset mixes to include an allocation to our hypothetical simple risk parity strategy. You can see how we modeled the pension plans' liabilities in the Appendix.

Hypothetical Case Study 1: An 80%-Funded Pension Plan

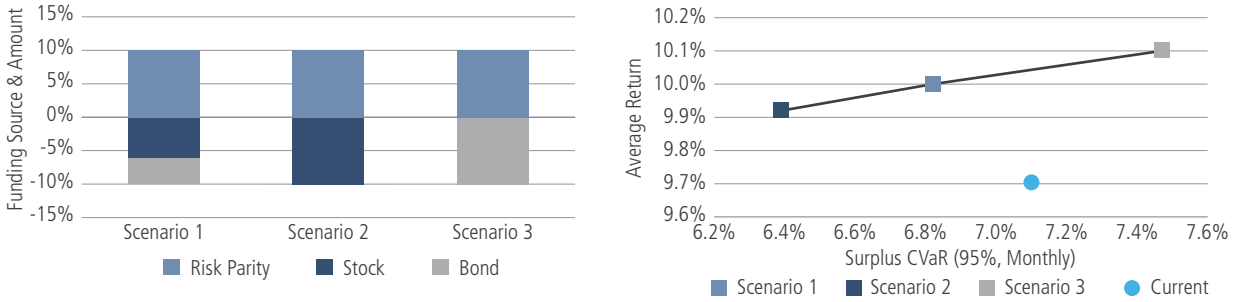
For a poorly funded plan, we believe that risk parity can deliver a return stream that can be customized to meet required return targets, but which exhibits less sensitivity to equity market risk, and brings interest-rate and credit-spread sensitivities that respond in a timely and generally beneficial way to changes in liabilities.

First of all, we will look at the headline performance of a model pension plan balance sheet that begins with 60% in equities and 40% in fixed income and then integrates a risk parity strategy in one of three ways:

- Scenario 1: Fund 10% risk parity pro rata from 60/40 portfolio
- Scenario 2: Fund 10% risk parity from stocks
- Scenario 3: Fund 10% risk parity from bonds

Figure 2 shows what the results would have been between 1962 and 2020, for a plan starting with a funded status of 80%. Returns improved in all three scenarios. Unsurprisingly, taking 10% pro rata from equities (scenario 2) improved the liability-matching characteristics of the portfolio, while taking 10% from bonds (scenario 3) made both the portfolio and the funded status more volatile.

FIGURE 2. ADDING VALUE BY ADDING RISK PARITY WITH FUNDED STATUS AT 80%, 1962 – 2020 (HYPOTHETICAL BACKTEST)
Three ways of integrating a risk parity strategy into a 60/40 portfolio



Summary statistics	60/40	Scenario 1	Scenario 2	Scenario 3
Excess Return	5.3%	0.2%	0.1%	0.4%
Return	9.7%	0.3%	0.2%	0.4%
Surplus Return	0.8%	0.2%	0.1%	0.4%
Volatility	10.5%	-0.2%	-0.5%	0.3%
CVaR	6.0%	-0.2%	-0.40%	0.2%
Surplus Volatility	9.7%	-0.3%	-0.9%	0.6%
Surplus CVaR	7.1%	-0.3%	-0.7%	0.4%
Sharpe Ratio	0.51	0.03	0.04	0.02
Return / CVaR	1.61	0.10	0.15	0.02
Surplus Sharpe	0.09	0.03	0.02	0.03
Surp Return / Surp CVaR	0.12	0.04	0.03	0.05
Correlation with Liability	0.53	0.02	0.06	-0.04
Beta to Liability	0.60	0.01	0.04	-0.04

Source: Bloomberg, Neuberger Berman. Data as of April 30, 2020. The model risk parity strategy is described in the note to figure 1. For the model pension plan liability proxy, see the Appendix. Please see important "Hypothetical Backtested Performance Disclosures" at the end of this material. **Past performance is no guarantee of future results.**

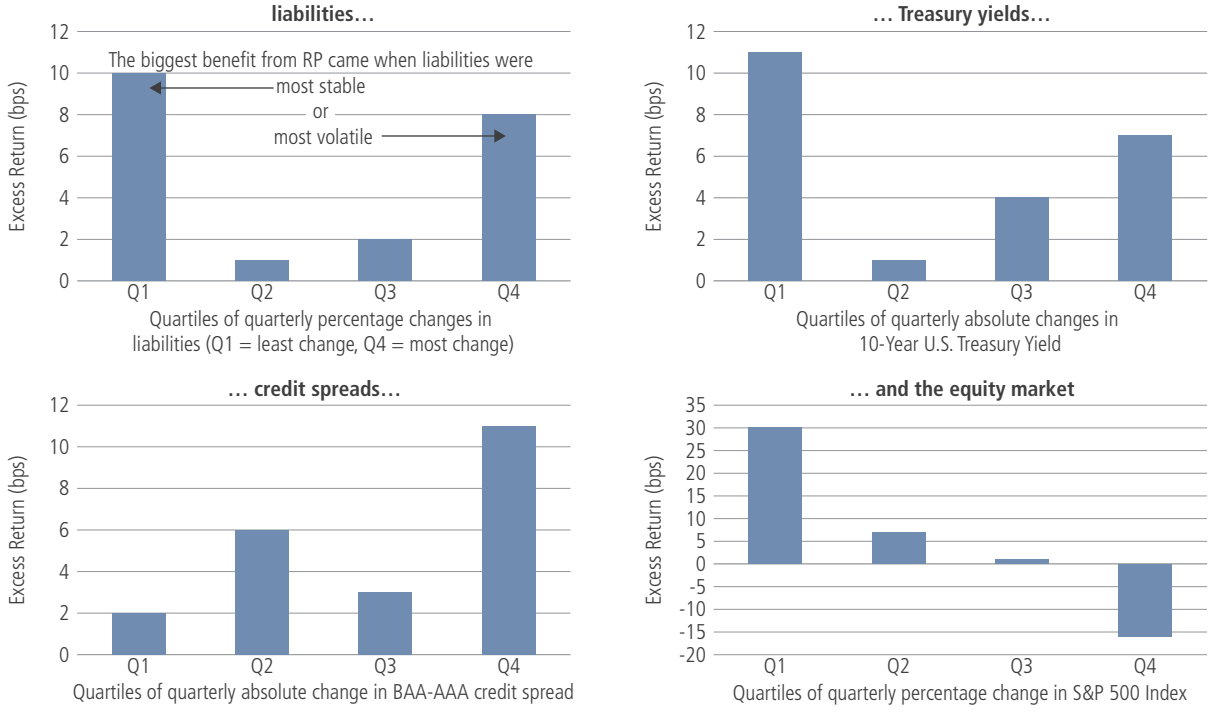
Taking 10% pro rata from the 60/40 mix (scenario 1) resulted in an attractive balance of meaningfully higher return and meaningfully improved liability matching. Let's focus on that solution—the "54/36/10" solution. Why exactly did risk parity add value over the period tested?

The results shown in figure 3 help us to understand. First of all, the excess returns to the 54/36/10 portfolio exhibited a convex sensitivity with quarterly changes in the 10-year U.S Treasury yield and the pension plan's liabilities—it tended to perform best when liabilities shrank the most, but also when they grew the most. Second, its highest excess returns coincided with times when risky assets were at their weakest—they tended to be best when investment grade bond spreads widened the most and when equity valuations declined the most. Adding the risk parity allocation detracted only when equities rallied steeply.

We also found that, during the major drawdowns caused by the oil shock of the early 1970s, the bursting of the dotcom bubble and the 2008 financial crisis, the 54/36/10 portfolio lost less value than the 60/40 portfolio on the way down and was quicker to recover its previous peak. Losses incurred during the COVID-19 sell-off in March 2020 were also lower than for 60/40.

FIGURE 3. AVERAGE EXCESS RETURNS TO THE 54% EQUITIES, 36% BONDS AND 10% RISK PARITY STRATEGY, 1962 – 2020 (HYPOTHETICAL BACKTEST)

Average excess returns relative to changes in…



Source: Bloomberg, Neuberger Berman. The model risk parity strategy is described in the note to figure 1. For the model pension plan liability proxy, see the Appendix. Please see important "Hypothetical Backtested Performance Disclosures" at the end of this material. **Past performance is no guarantee of future results.**

In our view, this presents a strong case for including risk parity in a defined benefit pension plan portfolio: there are no real advantages from achieving a funded status in excess of around 110%, as a plan might from a 60/40 mix in a sustained bull market for equities, whereas regulators often penalize quite severely plans with worsening funded statuses. Giving up some of the potential for more extreme upside scenarios in exchange for reduced downside risk therefore looks like an attractive option.

Investors starting with a poor funded status are likely to be looking to risk parity to boost or maintain their return targets. They could do that in two ways. Raising the leverage and volatility of the risk parity allocation and funding it pro rata from an existing equity-plus-bond portfolio would enable investors to benefit from the liability-matching duration and credit spread-sensitivity exposures the strategy introduces while improving the overall risk-return ratio. Allocating from the equity portfolio alone would instead release

risk budget, because risk parity can be scaled to deliver the same return as equities with less volatility, which could then be spent on investments that come with higher risk premia than public equities, such as illiquid alternatives.

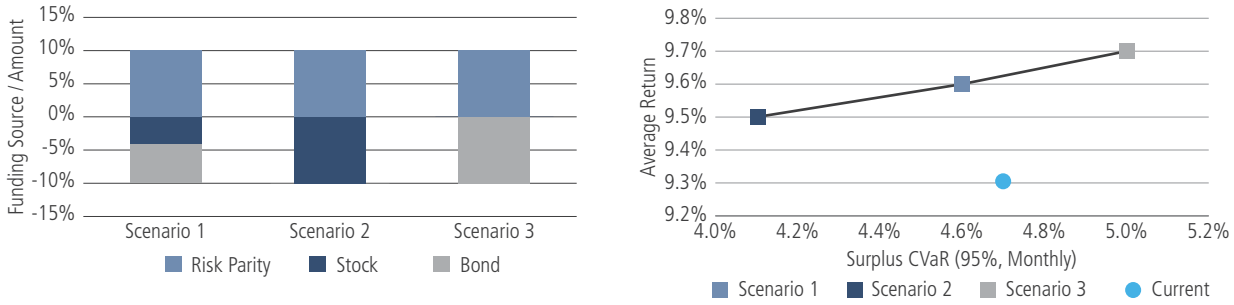
Hypothetical Case Study 2: A 90%-Funded Pension Plan

A more securely funded plan will tend to have higher allocations to fixed income in order to hedge most of their liability risks. To show the impact of a risk parity allocation on a plan like this, we look at the performance of a model pension plan balance sheet that begins with 40% in equities and 60% in fixed income (as opposed to the traditional 60/40 asset allocation) and then integrate a risk parity strategy in one of three ways:

- Scenario 1: Fund 10% risk parity pro rata from 40/60 portfolio
- Scenario 2: Fund 10% risk parity from stocks
- Scenario 3: Fund 10% risk parity from bonds

Figure 4 shows what the results would have been between 1962 and 2020 for a plan starting with a funded status of 90%. Again, returns improved in all three scenarios.

FIGURE 4. ADDING VALUE BY ADDING RISK PARITY WITH FUNDED STATUS AT 90%, 1962 – 2020 (HYPOTHETICAL BACKTEST)
Three ways of integrating a risk parity strategy into a 40/60 portfolio



Summary statistics	40/60	Scenario 1	Scenario 2	Scenario 3
Excess Return	4.8%	0.3%	0.1%	0.4%
Return	9.3%	0.3%	0.2%	0.4%
Surplus Return	1.3%	0.3%	0.1%	0.4%
Volatility	9.6%	-0.1%	-0.2%	0.0%
CVaR	5.3%	-0.1%	-0.19%	0.0%
Surplus Volatility	6.7%	-0.1%	-0.8%	0.4%
Surplus CVaR	4.7%	-0.1%	-0.6%	0.3%
Sharpe Ratio	0.51	0.04	0.03	0.04
Return / CVaR	1.77	0.10	0.10	0.07
Surplus Sharpe	0.20	0.05	0.05	0.04
Surp Return / Surp CVaR	0.29	0.07	0.08	0.06
Correlation with Liability	0.72	0.00	0.05	-0.03
Beta to Liability	0.84	-0.01	0.04	-0.04

Source: Bloomberg, Neuberger Berman. Data as of April 30, 2020. The model risk parity strategy is described in the note to figure 1. For the model pension plan liability proxy, see the Appendix. Please see important "Hypothetical Backtested Performance Disclosures" at the end of this material. **Past performance is no guarantee of future results.**

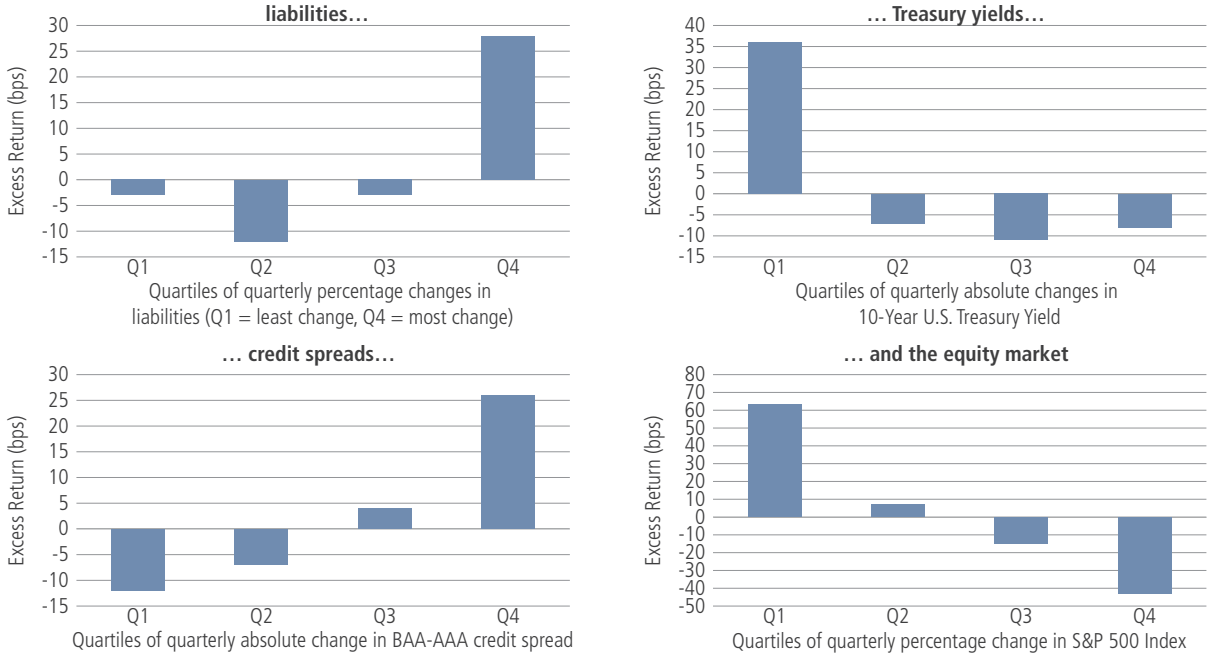
Whereas before we focused on the "54/36/10" solution, where 10% was taken pro rata from the 60/40 mix and allocated to risk parity, here we will focus on scenario two, where 10% is taken from equities alone—the "30/60/10" solution. We do that because it represents a more attractive solution for a well-funded plan: it may not have added as much to returns as the other two scenarios, but it still improved on the original 40/60 portfolio's return while cutting asset volatility and left tail risk, and substantially cutting the volatility and left tail risk in the plan's funded status.

Figure 5 shows why. Whereas the "balanced" 54/36/10 solution shown earlier resulted in a convex sensitivity with quarterly changes in the 10-year U.S Treasury yield and the pension plan's liabilities, this 30/60/10 solution exhibits something much more linear: it simply performs best when liabilities are growing the most and when Treasury yields are declining the most. It also has a clearer linear relationship with risky markets, performing best when credit spreads are widening and equity markets are selling off.

These are intuitive results. Allocating to risk parity exclusively from equities involves exchanging equity market risk for something more balanced, more bond-like, more sensitive to interest rate risk—and therefore better matched against liabilities.

FIGURE 5. AVERAGE EXCESS RETURNS TO THE 30% EQUITIES, 60% BONDS AND 10% RISK PARITY STRATEGY, 1962 – 2020 (HYPOTHETICAL BACKTEST)

Average excess returns relative to changes in…



Source: Bloomberg, Neuberger Berman. Data as of April 30, 2020. The model risk parity strategy is described in the note to figure 1. For the model pension plan liability proxy, see the Appendix. Please see important "Hypothetical Backtested Performance Disclosures" at the end of this material. **Past performance is no guarantee of future results.**

Having looked at what might have happened in the past, let's turn to some modeled scenarios for the future. We ran 10-year Monte Carlo simulations using the same model 90%-funded pension plan and two asset allocations: one with no risk parity strategy and one with 10% in risk parity.

The results shown in figure 6 confirm that funding risk parity from both equities and bonds achieves better results on both the upside and the downside, as we can see in the fan chart. In the best 10% of our 10,000 simulations, funded status was three percentage points higher with risk parity added, and in the worst 10%, funded status was four percentage points higher, while the median outcome also showed a slight improvement. The probability of ending the period with a funded status above 100% was improved slightly by adding risk parity, but the probability of ending with funded status below 80% was cut more substantially, from 43% to 38%. In all 10,000 simulations, maximum drawdown was lowered by adding risk parity.

FIGURE 6. FUNDED STATUS FLIGHTPATH, WITH AND WITHOUT RISK PARITY

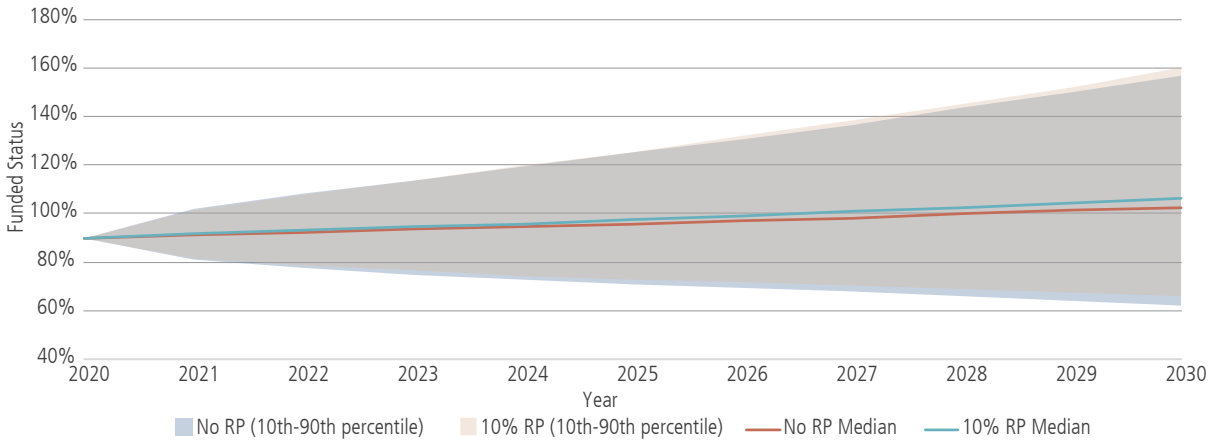
ASSET ALLOCATIONS

Asset Class	No RP	10% RP
Cash & Treasuries	8%	7%
IG Corp	35%	32%
HY	2%	2%
Equity	45%	41%
Risk Parity	0%	10%
Alternatives	10%	9%

FUNDED STATUS SIMULATIONS

	FS (1st yr)		FS (5th yr)		FS (10th yr)		Max DD (%FS)	
Percentile	No RP	10% RP	No RP	10% RP	No RP	10% RP	No RP	10% RP
90th	102%	102%	125%	125%	157%	160%	6%	6%
75th	97%	97%	110%	112%	129%	133%	11%	10%
50th	91%	92%	96%	97%	103%	106%	18%	16%
25th	86%	87%	82%	84%	80%	84%	28%	25%
10th	81%	82%	71%	73%	62%	66%	39%	36%

CVaR of Funding Status (10th yr)		
	No RP	10% RP
10% CVaR	50%	54%
5% CVaR	42%	46%
P(FS>100%)	71%	74%
P(FS<80%)	43%	38%



Source: Bloomberg, Cambridge Associates, FactSet, Neuberger Berman. Asset return inputs are expected returns derived from Neuberger Berman's capital market assumptions. Asset risk inputs are derived from historical return data between December 31, 2006 and April 30, 2020. Input data as of April 30, 2020. Indices used: Bloomberg Barclays U.S. Treasury 3M, 20-30 Years Indices; U.S. Corporate Credit A & Above 10-20, 20+ Years and BBB 20+ Years Indices; Bloomberg Barclays U.S. High Yield Index; S&P 500 Index; MSCI World ex U.S. Index; MSCI EM Index; Cambridge Associates LLC U.S. Private Equity Index; NCREIF Open End Diversified Core Equity (ODCE) Index; HFRI Global Hedge Fund Index; Credit Suisse Leveraged Loan Index. The model risk parity strategy is described in the note to figure 1. For the model pension plan liability proxy, see the Appendix.

These are promising results, but it is important to note that these forward-looking simulations do not take into account the way risk parity strategies typically behave during equity drawdowns. Because they are usually designed systematically to target a certain level of volatility, and because market volatility in general and equity volatility in particular tends to rise during drawdowns for risky assets, risk parity strategies generally respond to drawdowns by reducing both their allocations to equities and their portfolio leverage. This dynamic response further reduces the portfolio's exposure to downside risk as the drawdown persists.

Because that is not captured in our simulations, the estimates for drawdowns, conditional value at risk (CVaR) and the worst-case funded-status outcomes should be interpreted as lower bounds: the likelihood is that a real, dynamic risk parity strategy would return more favorable outcomes.

Hypothetical Case Study 3: A Fully Funded Pension Plan

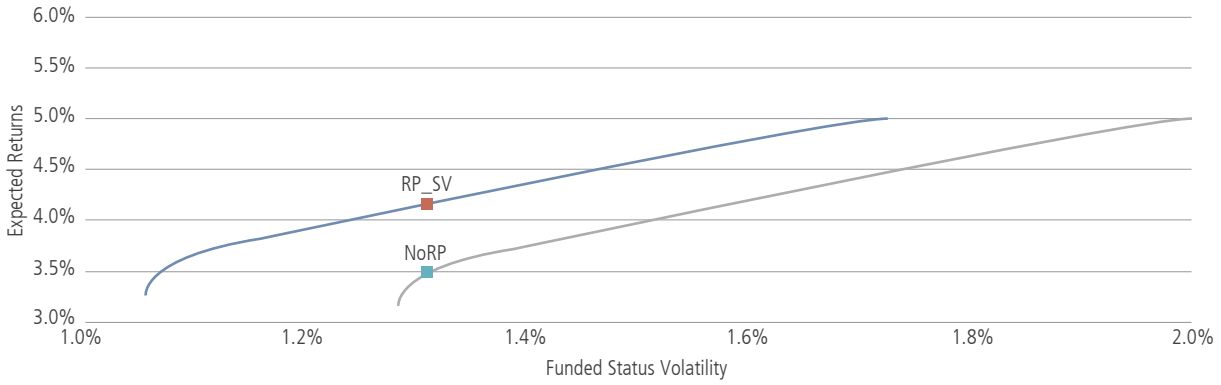
The goal for a fully funded pension plan is to honor projected cash flows and maintain fully funded status to the end of the plan's life; a small growth portfolio will often be maintained to pay for additional services or to help manage actuarial risks that cannot be hedged. Here, risk parity can play a role similar to the one it plays it plays in a 90%-funded plan: an investment that can be scaled for equity-like returns while reducing the left-tail risk associated with equities.

In our case study, we consider a pension plan that starts out 105% funded, with a target default-adjusted asset return of 3.5% and a target funded-status volatility of less than 1.5%. The asset allocation it holds to meet those targets, is 79% core fixed income, 13% extended fixed income and 8% equity and alternatives.

We constructed a strategic asset allocation that includes risk parity, optimized for the highest expected return while maintaining the original target funded status volatility. This suggested a 10% allocation to risk parity, with almost all of that coming from equity and alternatives. As figure 7 shows, our optimized portfolio raises the expected return to 4.22% for the same funded status volatility of 1.31%.

FIGURE 7. ADDING RISK PARITY CAN IMPROVE RISK-ADJUSTED RETURN EXPECTATIONS FOR A 105%-FUNDED PLAN

Efficient frontiers for portfolios without risk parity (NoRP) and with a 10% allocation to a risk parity strategy targeting the same funded-status volatility as the NoRP portfolio (RP_SV)



	Default-Adjusted Expected Return	Funded Status Volatility (%)	Duration	Spread Duration	Fixed Income Rating	Asset Allocation (%)		
NoRP	3.50%	1.31%	11.0	6.6	A/A-	79	13	8
RP_SV	4.22%	1.31%	11.0	7.0	A/A-	68	23	9

Core FI Extended FI Equity and Alts

Source: Bloomberg, Cambridge Associates, FactSet, Neuberger Berman. In the RP_SV asset allocation, risk parity accounts for all of Equity and Alternatives and also replaces 1% of Core Fixed Income. Asset return inputs are expected returns derived from Neuberger Berman's capital market assumptions. Asset risk inputs are derived from historical return data between December 31, 2006 and April 30, 2020. Input data as of April 30, 2020. Indices used: Bloomberg Barclays U.S. Treasury 3M, 20-30 Years Indices; U.S. Corporate Credit A & Above 10-20, 20+ Years and BBB 20+ Years Indices; Bloomberg Barclays U.S. High Yield Index; S&P 500 Index; MSCI World ex U.S. Index; MSCI EM Index; Cambridge Associates LLC U.S. Private Equity Index; NCREIF Open End Diversified Core Equity (ODCE) Index; HFRI Global Hedge Fund Index; Credit Suisse Leveraged Loan Index. The model risk parity strategy is described in the note to figure 1. For the model pension plan liability proxy, see the Appendix.

Once again we are able to make some forward-looking estimates of the impact of adding risk parity by conducting our 10,000, 10-year Monte Carlo simulations using the same model pension plan and the two different asset allocations. The summary results are shown in figure 8.

What we see is that adding risk parity in such a way as to target a higher expected return for the same level of funded-status volatility improved the picture across the board: funded status at the end of the period was better regardless of how good performance was, including in the 10% of worst-case scenarios; the maximum drawdown was lower in all scenarios; and the probability of ending with a funded status less than 100% was lower.

FIGURE 8. FUNDED STATUS FLIGHTPATH, WITH AND WITHOUT RISK PARITY

	2029 (10th yr)	
Percentile	**NoRP**	**RP_SV**
90th Funded Status	117%	123%
75th Funded Status	113%	118%
50th Funded Status	109%	113%
25th Funded Status	104%	107%
10th Funded Status	100%	102%
10% VaR Funded Status	100%	102%
10% CVaR Funded Status	96%	98%
P(FS<100%)	10%	6%

	Maximum Drawdown (%FS)	
Percentile	**NoRP**	**RP_SV**
90th Funded Status	2.36%	1.60%
75th Funded Status	3.61%	2.65%
50th Funded Status	5.59%	4.33%
25th Funded Status	8.20%	6.73%
10th Funded Status	11.24%	9.73%

Source: Bloomberg, Cambridge Associates, FactSet, Neuberger Berman. Asset allocations and indices used are given in figure 7. The model risk parity strategy is described in the note to figure 1.

Should an investor allocate more to risk parity, or scale up its volatility?

As a final word, it is worth noting that, for the model 90%-funded pension plan, we also ran Monte Carlo simulations with "low" and "high" risk parity allocations, as well as with the "modest" 10% allocation to risk parity strategies, and we also ran simulations with risk parity scaled not only for 10% volatility, but for also 8%, 12% and 15% volatility.

We found that allocating more to risk parity resulted in a return-for-downside mitigation trade-off—the more a plan had, the more it lagged in the best scenarios and outperformed in the worst, and the lower its probability of ending less than 80% funded went. Interestingly, however, when we scaled up the volatility of a risk parity allocation, we found not only that it raised the end-of-period funded status in the best scenarios, as one might expect, but it also improved performance in the worst scenarios and lowered the probability of ending less than 80% funded.

This is a powerful illustration of a key characteristic of risk parity as a strategy: it is not a straightforward exchange of higher-risk equity exposure for lower-risk bond exposure, but an exchange of equity risk exposure for a more balanced, genuinely diversified risk exposure. That diversified exposure delivers a very attractive risk-return profile, which is preserved no matter how much leverage is applied to target a higher or lower volatility.

Another way to put that is to observe that, as the volatility of a risk parity strategy is scaled up, the impact of both its return-boosting and liability-matching characteristics are enhanced at the whole balance sheet level.

Conclusion: Risk parity is a flexible solution for a range of pension plan challenges

Whether you manage a pension plan that is 80%-funded, and need to maintain a high return target while minimizing the risk to funded status, or manage a 90%- or even a 105%-funded plan where the main objective is to protect funded status and pay benefits. We believe that a risk parity allocation can help. Risk parity can be deployed in many different ways to meet the objectives and constraints of corporate plans. An 80%-funded plan may allocate 10 – 15% to risk parity taken pro-rata from its current asset allocation, whereas a 105%-funded plan may allocate 5 – 10% taken mostly from equities. Scaling the strategy's volatility up may work better than increasing the capital allocation to a risk parity strategy with a given volatility target.

We have presented three simple case studies in this paper, but the fact that risk parity can easily be scaled up or down to meet different risk-and-return targets gives it a lot of flexibility and adaptability to different challenges. It can be deployed as a risk-reducer, a return-enhancer, a liability-matcher or all three. That makes it customizable for a plan at any level of funded status, with any level of risk budget and constraints, and at any stage of its lifecycle.

Appendix

Proxy for the model pension plans' liabilities.

For all three hypothetical case studies, we modelled a typical U.S. pension plan's liabilities, with a duration of 12 years, using the following blend of fixed income indices:

44%	ICE BofAML 10+ Year AAA-AA US Corporate Index (C9B0)
29%	ICE U.S. Treasury 20+ Year TR Index (IDCOT20T)
27%	ICE BofAML 1-5 Year AAA-AA US Corporate Index (CVB0)

To create a full set of historical data for the backtests, we used the following proxies:

	From/To				
	12/31/1959	1/31/1976	2/28/1978	4/30/1987	1/31/2005
Index	12/31/1975	1/31/1978	3/31/1987	12/31/2004	4/30/2020
Ibbotson Long Term Government Bond Index	50%				
Ibbotson Long Term Corporate Bond Index	50%				
ICE BofAML 1-5 Year AAA-AA US Corporate Index (CVB0)			27% +(44% x 50%)	27%	27%
ICE BofAML 10+ Year AAA-AA US Corporate Index (C9B0)				44%	44%
ICE BofAML 15+ Year AAA-AA US Corporate Index (C8B0)		50%	44% x 50%		
Bloomberg Barclays US Long Treasury Total Return Index Value Unhedged (LUTLTRUU)		50%	29%	29%	
ICE U.S. Treasury 20+ Year TR Index (IDCOT20T)					29%

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Hypothetical Backtested Methodology:
The simulated portfolio seeks to achieve its objective by investing in stocks, bonds and real assets across global markets. Stocks are represented by the S&P 500 Index and backfilled with the Ibbotson U.S. Large Cap Index; bonds are represented by the 10-Year Treasury Index and backfilled by the Ibbotson U.S. Intermediate-Term Government Bond Index; real assets are represented by the Bloomberg Commodity Index. At any point in time, a simple risk parity portfolio is created by first creating a raw/unleveraged portfolio of assets that are weighted inversely on their rolling 2-year volatilities. Next this raw portfolio is scaled (leveraged) up to a point that the portfolio volatility equals 10% over the previous trailing 2-year period.

Hypothetical backtested returns have many inherent limitations. Unlike actual performance, it does not represent actual trading. Since trades have not been actually been executed, results may have under- or over-compensated for the impact, if any, of certain market factors, such as lack of liquidity, and may not reflect the impact that certain economic or market factors may have had on the decision-making process. Hypothetical backtested performance also is developed with the benefit of hindsight. Other periods selected may have different results, including losses. There can be no assurance that the Neuberger Berman will achieve profits or avoid incurring substantial losses. Neuberger Berman managed accounts in the manner reflected in the models during a portion of the backtested time periods shown.

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