S&P Dow Jones Indices
A Division of S&P Global

Indexing Risk Parity Strategies

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I. INTRODUCTION

The S&P Risk Parity Index Series provides a transparent, rules-based benchmark for equal-risk-weighted parity strategies. These indices construct risk parity portfolios by using futures to represent multiple asset classes and the risk/return characteristics of funds offered in the risk parity space. Because risk parity funds can have different volatility targets, our series consists of four indices with different target volatility (TV) levels: 8%, 10%, 12%, and 15%.

Modern Portfolio Theory (MPT), introduced by Harry Markowitz in 1952, sets the framework for market participants to potentially maximize portfolio returns for a given level of risk. The theory favors portfolio diversification by holding non-correlated assets. That is, it does not view individual asset returns and volatilities in isolation; rather, it takes into account the co-movements, or correlations, of asset returns that comprise a portfolio.

The theory, along with the expectation that long-term asset class Sharpe ratios are similar (Dalio et al., 2015), act as foundational pieces of risk parity. Risk parity strategies propose that portfolio diversification, defined as achieving the highest return per unit of risk, can be maximized when a portfolio's assets contribute equally to total portfolio risk.

Since the launch of the first risk parity fund, Bridgewater's All Weather Fund in 1996, many asset managers have offered their version of risk parity to clients. The risk parity industry especially gained traction in the aftermath of the 2008 global financial crisis, growing to an estimated USD 150-175 billion at year-end 2017 according to the IMF (Antoshin et al., 2018).

In the past, such strategies lacked an appropriate benchmark, leaving most investors to benchmark against a traditional 60/40 equity/bond portfolio. The problem with this approach is that a 60/40 portfolio reflects neither the construction nor the risk/return characteristics of risk parity strategies. While portfolio risk is generally considered to be diversified in U.S. dollar terms, the reality is that nearly all of the risk arises from the 60% allocation to equities (see Exhibit 6). Additionally, when a portfolio is equal-risk weighted as opposed to equal weighted, it may lead to superior risk-adjusted returns (see Exhibit 10).

In the first part of this paper, we cover the economic rationale for implementing a risk parity approach in a multi-asset portfolio construction. In the second part of the paper, we give an overview of the S&P Risk Parity Indices.

II. WHY RISK PARITY?

Asset Class Overview

Risk parity strategies have long lacked an adequate benchmark.

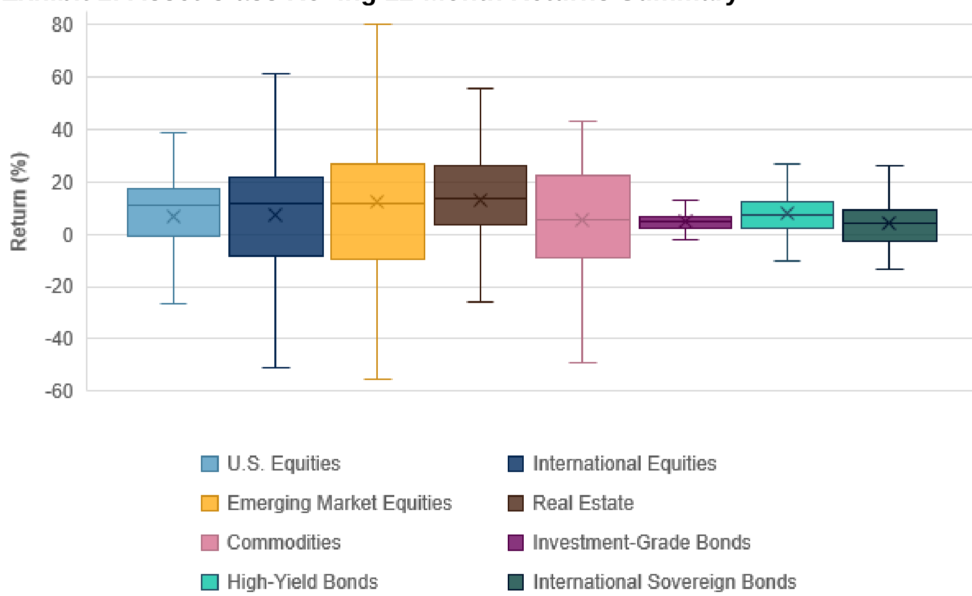
In this section, we demonstrate the potential diversification benefits of a risk parity strategy in terms of risk efficiency (risk-adjusted returns). Using a study period from January 2000 through June 2020, we first review the historical performance and cross-correlations of major asset classes.[1] We then compare the risk/return characteristics of multi-asset portfolios with various combinations of asset classes.

Lastly, we construct a rudimentary three-asset risk parity portfolio consisting of equities, bonds, and commodities. We use this portfolio to illustrate the potential benefits of a risk parity strategy by comparing it with other weighting schemes.

We employ a box and whisker chart[2] in Exhibit 1 to summarize the historical performance of each asset class, based on rolling 12-month total returns of overlapping periods.

To fill this absence, S&P Dow Jones Indices has launched the S&P Risk Parity Indices…

Exhibit 1: Asset Class Rolling 12-Month Returns Summary



…using equities, fixed income, and commodity futures and spreading the risk evenly among them.

Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to June 30, 2020. Index performance based on monthly total return in USD. See Endnote 2 for an explanation of the chart contents. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

We studied correlations between asset classes to form a better understanding of how they could play a part in risk parity.

For each asset class, we observe the average ("x") and median (horizontal line across the shaded area) 12-month returns, as well as the distribution of returns. Emerging market equities and real estate delivered the highest average 12-month returns (10.9% and 12.4%, respectively) for the study period. However, their dispersion of returns, which indicates the magnitude of return uncertainty, was generally larger than the other asset classes.

The dispersion of returns for each asset class is indicated by the height of the inter-quartile range (colored box on vertical line) and the distance between the minimum and maximum returns (the endpoints of the lines extending out from the boxes). While emerging market equities and real estate delivered the highest average returns, they also exhibited higher return uncertainty compared with other asset classes, such as investment-grade bonds.

Exhibit 2 shows the return correlations for each asset pair over the full period. For the 20-year period, there were strong positive correlations between the equity regions, ranging from 0.75 to 0.87. Additionally, equities had moderately positive correlations to real estate, commodities, and high-yield bonds. Meanwhile, equities were negatively correlated with investment-grade bonds. Therefore, adding investment-grade bonds, particularly to an equities portfolio, could lower portfolio volatility and potentially deliver higher returns per unit of risk.

Exhibit 2: Asset Class Correlations

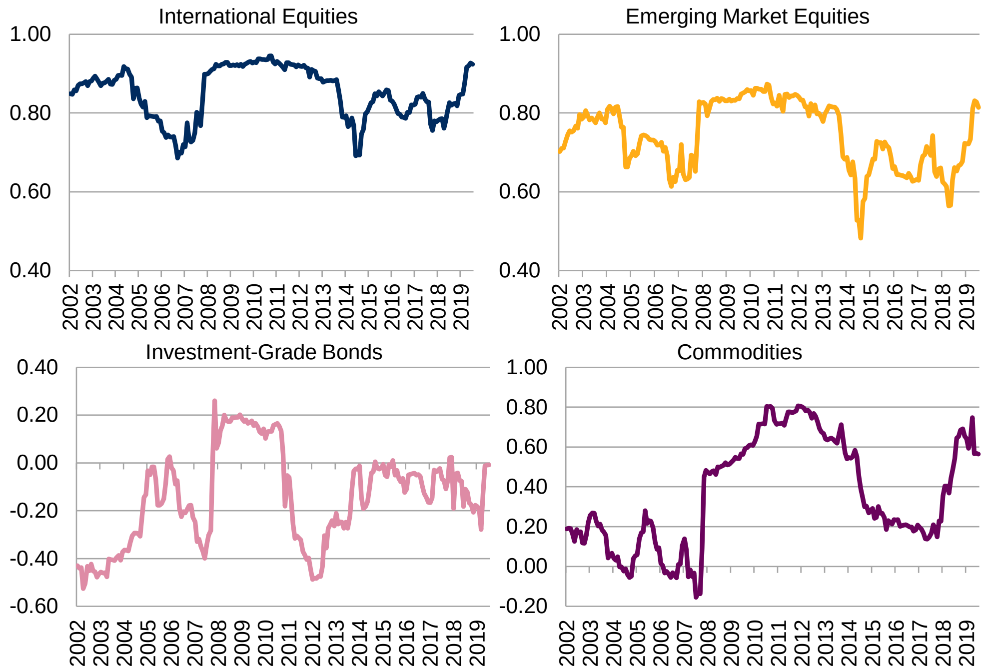
ASSET CLASS	U.S. EQUITIES	INTERNATIONAL EQUITIES	EMERGING MARKET EQUITIES	REAL ESTATE	COMMODITIES	INVESTMENT-GRADE BONDS	HIGH-YIELD BONDS	INTERNATIONAL SOVEREIGN BONDS
U.S. EQUITIES	-	0.87	0.75	0.64	0.42	-0.13	0.66	0.11
INTERNATIONAL EQUITIES	0.87	-	0.87	0.63	0.57	-0.02	0.71	0.30
EMERGING MARKET EQUITIES	0.75	0.87	-	0.54	0.57	0.00	0.70	0.26
REAL ESTATE	0.64	0.63	0.54	-	0.32	0.13	0.63	0.24
COMMODITIES	0.42	0.57	0.57	0.32	-	-0.02	0.47	0.30
INVESTMENT-GRADE BONDS	-0.13	-0.02	0.00	0.13	-0.02	-	0.13	0.53
HIGH-YIELD BONDS	0.66	0.71	0.70	0.63	0.47	0.13	-	0.18
INTERNATIONAL SOVEREIGN BONDS	0.11	0.30	0.26	0.24	0.30	0.53	0.18	-

Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

While Exhibit 2 shows the correlations over the entire 20-year period, correlations between asset classes can vary greatly in shorter time windows while markets go through different cycles. To examine how correlations changed over time, we computed rolling 36-month correlations for U.S. equities compared with international equities, emerging market equities, investment-grade bonds, and commodities.

Correlations among asset classes varied over time.

Exhibit 3: 36-Month Rolling Correlations of Select Asset Classes to U.S. Equities



Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

This demonstrated the importance of the length of the lookback window used when constructing the strategy.

We can see that the correlations between the asset pairs varied over time. For example, the correlation between U.S. equities and investment-grade bonds for the full period was -0.13; however, there were multiple instances where the rolling correlation dropped below -0.40. Additionally, a sharp spike in correlation between U.S. equities and other asset classes took place during the global financial crisis in late 2008.

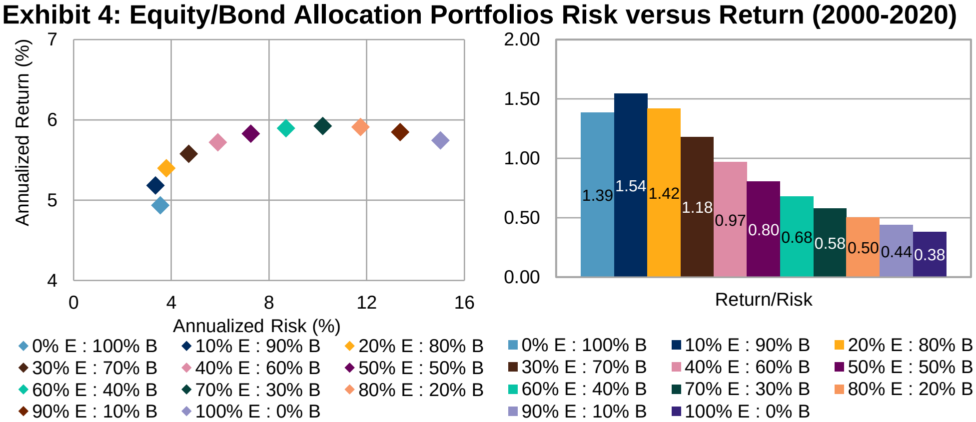
The Impact of Correlations on Portfolio Return and Volatility

Next, we evaluate the effectiveness of incorporating asset class correlations to diversify a multi-asset portfolio. We constructed two-asset portfolios consisting of U.S. equities and investment-grade bonds. In addition to the classic 60/40 equity/bond mix, additional portfolios were created in 10% weight increments, resulting in 11 total portfolios.[3] These portfolios enabled us to view the incremental effect of adding and removing an asset class in a portfolio.

We constructed two-asset portfolios in order to evaluate the use of those correlations as diversification.

Exhibits 4 and 5 show the performance results of the allocation mixes for two periods; Exhibit 4 is the full period from 2000 to 2020, and Exhibit 5 is the 10-year period through June 2020. The left charts are scatter plots of annualized risk and return, while the right charts are the return-per-unit-of-risk ratio.

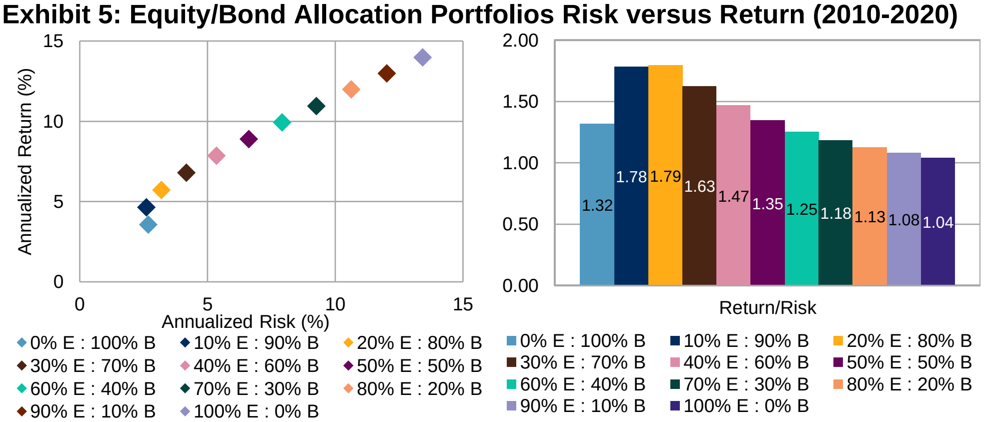
Exhibit 4: Equity/Bond Allocation Portfolios Risk versus Return (2000-2020)



The portfolios consisted of U.S. equities and investment-grade bonds.

All portfolios are hypothetical portfolios.
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 5: Equity/Bond Allocation Portfolios Risk versus Return (2010-2020)



All portfolios are hypothetical portfolios.
Source: S&P Dow Jones Indices LLC. Data from June 30, 2010, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

In Exhibit 4, equities outperformed bonds over the 20-year period, but the excess performance came with significantly higher volatility (left charts). The risk-adjusted return ratios (right charts) show the return per unit of risk for each portfolio; bonds had a significantly higher risk-adjusted ratio of 1.39 versus 0.38 for equities. Thus, on a risk-adjusted return basis, bonds fared better than equities.

There was a non-linear relationship with the changes in portfolio return and risk…

Given the low correlations and higher risk-adjusted return ratio for bonds, combining the two assets led to several allocation mixes with even higher risk-adjusted ratios (e.g., 10/90 equity/bond and 20/80 equity/bond). In fact, the 10/90 equity/bond portfolio had lower volatility relative to bonds along with higher returns—resulting in the highest risk-adjusted return ratio (1.54) out of all the mixes.

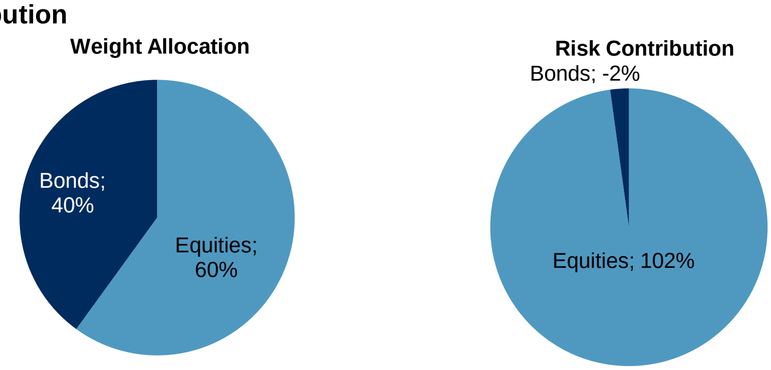
Starting from the initial 100/0 equity/bond portfolio and progressively increasing weight to bonds led to higher absolute returns (until 70/30) and higher risk-adjusted return ratios (until 10/90). **These results are a testament to the potential diversification benefit of combining low-correlated assets in a portfolio.**

Exhibit 5 covered a relatively bullish decade of performance for equities. In this period, the 100% equity portfolio would have been the best-performing portfolio; however, the 20/80 equity/bond portfolio had the highest return/risk ratio (1.79)—substantially higher than the 100% equity portfolio (1.04).

…and the best-performing portfolio was often not the one with the highest return-to-risk ratio.

To highlight the drivers of return and volatility for the allocations, we calculated the marginal contribution to total portfolio risk for each asset class.[4] Since equities are almost always more volatile than bonds, we could expect that they would contribute more to total risk than the bond component. Exhibit 6 shows the allocations of the two asset classes first by weight and then by risk contribution for the 60/40 portfolio.

Exhibit 6: 60/40 Equity/Bond Portfolio Weight Allocation versus Risk Contribution

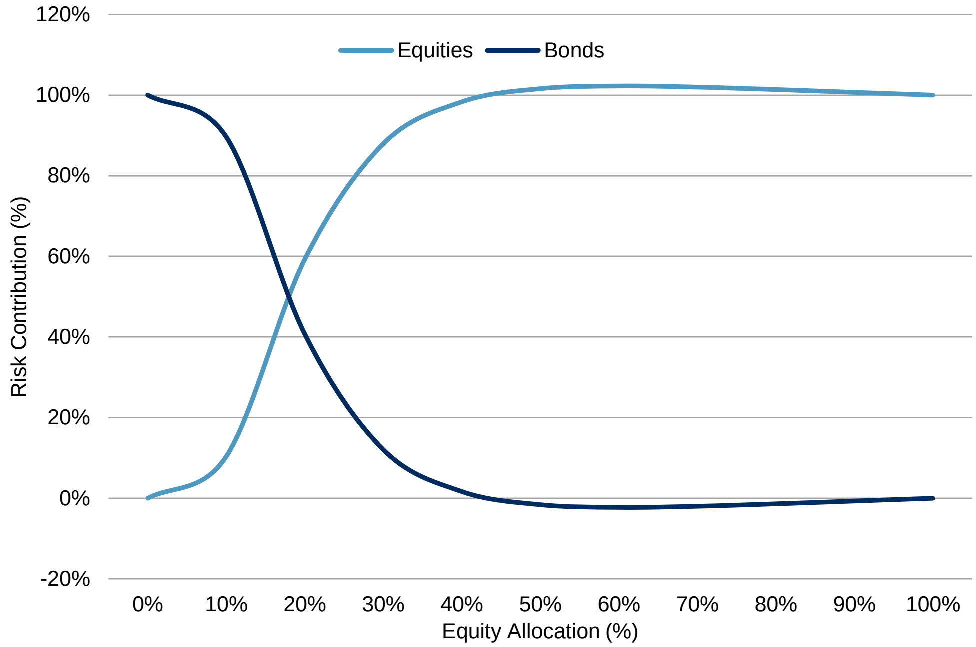


The 60/40 equity/bond portfolio is a hypothetical portfolio.
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to Dec. 31, 2019. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Charts are provided for illustrative purposes and reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Exhibit 6 shows that for the 60/40 equity/bond mix, on average, all of the total portfolio volatility came from equities. In fact, the average contribution for equities was 102%, leading to a -2% average contribution to total risk for bonds. The results demonstrate the volatility contributions of different asset classes, compared with their weights in a portfolio. To see how risk contributions change as weight allocations move from 0%-100% in equities (and 100%-0% in fixed income), Exhibit 7 shows the annual averages.

In the 60/40 equity/bond portfolio, almost all of the total portfolio risk came from equities…

Exhibit 7: Equity/Bond Portfolio Weight Allocation versus Risk Contribution



…while in the 10/90 equity/bond portfolio, the average contribution to risk generally mirrored the allocation weights.

All portfolios are hypothetical.
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to Dec. 31, 2019. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

There is clearly a non-linear relationship between the change in weight and the change in risk contribution. Since equities tend to be more volatile than bonds and the return correlation between the two is low, as the allocation to equities increases, their risk contribution to total portfolio volatility increases at a higher rate. The point where the two asset classes most closely contribute equally to portfolio volatility is at the 20/80 equity/bond mix.

Exhibits 6 and 7 show that the risk contribution percentages can be materially different from weight allocation percentages for assets in a portfolio. Building upon this conclusion, we construct a basic three-asset risk parity strategy and compare it to an equal-weight portfolio.

Equal-Weighting versus Equal-Risk-Weighting Strategies

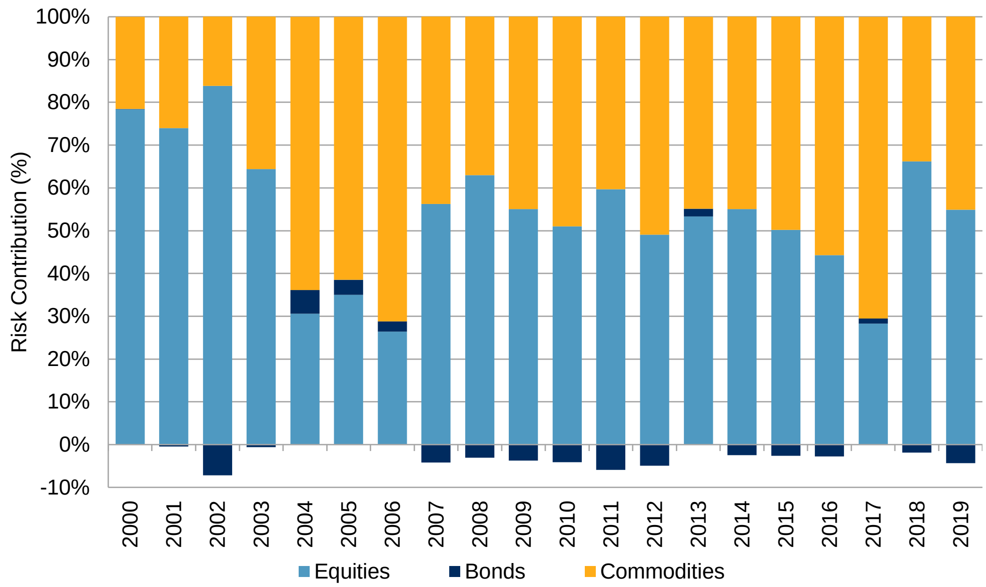
We then extended the analysis by adding commodities to construct a three-asset portfolio.

Here, we extend the analysis by adding commodities in order to construct a three-asset class portfolio. Commodities tend to show relatively low-to-moderate correlation to traditional asset classes such as equities and bonds and thereby provide diversification benefits in a multi-asset portfolio. Moreover, commodities generally perform well in periods of high growth and rising inflation. Like equities, commodities historically had relatively high return volatility. Hence, when combined in a three-asset portfolio with bonds, we anticipate that equities and commodities would contribute most to the total portfolio volatility.

We weighted the demonstration portfolios in two ways; one was equally weighted, and the other assumed an equal-risk-contribution approach.[5, 6] These will help us understand the effectiveness of weighting a portfolio where each asset contributes equally to portfolio risk, as opposed to equally weighting the assets. We first look at the risk decomposition of the equal-weight portfolio. To do so, we compute the contribution to risk for the portfolio on an annual basis (see Exhibit 8).

The equity and commodity asset classes were the primary contributors to total portfolio risk…

Exhibit 8: Equal-Weight Portfolio Risk Decomposition



The equal-weight portfolio is a hypothetical portfolio.
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to Dec. 31, 2019. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

…and in fact, bonds had a negative contribution to the total risk.

In 2019, equities contributed the most to portfolio volatility, at 55%—significantly higher than their one-third weight allocation. Commodities contributed the second most, at 49%, while fixed income actually contributed negatively, at -4%. For the whole period, we observed that equities and commodities were the dominant contributors to total portfolio risk.

In a market-cap-weighted portfolio, the risk is often significantly out of proportion with the weight of the asset class.

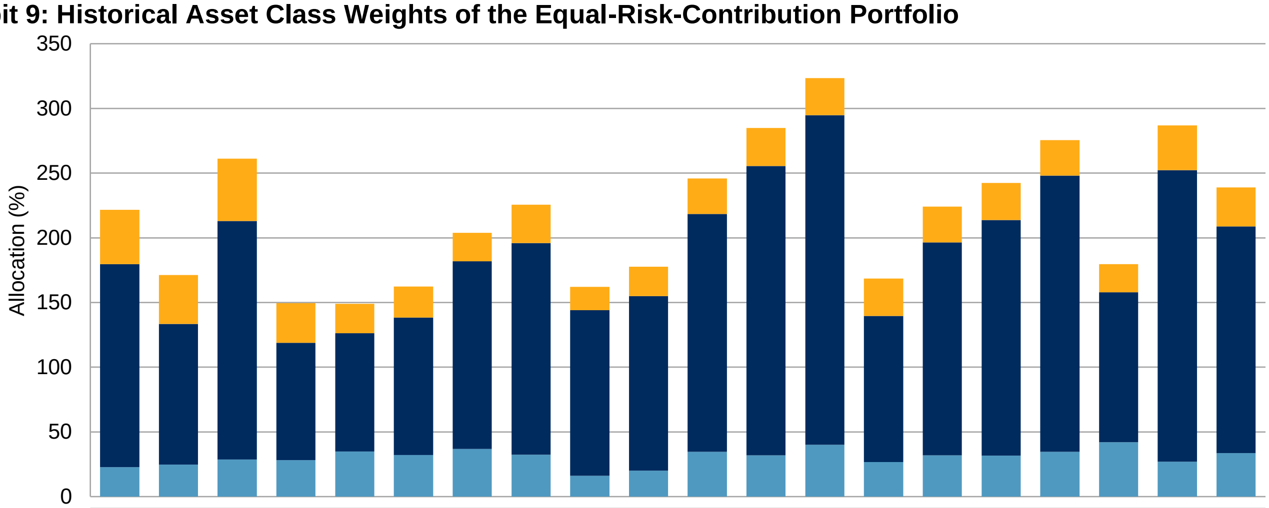
On average, equities contributed 54% and commodities 48%—therefore, bonds negatively contributed (nearly -2%) to the total risk. However, contributions varied from year to year; equities contributed as much as 84% to portfolio volatility in 2002, fixed income contributed 6% in 2004, and commodities contributed 71% in 2006 and 2017.

Next, we constructed an equal-risk-contribution portfolio with the same three assets. The portfolio was rebalanced annually, with the objective of arriving at an asset class mix where: 1) each asset class would contribute one-third of the total portfolio risk, and 2) the target volatility level would be set as the volatility of the equal-weight portfolio from the previous year.[6]

In an equal-risk-contribution portfolio, fixed income often exceeds 100% to get the risk contribute up to the risker asset classes' contributions.

Exhibit 9 shows the resulting weights of each asset class on an annual basis. The asset class weights of the equal-risk-contribution portfolio are quite different from the weights of the same asset classes in an equal-weight portfolio. In fact, the weight for fixed income often exceeds 100%, which is necessary to get the risk contribution up to the riskier asset classes' contributions. As individual asset class volatility and cross-correlations vary through time, the total nominal weight of the portfolio at the end of each year ranged from 149% to 324%.

Exhibit 9: Historical Asset Class Weights of the Equal-Risk-Contribution Portfolio



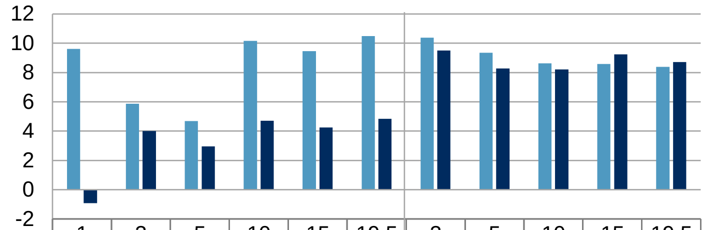
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Commodities	42	38	48	31	23	24	22	30	18	23	27	29	29	29	28	29	27	22	35	30
Bonds	157	109	184	91	91	106	145	163	128	135	184	224	255	113	164	182	214	116	225	175
Equities	23	25	29	28	35	32	37	32	16	20	35	32	40	27	32	32	35	42	27	34

The equal-risk-contribution portfolio is a hypothetical portfolio.
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to Dec. 31, 2019. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Comparing an equal-risk-contribution portfolio to an equal-weight portfolio shows us that they can have large differences in their performance…

Shifting to the impact that the two weighting schemes had on portfolio returns, Exhibit 10 shows the historical annualized return and volatility figures (see Appendix A for asset class returns and volatilities).

Exhibit 10: Historical Risk/Return Profile



	Annualized Return (%)						Annualized Volatility (%)				
	1 Year	3 Year	5 Year	10 Year	15 Year	19.5 Year	3 Year	5 Year	10 Year	15 Year	19.5 Year
Equal-Risk-Contribution Portfolio	9.62	5.86	4.69	10.15	9.47	10.49	10.39	9.35	8.63	8.58	8.39
Equal-Weight Portfolio	-0.93	4.02	2.96	4.71	4.25	4.84	9.51	8.27	8.22	9.24	8.71

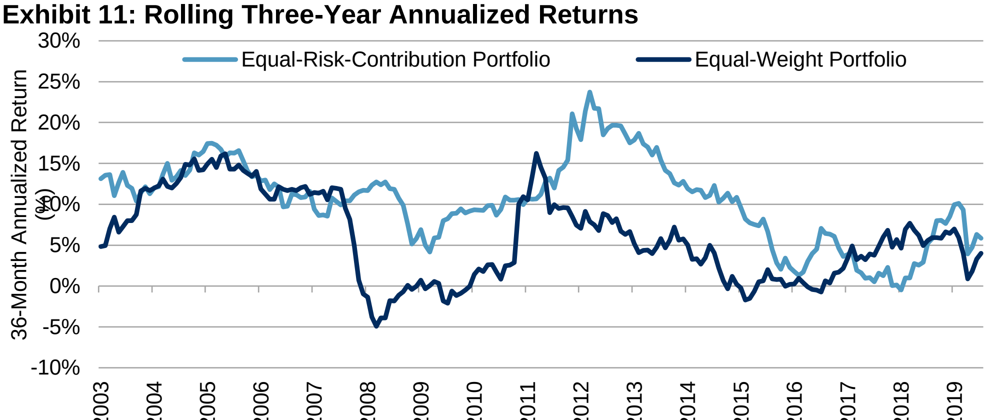
The equal-risk-contribution and equal-weight portfolios are hypothetical portfolios.
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Since the target volatility for the equal-risk-contribution portfolio is that of the equal-weight portfolio, the realized historical portfolio volatilities were similar. However, the return for the equal-risk-contribution portfolio was higher than its equal-weight counterpart across all periods measured.

…and in fact, the former outperformed the latter 84% of the time.

The long-term horizons (10, 15, and 19.5 years), covering multiple periods of bear markets in equities and commodities, show relatively high return spreads, and therefore showed substantially higher risk-adjusted returns. To further isolate performance in different periods, we also computed the rolling three-year annualized returns (see Exhibit 11).

Exhibit 11: Rolling Three-Year Annualized Returns



The equal-risk-contribution and equal-weight portfolios are hypothetical portfolios.
Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

In certain periods, the two portfolios performed similarly, while in others the equal-risk portfolio noticeably outpaced the equal-weight portfolio. The equal-risk portfolio outperformed the equal-weight portfolio 77% of the time and by an average of 4.51%.

Up to this point, we have shown that an equal-risk-contribution approach to constructing a multi-asset portfolio can potentially lead to higher absolute or risk-adjusted returns than an equal-weight approach. Building upon these findings, we introduce the S&P Risk Parity Indices in the sections below.

Risk parity aims to have equal contribution to portfolio volatility by the underlying asset classes…

III. INTRODUCING THE S&P RISK PARITY INDICES

Since 1996, many investment companies have begun to offer risk parity funds to their clients, especially in the aftermath of the global financial crisis. Such strategies have lacked an appropriate benchmark, leaving many to fall back on a traditional 60/40 equity/bond portfolio benchmark. One of the issues with this approach is that a 60/40 portfolio has a different construction and risk/return characteristics than risk parity portfolio strategies.

As we discussed previously, the traditional 60/40 approach leads to a disproportionate allocation of risk to equities (see Exhibit 6). A risk parity strategy, on the other hand, attempts to have a balanced risk contribution from all asset classes. Some benchmarks, such as the HFR Risk Parity Indices, bypass the portfolio construction of a risk parity strategy and instead use weighted average returns of active risk parity managers. Unfortunately, this approach lacks transparency in holdings and return attribution and may be subject to survivorship bias.

…and there are multiple ways to construct a risk parity portfolio.

With that in mind, we introduced the S&P Risk Parity Indices in an effort to provide transparent, rules-based benchmarks for risk parity strategies. The series constructs risk parity portfolios by using liquid futures that represent various asset classes and seeks to reflect the risk/return characteristics of strategies offered in this space. The index series comprises four indices with volatility targets of 8%, 10%, 12%, and 15%.

Constructing a Risk Parity Portfolio

As we noted in earlier sections, risk parity, or equal risk contribution by definition, aims to have equal portfolio volatility contribution by the underlying asset classes. There are multiple ways to construct a risk parity portfolio, depending on how one measures and defines risk.

In a standard Markowitz mean-variance framework, risk is defined as the standard deviation of an asset's returns. Alternatively, one could use value at-risk (VaR) as a measure of risk. The advantage of using VaR over standard deviation is that it incorporates skewness and kurtosis.

The simplest approach may be to set each asset's weight to be proportional to the inverse of its standard deviation.

The result is that on a relative basis, lower volatile assets will have a higher weight than higher volatile assets.

However, in practice, standard deviation, or volatility, of returns is the default adopted by investors to measure risk. Since we measure risk by volatility, the contribution of each asset class to the total risk of the portfolio is easily determined. For a multi-asset portfolio, the marginal contribution of the i^{th} asset to total portfolio risk is illustrated in Equations 1a and 1b.

$$\mathrm{MC_i} = \mathrm{w_i} * \sigma_\mathrm{p} * \beta_\mathrm{i} \tag{1a}$$

Where β_i is defined as:

$$\beta_\mathrm{i} = \frac{\mathrm{Cov}(\sigma_\mathrm{i},\sigma_\mathrm{p})}{{\sigma_\mathrm{p}}^2} \tag{1b}$$

A top-down approach to building a risk parity portfolio often uses an optimizer to adjust asset class weights until the marginal contributions to portfolio risk are all equal. However, the computational complexity of the covariance matrix estimation is proportional to the square of the number of underlying securities. The result is that the process could be data intensive and time consuming. Besides, many market participants tend to steer away from the "black box" nature of optimizers and prefer transparency in the allocation process.

Arguably, the simplest approach to build an equal-risk portfolio is to set each asset's weight to be proportional to the inverse of its standard deviation (see Equation 2). The result is that on a relative basis, lower volatile assets will have a higher weight than higher volatile assets.

$$\mathrm{w_i} = \frac{1/\sigma_\mathrm{i}}{\Sigma(\frac{1}{\sigma_i})} \tag{2}$$

In the actual implementation of risk parity, the cross-correlation of assets is typically considered in addition to individual asset class volatility. Other measures of risk can be used in certain cases, but this simple approach is often a starting point for more advanced techniques.

In *Understanding Risk Parity* (Hurst et al., 2010), AQR proposes another simple risk parity strategy, which targets a similar amount of volatility from each asset class each month. This approach begins by estimating an expected volatility for each asset class. The position weight for each asset class, calculated at the beginning of each month, is the TV level divided by the forecasted volatility for that asset class (see Equation 3).

$$\mathrm{w_i} = \frac{\text{Target Volatility}}{\sigma_\mathrm{i}} \tag{3}$$

Actual portfolio construction would then incorporate asset class correlations, volatility forecasting, and volatility targeting, as well as tactical over- and underweights.

Indexing Risk Parity Strategies

The approach taken by the S&P Risk Parity Indices uses a fixed volatility target and aims for the same amount of volatility from each asset class…

The approach taken by the S&P Risk Parity Indices is similar to AQR's proposal in that it uses a fixed volatility target and aims for the same amount of volatility from each asset class. This ensures that: 1) less capital is allocated to more volatile asset classes, and 2) portfolio holdings shift as volatility changes.

We also believe that a fixed volatility target can lead to more consistent risk/return statistics for the overall portfolio. To avoid the complexities involved with volatility forecasting, we instead use the long-term realized volatility of the asset classes. The lookback window for realized volatility is a minimum of five years at the beginning of the historical back-test and increases up to 15 years as time passes and the strategy accumulates more data.

…which ensures that less capital is allocated to more volatile asset classes…

CONSTITUENTS

The benchmark includes 26 liquid futures that cover developed market equities, fixed income, and commodities. Futures contracts are the implementation vehicle of choice for several reasons. First, they provide liquid, low cost, and transparent access to commodities. Second, they provide efficient coverage of equities—the three equity index futures in the risk parity indices cover 775 individual securities. Third, the structure of futures contracts limits the total foreign currency exposure inherent in investing in international markets; the exposure is limited to the profit or loss of the position, as opposed to the entire notional value of the contract. Finally, funding rates are implicit in futures contract pricing. Therefore, we know that all investors will get the same outcome. This is particularly important given that a risk parity strategy usually uses leverage. To be considered liquid, futures contracts must have a minimum annual total dollar value traded of USD 5 billion. Please refer to Appendix A for the complete list of futures contracts and their roll schedules.

…and portfolio holdings shift as volatility changes.

We use long-term realized volatility rather than forecasted volatility to measure risk, to avoid the dependency of volatility forecasting models.

Exhibit 12: Constituents

EQUITIES		BONDS		COMMODITIES	
CONTRACT	**CODE**	**CONTRACT**	**CODE**	**CONTRACT**	**CODE**
S&P 500®	ES	U.S. T-Notes (5-year)	FV	Crude Oil	CL
Euro Stoxx 50	FESX	U.S. T-Notes (10-year)	TY	Natural Gas	NG
Nikkei 225 Futures	NKJ	U.S. T-Bonds (30-year)	US	Brent Crude	B
		Euro-Bobl	FGBM	Gasoline	RB
		Euro-Bund	FGBL	Heating Oil #2	HO
		Long Gilt	LG	Gas Oil	G
		JBG (10-year)	JGB	Gold (100 oz.)	GC
				Silver	SI
				Copper	HG
				Corn	C
				Wheat	W
				Soybeans	S
				Live Cattle	LC
				Sugar #11	SB
				Coffee "C"	KC
				Cotton #2	CT

Source: S&P Dow Jones Indices LLC. Data as of June 30, 2020. Table is provided for illustrative purposes.

To balance true risk over at least one full market cycle and avoid incorporating historical volatility in the distant past…

RISK MEASUREMENT

In the S&P Risk Parity approach, we use long-term realized volatility to measure risk. Realized volatility rather than forecasted volatility is used to avoid the dependency of volatility forecasting models. A short lookback window may react more quickly to market movement, but it may not reflect the true risk over time. To balance true risk over at least one full market cycle and avoid incorporating historical volatility in the distant past, the preference is to use a 15-year lookback window.

…the preference is to use a 15-year lookback window.

Due to data limitations, the lookback window in the historical back-test has a minimum of a five-year history for each asset class at the start and then is increased until the maximum of 15 years is reached.

WEIGHTING MECHANISM

We use a bottom-up approach to determine the weight of each futures contract…

We use a bottom-up approach to construct the hypothetical portfolio. Within each asset class, futures are weighted to the inverse of its realized volatility. We then calculate the realized volatility for each asset class, given the current composition of the portfolio calculated in the previous step. The hypothetical portfolio is then constructed so that each asset class is weighted to the inverse of its realized volatility. Finally, we compute the realized volatility of this multi-asset portfolio, using the current composition, compare it with the predetermined TV level, and calculate the leverage. This approach avoids estimating the variance-covariance matrix, while still capturing historical correlation effects.

We repeat this process at the end of each month and rebalance to new weights on the second trading day of the following month.

S&P RISK PARITY INDEX CONSTRUCTION

…and then we group these securities into three asset classes: equity, fixed income, and commodities.

In this section, we illustrate the index construction process of the S&P Risk Parity Index – 10% Target Volatility (TV). The futures' and asset classes' realized volatility used in the illustration are hypothetical. While 10% is the TV set in this example, the process is the same for the other volatility targets of 8%, 12%, and 15%.

There are three major steps to constructing the index.

We combine all the asset classes and compute the realized volatility of the portfolio, which is usually lower than the target volatility due to the correlation among asset classes.

1) We use a bottom-up approach to determine the weight of each futures contract. We begin by calculating the long-term realized volatility for each futures contract. We then group these securities into three asset classes: equity, fixed income, and commodities. The contract position weight within each asset class is proportional to the inverse of its standard deviation (see Equation 2).
2) We then compute the realized volatility of each asset class, using the composition calculated in the previous step. The asset class weight in the final portfolio is proportional to the inverse of its standard deviation.
3) We compute the realized volatility of the portfolio, using the current composition calculated in the previous step. This is usually lower than the TV due to the correlation among asset classes. We then calculate a portfolio-level leverage as the TV divided by the realized volatility of the portfolio.

   Note that this final step is not required for the purpose of equal risk allocation among assets; this step keeps the portfolio's long-term risk in line with its target.

Positions of each constituent are calculated at the end of each month, and they become effective on the second trading day of the next month.

Historical Performance

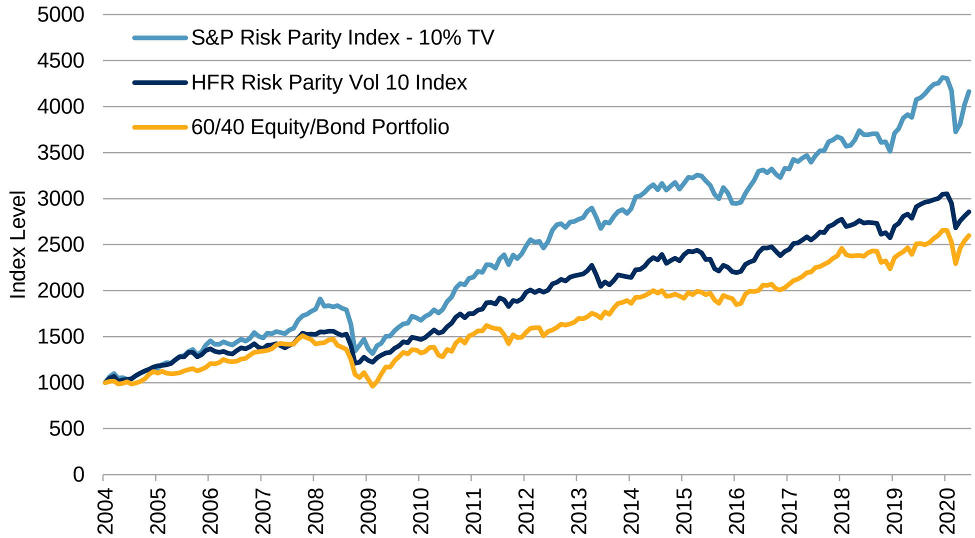
We use the S&P Risk Parity Index – 10% Target Volatility as an example to illustrate historical performance and risk/return characteristics.

In this section, we use the S&P Risk Parity Index – 10% TV as an example to illustrate historical performance and risk/return characteristics. Exhibits 13 and 14 show the cumulative returns of the index and other key performance statistics.

We compared it with a traditional 60/40 equity/bond portfolio and the HFR Risk Parity Vol 10 Index as a proxy of active risk parity funds in the market.[7] For reference, the HFR Risk Parity Indices represent the weighted average performance of the universe of active fund managers, employing an equal-risk-contribution approach in their portfolio construction. These indices have three volatility targets (10%, 12%, and 15%).

The historical performance shows that the index tracked the risk parity active fund managers much closer than the 60/40 portfolio…

Exhibit 13: Cumulative Returns



The 60/40 equity/bond portfolio is a hypothetical portfolio.
Source: S&P Dow Jones Indices LLC, HFR Index, LLC. Data from Jan. 31, 2004, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

…with higher correlation and lower tracking error.

Exhibit 14: Performance Statistics

METRIC	S&P RISK PARITY INDEX – 10% TV	HFR RISK PARITY VOL 10 INDEX	60/40 EQUITY/BOND PORTFOLIO
Annual Return (%)	9.08	6.60	5.99
Annual Volatility (%)	10.28	8.55	10.22
Sharpe Ratio	0.88	0.77	0.59
Maximum Peak-to-Trough Drawdown (%)	-31.16	-22.44	-36.42
Annualized Tracking Error (%)	4.21	-	6.33
Correlation	0.92	-	0.79

The 60/40 equity/bond portfolio is a hypothetical portfolio.
Source: S&P Dow Jones Indices LLC, HFR Index, LLC. Data from Jan. 31, 2004, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Risk parity, by definition, aims for balanced risk contribution from all asset classes.

The historical performance shows that the S&P Risk Parity Index – 10% TV tracked the risk parity active fund managers much closer than the 60/40 portfolio, with higher correlation (0.92 versus 0.79) and lower tracking error (4.21% versus 6.33%). The overall annualized return, realized volatility, and Sharpe ratio of the S&P Risk Parity Index – 10% TV were higher than the average numbers of active risk parity fund managers in the market. Performance statistics of the other indices in the S&P Risk Parity Index Series can be found in Appendix C.

Attribution and Allocation

Hence, a proper benchmark of risk parity strategies should demonstrate roughly equal risk contribution from all asset classes.

Risk parity, by definition, aims for balanced risk contribution from all asset classes. Hence, a proper benchmark of risk parity strategies should demonstrate roughly equal risk contribution from all asset classes. In this section, we continue to use the S&P Risk Parity Index – 10% TV as an example to illustrate volatility distribution, return contribution, and capital allocation.

VOLATILITY DISTRIBUTION

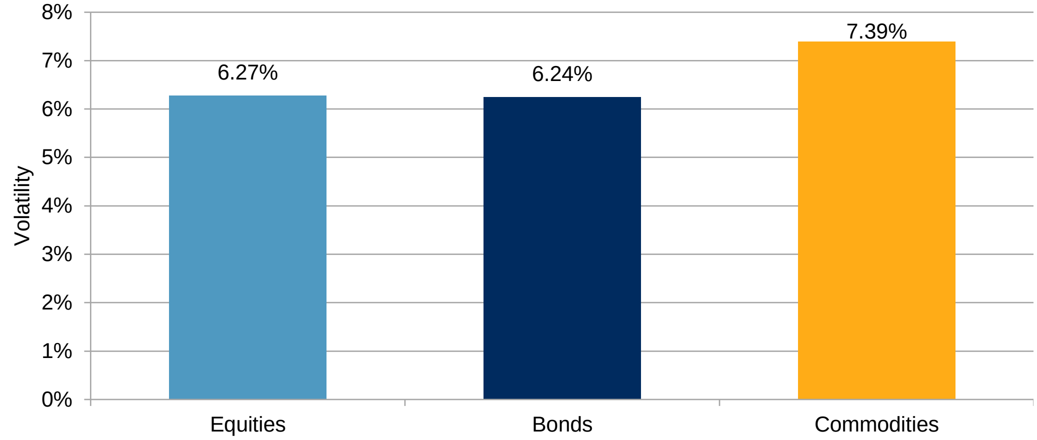
For the 16.5-year period, equities, fixed income, and commodities showed roughly the same volatility.

Exhibit 15 shows the back-tested historical volatility at the asset class level, weighted as in the index composition. Over the past 16.5 years, equities and fixed income displayed roughly the same volatility after they were weighted to the inverse of their volatilities. Commodities' realized volatility was generally higher. This is because commodities as an asset class experienced elevated volatility between 2008 and 2012, which was slowly factored into the allocation process since the index has a long lookback window for volatility calculation.

Nevertheless, no single asset class had an overwhelming realized volatility in the back-tested period. This was not surprising, since we used realized historical volatilities as the risk measure. For example, at the beginning of October 2008, the index allocated 15.75% (prior to leverage) to equities. After incorporating the volatility of 2008 into the historical lookback period for the realized volatility calculation, equity allocation gradually dropped and was below 15% one year later.

Historical capital allocation verifies that an equal-risk allocation is materially different from an equal weight allocation.

Exhibit 15: Realized Volatility of Weighted Asset Class of the S&P Risk Parity Index – 10% TV (Post Leverage)



Source: S&P Dow Jones Indices LLC. Data from Jan. 6, 2004, to July 6, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

CAPITAL ALLOCATION

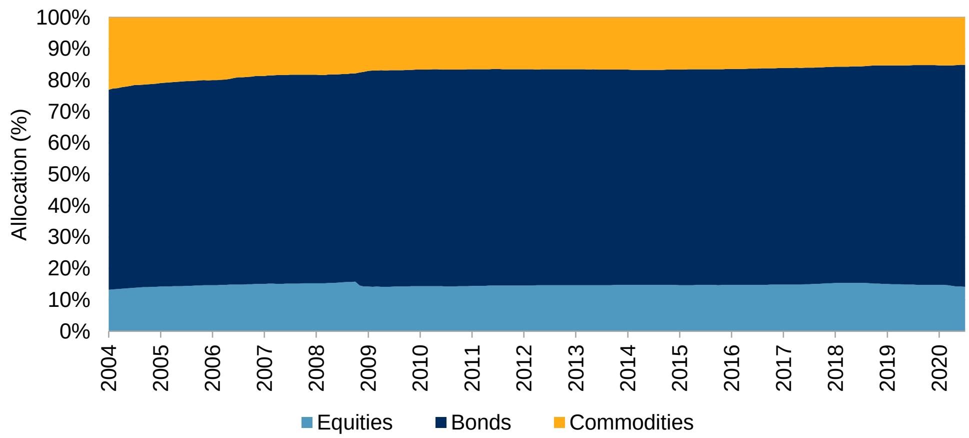
Fixed income had the largest capital allocation, to ensure its equal risk contribution to the portfolio (about two-thirds)…

Historical capital allocation verifies that an equal-risk allocation is materially different from an equal weight allocation (see Exhibit 16). Fixed income, the least volatile asset class, had the largest capital allocation to ensure its equal risk contribution to the portfolio.

…while the remaining one-third was split roughly evenly between equities and commodities.

In the 16.5-year back-tested period, approximately two-thirds of the capital was allocated to fixed income (mean = 67.8%, median = 68.7%). The remaining one-third of capital was split roughly evenly between equities (mean = 14.7%, median = 14.7%) and commodities (mean = 17.5%, median = 16.6%). The allocations among the three asset classes were stable over time.

Exhibit 16: Capital Allocation by Asset Class of the S&P Risk Parity Index – 10% TV



Source: S&P Dow Jones Indices LLC. Data from Jan. 6, 2004, to July 6, 2020. Chart is provided for illustrative purposes.

RETURN CONTRIBUTION

The equal risk allocation did not lead to equal return contribution.

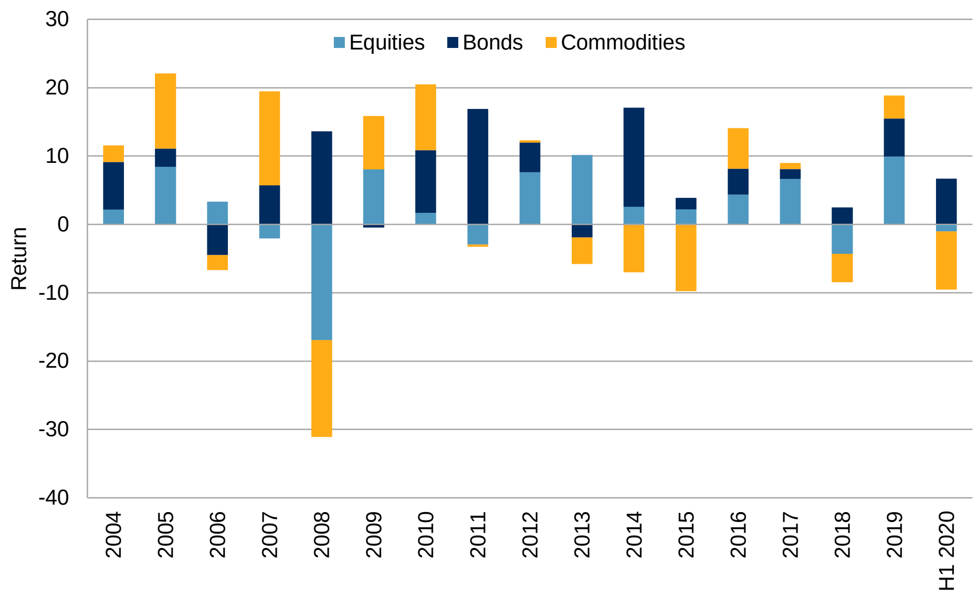
The historical performance of each asset class shows that equal risk allocation did not lead to equal return contribution (see Exhibit 17). Fixed income contributed the highest return to the overall portfolio over the full period studied, as this low-volatility asset class tends to be overweighted in risk parity strategies.

The return decomposition of the S&P Risk Parity Index – 10% TV showed that the return contribution of the three asset classes varied significantly from year to year, due to changes in the performance of individual asset classes and the correlation among them, affecting the overall portfolio performance. In 2008 and early 2020, equities and commodities experienced market drawdown, and only fixed income had a positive return. As a result, the overall portfolio posted a loss.

Fixed income contributed the highest return to the overall portfolio over the full period studied…

…as this low-volatility asset class has been overweighted in risk parity strategies.

Exhibit 17: Annual Weighted Return by Asset Class of the S&P Risk Parity Index – 10% TV



Source: S&P Dow Jones Indices LLC. Data from Jan. 6, 2004, to July 6, 2020. Past performance is no guarantee of future results. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

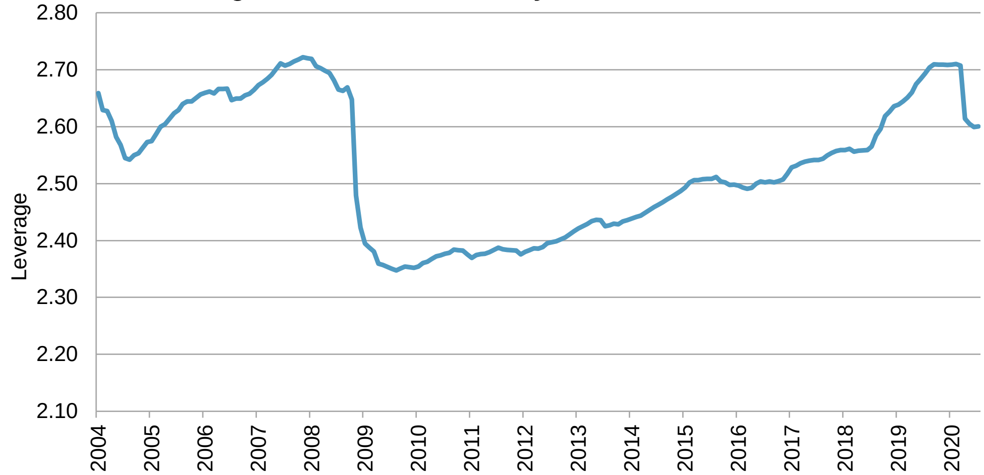
Leverage

Another key feature of risk parity strategies is the application of leverage. According to the capital asset pricing model, long-term asset class returns are generally proportional to the risk taken. Since risk parity portfolios tend to have a higher allocation to asset classes with lower volatility, such as fixed income, fund managers usually use leverage to make the risk contribution the same among the asset classes. The combination of equal-risk contribution and leverage helps the risk parity portfolio to meet the challenges of achieving market returns while reducing the risk of a multi-asset portfolio.

Risk parity strategies aim to build balanced risk portfolios that deliver higher risk-adjusted returns than the broad-based market.

Employing the S&P Risk Parity Index – 10% TV as an example, leverage historically ranged between 2.35 and 2.72 (see Exhibit 18). On average, the portfolio had a leverage of 2.53. As leverage is dependent on the TV, it typically increased in low-volatility environments and dropped in high-volatility environments. It is expected that leverage would climb higher as the TV increases.

Exhibit 18: Leverage of the S&P Risk Parity Index – 10% TV



Source: S&P Dow Jones Indices LLC. Data from Jan. 6, 2004, to July 6, 2020. Chart is provided for illustrative purposes.

IV. CONCLUSION

Variations in implementation have led to the lack of an appropriate benchmark.

Risk parity strategies aim to build balanced risk exposure portfolios that deliver higher risk-adjusted returns than the broad-based market or a traditional 60/40 portfolio. Although the concept is widely accepted, variations in implementation have led to the lack of an appropriate benchmark in the market. Some existing indices use a weighted average of active risk parity fund performance, but these lack transparency and are also subject to survivorship bias.

The S&P Risk Parity Indices aim to serve as a transparent, rules-based implementation of risk parity strategies.

The S&P Risk Parity Indices aim to serve as a transparent, rules-based passive implementation of risk parity strategies. Data show that the indices track active risk parity funds much closer than a traditional 60/40 equity/bond portfolio. Additionally, the realized volatilities of weighted asset classes were roughly equal; no asset class had an overwhelming volatility compared with the others.

ENDNOTES

1. The S&P 500 represented U.S. equities; the S&P Developed Ex.-U.S. BMI represented international equities; the S&P Emerging BMI represented emerging market equities; the Dow Jones U.S. Real Estate Index represented real estate; the Dow Jones Commodity Index represented commodities; the S&P U.S. Treasury Bond Index represented investment-grade bonds from Dec. 31, 1999, to April 30, 2002, and after that, the category was represented by the S&P U.S. Aggregate Bond Index; the S&P U.S. High Yield Corporate Bond Index represented high-yield Bonds, and the S&P Global Developed Sovereign Ex-US Bond Index represented international sovereign bonds.
2. The box and whisker chart summarizes the distribution of the returns of a time series, highlighting the mean and outlier range. What follows is a description of the chart content. The shaded box is the inter-quartile range, which includes all returns between quartile 1 and quartile 3. Inside the box, the "x" represents the mean and the line across the box represents the median. The endpoints of the whisker lines, which extend out below and above the shaded area, are the local minimum and local maximum. The local range signifies that the chart excludes outliers. A data point is considered an outlier if it is greater (less) than quartile 3 (1) plus (minus) 150% times the inter-quartile range distance. The inter-quartile range distance is the distance from quartile 1 to quartile 3.
3. We rebalanced the allocation mixes to their target weights annually at the end of each year.
4. The contribution to portfolio risk for each asset class was determined at the end of each year based on that year's daily returns. Computationally, the marginal contribution of asset i to the portfolio risk is:

$$MC_i = w_i * \sigma_p * \beta_i$$

   Where β_i is defined by:

$$\beta_i = \frac{Cov(\sigma_i, \sigma_p)}{{\sigma_p}^2}$$

5. The portfolio is equally weighted and rebalanced annually at the end of the year.
6. To construct the equal-risk-contribution portfolio, at the beginning of each calendar year, we used the past one year of daily returns and the resulting covariance matrix to compute the marginal contribution to risk for each asset class. We employed an optimizer to determine the final set of weights such that each asset class contributed approximately one-third of the total portfolio volatility, subject to several constraints. We set the target portfolio volatility to be equal to the realized portfolio volatility of the equal-weight portfolio from the prior year, subject to a maximum of 10%. The portfolio is constrained to be long only (no negative weights or shorting). Lastly, using the three-month U.S. Treasury bill as the borrow cost, leverage was allowed for fixed income. Hence, the total nominal portfolio weight could exceed 100%.
7. The 60/40 equity/bond portfolio was hypothetically constructed by combining the S&P Developed BMI with 60% weight and the S&P Global Developed Aggregate Ex-Collateralized Bond Index with 40% weight, rebalanced monthly.

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APPENDIX A: ASSET CLASS AND THREE-ASSET PORTFOLIO PERFORMANCE

Exhibit A1: Asset Class Performance

PERIOD	EQUITIES	BONDS	COMMODITIES
ANNUALIZED RETURN (%)			
1-Year	7.51	8.37	-19.05
3-Year	10.73	5.05	-4.54
5-Year	10.73	4.02	-6.71
10-Year	13.99	3.55	-4.21
15-Year	8.83	4.14	-1.89
18-Year	5.74	4.93	2.54
ANNUALIZED VOLATILITY (%)			
3-Year	16.95	3.04	16.25
5-Year	14.76	2.85	15.26
10-Year	13.42	2.69	15.44
15-Year	14.71	3.22	17.36
18-Year	15.02	3.56	16.34
RETURN/RISK			
3-Year	0.63	1.66	-0.28
5-Year	0.73	1.41	-0.44
10-Year	1.04	1.32	-0.27
15-Year	0.60	1.29	-0.11
18-Year	0.38	1.39	0.16

Source: S&P Dow Jones Indices LLC. Data from Dec. 31, 1999, to June 30, 2020. Index performance based on monthly total return in USD. The portfolio resets to equal weights annually at each year's end. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

APPENDIX B: FUTURES CONTRACTS AND ROLL SCHEDULES

Exhibit B1: Futures Contracts and Roll Schedules

SECTOR/REGION	CONSTITUENT	EXCHANGE	SECTOR	CURRENCY	INDEX NAME
CURRENT COMMODITIES					
Energy	Natural Gas	NYMEX	E	USD	S&P GSCI Natural Gas
	Heating Oil #2	NYMEX	E	USD	S&P GSCI Heating Oil
	Gas Oil	ICE	E	USD	S&P GSCI Gasoil
	Crude Oil	NYMEX	E	USD	S&P GSCI Crude Oil
	Brent Crude	ICE	E	USD	S&P GSCI Brent Crude Oil
	Gasoline	NYMEX	E	USD	S&P GSCI Unleaded Gasoline
Softs & Livestock	Sugar #11	ICE	C	USD	S&P GSCI Sugar
	Live Cattle	CME	C	USD	S&P GSCI Live Cattle
	Coffee "C"	ICE	C	USD	S&P GSCI Coffee
	Cotton #2	ICE	C	USD	S&P GSCI Cotton
Grains	Soybeans	CBOT	C	USD	S&P GSCI Soybeans
	Corn	CBOT	C	USD	S&P GSCI Corn
	Wheat	CBOT	C	USD	S&P GSCI Wheat
Metals	Copper	COMEX	C	USD	S&P GSCI North American Copper
	Gold (100 oz.)	COMEX	C	USD	S&P GSCI Gold
	Silver	COMEX	C	USD	S&P GSCI Silver
FIXED INCOME					
U.S.	T-Notes (10-year)	CBOT	FI	USD	S&P 10-Year U.S. Treasury Note Futures Index
	T-Notes (5-year)	CBOT	FI	USD	S&P 5-Year U.S. Treasury Note Futures Index
	T-Bonds (30-year)	CBOT	FI	USD	S&P U.S. Treasury Bond Futures Index
Europe	Long Gilt	ICE	FI	GBP	S&P Long Gilt Futures Index
	Euro-Bund	EUREX	FI	EUR	S&P Euro-Bund Futures Index
	Euro-Bobl	EUREX	FI	EUR	S&P Euro-Bobl Futures Index
Asia	JGB (10-year)	JPX	FI	JPY	S&P 10-Year JGB Futures Index
EQUITIES					
U.S.	S&P 500 E-mini	CME	SI	USD	S&P 500 Futures ER Index
Europe	Euro Stoxx 50	EUREX	SI	EUR	Euro Stoxx 50 Futures Index
Asia	Nikkei 225 Futures	JPX	SI	JPY	Nikkei 225 Futures Index

Source: S&P Dow Jones Indices LLC. Data as of July 2020. Table is provided for illustrative purposes.

The Euro Stoxx 50 Futures Index and the Nikkei 225 Futures Index both use the first month futures and roll to the next month futures three business days prior to the expiry.

APPENDIX C: HISTORICAL PERFORMANCE

Exhibit C1 compares the historical performance of the S&P Risk Parity Indices to the traditional 60/40 equity/bond portfolio over the period from January 2004 to June 2020. There are three key observations.

First, the S&P Risk Parity Indices with different volatility targets delivered similar Sharpe ratios during the period. This was expected, since they are essentially the same portfolio in terms of relative weighting, but with different levels of leverage.

Second, the indices had a higher Sharpe ratio compared with the 60/40 equity/bond portfolio. The material increase in risk-adjusted returns could be driven by the portfolio construction methodology and improved risk diversification. The 60/40 equity/bond portfolio delivered similar annualized volatility compared with the S&P Risk Parity Index – 10% TV, but with a lower Sharpe ratio and a larger maximum drawdown.

Third, these indices did relatively better in most of the major market shocks (equities or bonds) since 2003, including the global financial crisis from 2007-2009, the Europe/Greece debt crisis in 2010, and the downgrade of U.S. debt in 2011. When the market experienced a sudden drop in a short time frame, as we saw in March 2020, however, the risk parity indices did not respond quickly enough and lagged the 60/40 equity/bond portfolio, due to the long lookback period used in realized volatility calculation.

Exhibit C1: Historical Performance of S&P Risk Parity Indices versus a 60/40 Equity/Bond Portfolio

METRIC	S&P RISK PARITY INDEX – 8% TV	S&P RISK PARITY INDEX – 10% TV	S&P RISK PARITY INDEX – 12% TV	S&P RISK PARITY INDEX – 15% TV	60/40 EQUITY/BOND PORTFOLIO
Annual Return (%)	7.63	9.14	10.61	12.76	6.05
Annual Volatility (%)	8.21	10.26	12.31	15.39	10.19
Sharpe Ratio	0.93	0.89	0.86	0.83	0.59
Maximum Peak-to-Trough Drawdown (%)	-25.41	-31.16	-36.59	-44.13	-36.42
CUMULATIVE RETURNS (%) – SELECT PERIODS					
Global Financial Crisis (October 2007-February 2009)	-18.9	-23.8	-28.6	-35.4	-36.4
Europe/Greece Debt Crisis (March-June 2010)	2.4	3.0	3.5	4.4	-7.2
Downgrade of U.S. Debt (August-November 2011)	-1.3	-1.7	-2.0	-2.7	-2.2
Inflation Fears (January 2018-March 2018)	-1.6	-2.0	-2.5	-3.2	-3.4
March 2020	-8.5	-10.7	-12.9	-16.3	-9.3

Source: S&P Dow Jones Indices LLC. Data from Jan. 6, 2004, to June 30, 2020. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. Table is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

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PERFORMANCE DISCLOSURE

The Dow Jones Commodity Index was launched October 26, 2011. The S&P U.S. Treasury Bond Index was launched March 24, 2010. The S&P U.S. Aggregate Bond Index was launched July 15, 2014. The S&P U.S. High Yield Corporate Bond Index was launched December 15, 2016. The S&P Global Developed Sovereign Ex-US Bond Index was launched January 22, 2016. The S&P Global Developed Aggregate Ex-Collateralized Bond Index was launched July 5, 2016. The S&P Risk Parity Index – 10% Target Volatility, S&P Risk Parity Index – 12% Target Volatility, and S&P Risk Parity Index – 15% Target Volatility were launched July 11, 2018. All information presented prior to an index's Launch Date is hypothetical (back-tested), not actual performance. The back-test calculations are based on the same methodology that was in effect on the index Launch Date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. Complete index methodology details are available at www.spdji.com. Past performance of the Index is not an indication of future results. Prospective application of the methodology used to construct the Index may not result in performance commensurate with the back-test returns shown.

S&P Dow Jones Indices defines various dates to assist our clients in providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the Index is set at a fixed value for calculation purposes. The Launch Date designates the date upon which the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P Dow Jones Indices defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its datafeed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

The back-test period does not necessarily correspond to the entire available history of the Index. Please refer to the methodology paper for the Index, available at www.spdji.com for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations.

Another limitation of using back-tested information is that the back-tested calculation is generally prepared with the benefit of hindsight. Back-tested information reflects the application of the index methodology and selection of index constituents in hindsight. No hypothetical record can completely account for the impact of financial risk in actual trading. For example, there are numerous factors related to the equities, fixed income, or commodities markets in general which cannot be, and have not been accounted for in the preparation of the index information set forth, all of which can affect actual performance.

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