Risk Parity

Portfolio allocation based on equal risk contribution

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2026-01-12

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1 Abstract

Risk Parity is a portfolio allocation strategy where each asset contributes equally to the total portfolio risk. Unlike equal-weight portfolios (where each asset receives equal capital), risk parity allocates less capital to high-volatility assets and more capital to low-volatility assets. This approach was popularized by Bridgewater Associates' "All Weather" fund and formalized by Qian (2005).

2 Definitions

Consider a portfolio of n assets with weights w_i where $\sum_{i=1}^{n} w_i = 1$.

For the **simplified case** (assuming uncorrelated assets), the inverse volatility weighting formula is:

$$w_i = \frac{\frac{1}{\sigma_i}}{\sum_{j=1}^{n} \frac{1}{\sigma_j}}$$

Where σ_i is the standard deviation (volatility) of asset i.

For a **two-asset portfolio** (assets A and B):

$$w_A = \frac{\frac{1}{\sigma_A}}{\frac{1}{\sigma_A} + \frac{1}{\sigma_B}} = \frac{\sigma_B}{\sigma_A + \sigma_B}$$

$$w_B = \frac{\frac{1}{\sigma_B}}{\frac{1}{\sigma_A} + \frac{1}{\sigma_B}} = \frac{\sigma_A}{\sigma_A + \sigma_B}$$

Note: This simplification assumes zero correlation between assets. For correlated assets, the full covariance matrix must be considered (Maillard et al., 2010).

3 Theoretical Example

Given two assets with annualized volatilities:

- Asset A: $\sigma_A = 4.50\%$
- Asset B: $\sigma_B = 1.62\%$

Applying the inverse volatility formula:

$$w_A = \frac{1.62}{4.50 + 1.62} = \frac{1.62}{6.12} \approx 26.47\%$$

$$w_B = \frac{4.50}{4.50 + 1.62} = \frac{4.50}{6.12} \approx 73.53\%$$

The higher-volatility asset (A) receives less capital, while the lower-volatility asset (B) receives more.

4 Compute (Python)

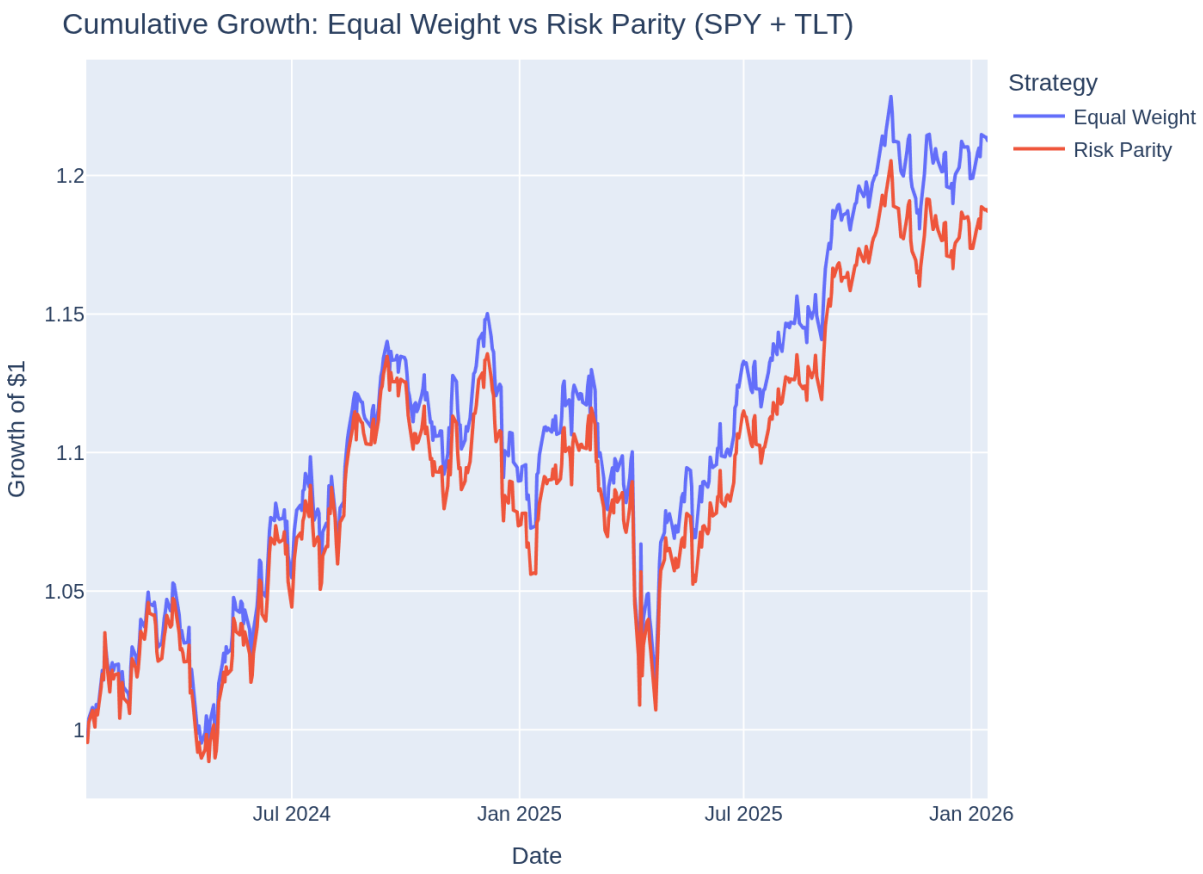
We apply risk parity to a classic stock-bond portfolio using SPY (S&P 500 ETF) and TLT (20+ Year Treasury Bond ETF).

Ticker	Ticker	Ann. Volatility (%)	Risk Parity Weight (%)
SPY	SPY	16.26	44.42
TLT	TLT	13.00	55.58

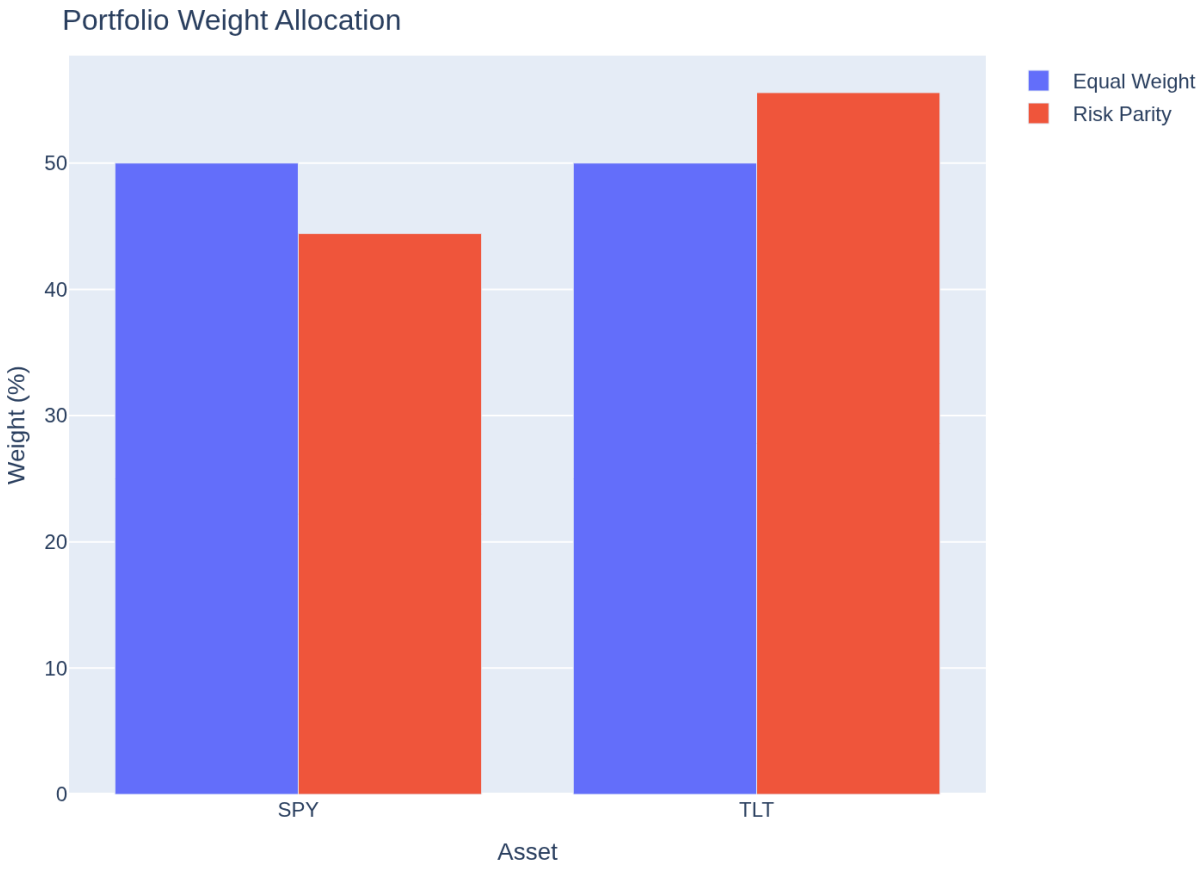
5 Comparison: Equal Weight vs Risk Parity

	Portfolio	Ann. Return (%)	Ann. Volatility (%)	Sharpe Ratio
0	Equal Weight	10.28	10.78	0.95
1	Risk Parity	9.19	10.59	0.87

6 Portfolio Performance



7 Weight Allocation



8 Conclusion

Risk parity allocates capital inversely proportional to volatility, ensuring each asset contributes similar risk to the portfolio. In a stock-bond portfolio, this typically results in overweighting bonds (lower volatility) relative to stocks (higher volatility). This approach often achieves lower portfolio volatility and improved risk-adjusted returns compared to equal-weight allocations.

References

Maillard, S., Roncalli, T., & Teïletche, J. (2010). The properties of equally weighted risk contribution portfolios. *Journal of Portfolio Management*, *36*(4), 60–70.

Qian, E. (2005). Risk parity portfolios: Efficient portfolios through true diversification. *Panagora Asset Management*.