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July 2017

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Asset Allocation

CONTRIBUTION TO RISK: AN INSIGHTFUL METRIC FOR PORTFOLIO CONSTRUCTION

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EXECUTIVE SUMMARY

- When developing their strategic asset allocations, investors often use a range of diagnostic tools to analyze the impact that a given position could have on portfolio outcomes. These estimates are typically based on a given set of portfolio exposures, the expected returns and volatilities of the asset classes involved, and the expected correlations among those asset classes.
- In this paper, we explore the use of an additional metric—contribution to risk (CTR)—that can help investors and analysts measure the expected contribution of each allocation to potential loss within a portfolio.
- CTR serves as a risk disaggregation measure, estimating the contribution to total portfolio volatility expected from each individual asset class. By analyzing their portfolios in this manner, investors can determine the sensitivity of the portfolio optimization process to small changes in their modeling assumptions.
- We examine CTR across two common portfolio construction methods: a standard multi-asset balanced portfolio and a portfolio constructed using a risk parity approach. We also show how expected portfolio volatility and the sources of that volatility can change in market environments that are more stressful than an investor's original assumptions.

THE EVOLUTION OF RISK DISAGGREGATION

Future asset class returns, volatilities, and cross-correlations are unknown and unknowable ex-ante; however, investors seeking to design efficient portfolios will often make assumptions about the expected values of these variables. While each asset class contributes to the total risk of a portfolio, these contributions are not equal across asset classes and can change significantly

with small changes in the underlying assumptions. The magnitude of these changes also can differ across asset classes. Stocks are more volatile than bonds, for example, but contributions to total risk from bond allocations tend to be more sensitive to estimation error.

CTR DEFINED

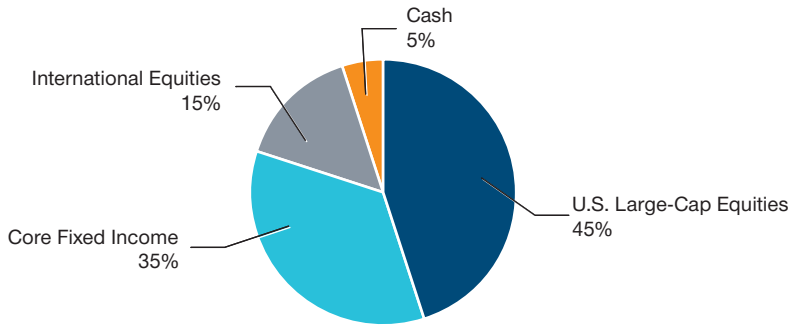
CTR is the percentage contribution to expected total portfolio volatility from each position in an investor's portfolio. It is a function of the current allocation, volatility and cross-correlation assumptions. A useful interpretation of CTR is expected percentage contribution to portfolio loss from a particular position. For this reason, CTR is often used as a measure of diversification.

CTR UNDER A BALANCED PORTFOLIO APPROACH

Based on a portfolio's asset allocation and the volatility and correlation assumptions behind those allocations, investors can calculate an insightful breakout of risk using the CTR metric. We illustrate this process by applying it to two hypothetical portfolios. Our first example can be considered a typical multi-asset balanced portfolio, allocated 60% to equities (split between U.S. and international stocks) and 40% to fixed income or cash instruments (Figure 1).[1]

Using the allocation, correlation, and volatility assumptions shown in Figure 2, we can calculate the risk contribution made by each portfolio holding using the CTR metric. As is commonly observed, the risk contributed by equities is much higher relative to their weight in the portfolio compared with the contribution from fixed income and cash (Figure 3). About 97% of total portfolio volatility can be attributed to the 60% allocation to equities, given the assumptions in Figure 2.

FIGURE 1: A Hypothetical Balanced Portfolio



Source: T. Rowe Price
The above details are indicative and are for illustrative purpose only. These are subject to change without further notice.

FIGURE 2: Baseline Assumptions

			Correlation			
Asset Class	Weight	Volatility	U.S. Large-Cap Equities	Core Fixed Income	International Equities	Cash
U.S. Large-Cap Equities	45%	18%	1.00	—	—	—
Core Fixed Income	35	6.5	-0.11	1.00	—	—
International Equities	15	20	0.93	0.05	1.00	—
Cash	5	0	0.00	0.00	0.00	1.00

Source: T. Rowe Price
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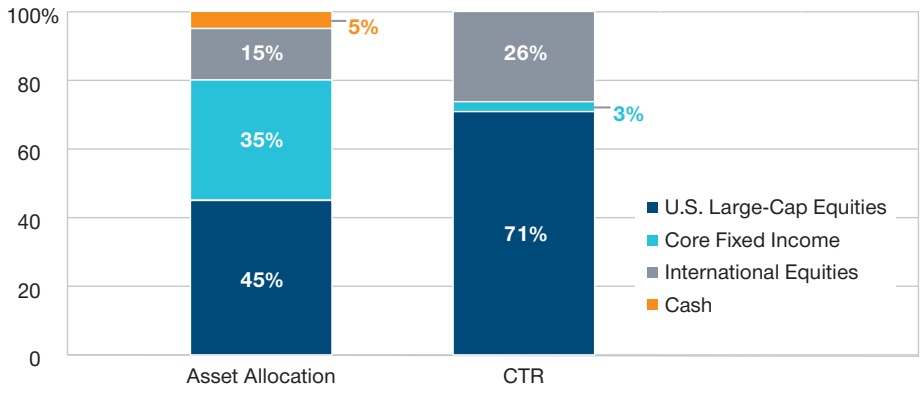
FIGURE 3: Asset Allocation and CTR for a Balanced Portfolio



Source: T. Rowe Price
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[1]In the allocations shown in Figure 1, U.S. large-cap equity is represented by the S&P 500 Index, international equity is represented by the Morgan Stanley Capital International All Country World Index, core fixed income is represented by the Bloomberg Barclays U.S. Aggregate Bond Index, and cash is represented by the 30-Day Treasury Bill.

CTR UNDER A RISK PARITY APPROACH

As noted above, almost all of the expected risk in a balanced portfolio comes from equities. This relationship has led some investors to adopt a risk-based approach to portfolio construction, in which allocation weights are set so that each asset class contributes a relatively equal amount to total portfolio risk. The resulting "risk parity" portfolio differs from a balanced portfolio by increasing allocations to less volatile assets. An investor desiring an equal contribution to risk from fixed income, international equity, and U.S. equity allocations might design the hypothetical portfolio shown in Figure 4.

As expected, the risk parity approach increases the fixed income allocation relative to the balanced portfolio. Contributions to portfolio volatility are evenly distributed across the asset classes, given the initial assumptions. However, we will see that as these assumptions are changed, the CTRs for each asset class will drift from parity.

IMPACT OF ESTIMATION ERROR IN A CTR FRAMEWORK

In addition to decomposing portfolio risk, CTR also can be used to test the sensitivity of portfolio risk to shifts in capital market expectations. Since the CTR metric relies on asset allocation, volatility, and correlation assumptions, changes in these variables will result in nonlinear shifts in CTR itself. To illustrate these portfolio sensitivities, we modeled the three scenarios described in Figure 5.[2]

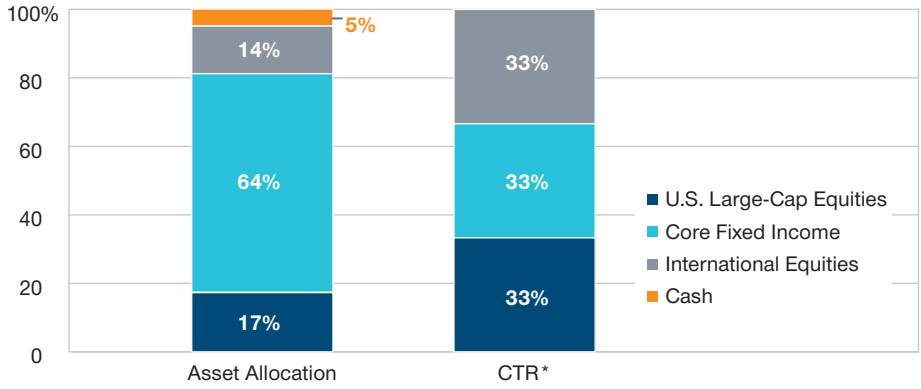
Under each of these scenarios, we compared the resulting portfolio asset allocations and CTRs with those of the hypothetical portfolios shown above—i.e., with both a traditional 60/40 balanced portfolio and a risk parity portfolio.

As shown in Figure 6, page 4, and Figure 7, page 4, the contribution to total portfolio risk from fixed income increases significantly in both portfolios when asset class cross-correlations increase (scenario one). This suggests the fixed income/equity correlation assumption is a particularly significant variable in portfolio optimization and construction. Even a small shift in that assumption will have a broad effect on portfolio structure and estimated portfolio risk.

Additionally, the risk parity portfolio is particularly sensitive to changes in the volatility assumptions for low-volatility asset classes (scenario two). This is due in part to the large relative allocations to those asset classes that stem from the risk parity approach.

In scenario three, we see that negligence in portfolio rebalancing can further increase the risk exposure contributed by equity allocations. In the risk parity portfolio, a 16% reduction in the fixed income allocation (from 64% to 54% of the total portfolio) reduces the fixed income CTR by 52% (a decrease from 33% to 16% of the total portfolio). These scenarios, and others, can be tested in this manner during the portfolio design process to expose the most critical assumptions.

FIGURE 4: Asset Allocation and CTR in a Risk Parity Portfolio



*Percentage does not total100% due to rounding.
Source: T. Rowe Price
The above details are indicative and are for illustrative purpose only. These are subject to change without further notice.

FIGURE 5: Capital Market Scenarios

Scenario	Model Effect	Market Conditions
Correlation Shock	All asset class correlations increase.	In stressful market situations, return correlations between asset classes tend to increase.
Volatility Shock	Fixed income volatility assumption increases two percentage points.	Central banks ending easing programs could result in rising bond volatility.
Exposure Shock	U.S. and international equity exposures increase five percentage points, and bond exposure falls 10 percentage points.	A portfolio that is not rebalanced may experience a large allocation drift during equity bull markets.

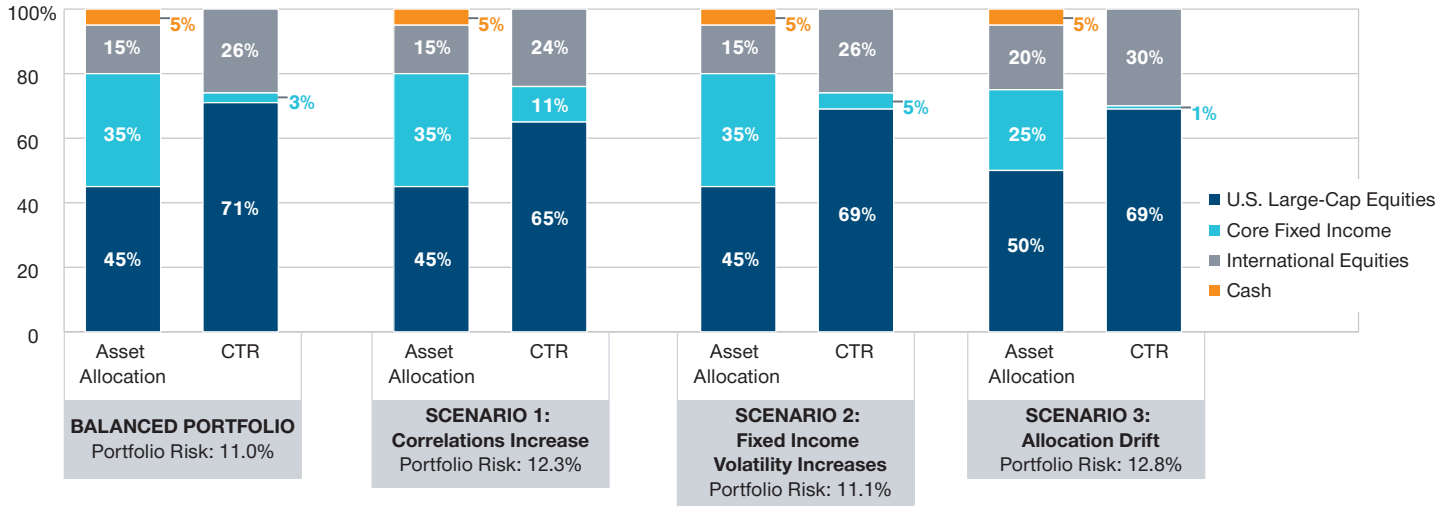
Source: T. Rowe Price

[2]Please see the appendix on page 5 for the volatility and correlation assumptions used in each scenario.

CONCLUSIONS

- The CTR metric is a tool that allows investors and managers to understand the contribution to total portfolio volatility made by each asset class in the portfolio, as well as the sensitivity of each modeling assumption to the overall portfolio outcome.
- This scenario testing capability can provide useful insights and modeling capabilities during portfolio construction and strategic asset allocation exercises.
- Risk-based portfolios are significantly more sensitive to parameter estimation changes than balanced portfolios.

FIGURE 6: Asset Allocation and CTR Scenarios for a Balanced Portfolio



Source: T. Rowe Price
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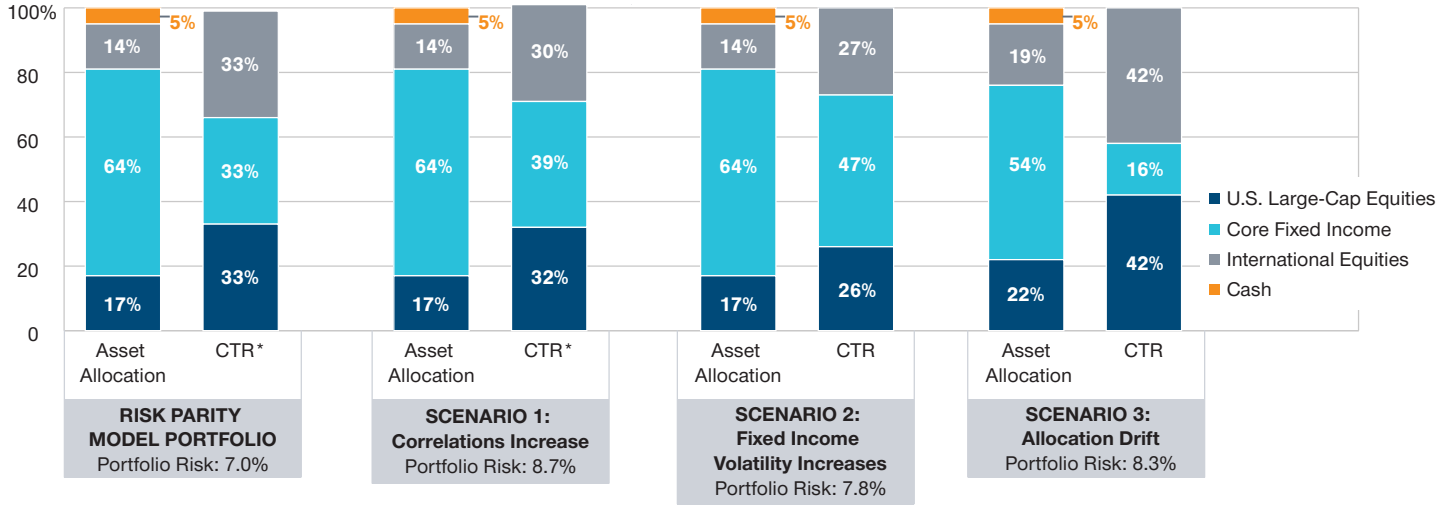
FIGURE 7: Asset Allocation and CTR Scenarios for a Risk Parity Model Portfolio



*Percentage does not total100% due to rounding.
Source: T. Rowe Price
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APPENDIX

Figures A1 and A2 below show the CTRs for each asset class in the three shock scenarios tested. Figure A1 uses the balanced portfolio as the baseline, while Figure A2 uses the risk parity portfolio.

FIGURE A1: CTRs for a Balanced Portfolio

	CTR			
Asset Class	Balanced Portfolio	Correlation Shock	Volatility Shock	Exposure Shock
U.S. Large-Cap Equities	70.9%	64.7%	68.9%	68.8%
Core Fixed Income	2.9	11.3	5.3	0.8
International Equities	26.3	24.0	25.8	30.4
Cash	0.0	0.0	0.0	0.0
Total Portfolio Risk	11.0	12.3	11.1	12.8

FIGURE A2: CTRs for a Risk Parity Model Portfolio

	CTR			
Asset Class	Risk Parity Model Portfolio	Correlation Shock	Volatility Shock	Exposure Shock
U.S. Large-Cap Equities	33.3%	31.8%	26.2%	41.5%
Core Fixed Income	33.3	38.7	46.6	16.4
International Equities	33.4	29.5	27.2	42.1
Cash	0.0	0.0	0.0	0.0
Total Portfolio Risk	7.0	8.7	7.8	8.3

Source: T. Rowe Price

The portfolio weights and the volatility and correlation assumptions used in the three shock scenarios are shown in Figures A3 through A5.

FIGURE A3: Correlation Shock: Correlations Increase and Trend to 1.0

				Correlation			
Asset Class	Balanced Portfolio Weight	Risk Parity Weight	Volatility	U.S. Large-Cap Equities	Core Fixed Income	Intl. Equities	Cash
U.S. Large-Cap Equities	45%	17%	18%	1.00	—	—	—
Core Fixed Income	35	64	6.5	0.45	1.00	—	—
International Equities	15	14	20	0.97	0.53	1.00	—
Cash	5	5	0	0.50	0.50	0.50	1.00

FIGURE A4: Volatility Shock: Fixed Income Volatility Increases Two Percentage Points

				Correlation			
Asset Class	Balanced Portfolio Weight	Risk Parity Weight	Volatility	U.S. Large-Cap Equities	Core Fixed Income	Intl. Equities	Cash
U.S. Large-Cap Equities	45%	17%	18%	1.00	—	—	—
Core Fixed Income	35	64	8.5	-0.11	1.00	—	—
International Equities	15	14	20	0.93	0.05	1.00	—
Cash	5	5	0	0.00	0.00	0.00	1.00

FIGURE A5: Exposure Shock: Equity Allocations Drift Higher

				Correlation			
Asset Class	Balanced Portfolio Weight	Risk Parity Weight	Volatility	U.S. Large-Cap Equities	Core Fixed Income	Intl. Equities	Cash
U.S. Large-Cap Equities	50%	22%	18%	1.00	—	—	—
Core Fixed Income	25	54	6.5	-0.11	1.00	—	—
International Equities	20	19	20	0.93	0.05	1.00	—
Cash	5	5	0	0.00	0.00	0.00	1.00

Source: T. Rowe Price

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