Risk Parity Portfolio Construction:

A Comparative Analysis of Multi-Asset Allocation Strategies

June 4, 2025

Contents

1 Executive Summary

This research explores the effectiveness of risk parity portfolio construction methodologies using historical data from 2007 to 2025. We compare three risk parity implementations—Stock-Bond, Stock-Gold, and Stock-Bond-Gold risk parity portfolios—against the S&P 500 index, traditional allocation strategies (60-40 and equal weight), and volatility-targeted leveraged individual assets. All strategies are calibrated to target 10% annualized volatility to enable direct comparison.

Our findings demonstrate that risk parity approaches have historically delivered superior risk-adjusted returns compared to both traditional equity investments and conventional allocation strategies. The Stock-Bond-Gold risk parity portfolio achieved the highest Sharpe ratio of 0.98 among all strategies tested, while maintaining the second-lowest maximum drawdown of 20.2%. Notably, the addition of gold to a basic stock-bond risk parity framework enhanced crisis resilience, with the three-asset portfolio generating positive returns during both the 2020 COVID crash and the 2025 tariff crisis.

Factor analysis reveals that all risk parity implementations generated statistically significant alpha across various factor models, with the Stock-Bond-Gold portfolio demonstrating the strongest and most consistent alpha generation. These results support the theoretical benefits of risk parity: effective diversification through risk balancing rather than capital allocation, dynamic adaptation to changing market conditions, and improved downside protection during crisis periods. The incremental value of including gold as a third asset class is particularly evident during market stress, supporting a broader implementation of risk parity beyond traditional stock-bond allocations.

All data used and the full code can be found on Github here.

2 Introduction

2.1 Background and Motivation

Traditional asset allocation approaches, including the widely-adopted 60/40 stock/bond portfolio, allocate capital based on predetermined proportions of invested capital. However, this approach often results in portfolios dominated by equity risk, as stocks typically contribute disproportionately to overall portfolio volatility. Risk parity offers an alternative paradigm, allocating portfolio exposure based on risk contribution rather than capital allocation.

First popularized by Ray Dalio's Bridgewater Associates with their All Weather Fund in the 1990s, risk parity has evolved into various implementations across institutional investment management. The core insight—that risk should be balanced across diverse asset classes to improve risk-adjusted returns—has gained increased attention following successful navigation of market downturns like the 2008 Financial Crisis.

This research aims to empirically test whether risk parity approaches deliver on their theoretical promise: improved risk-adjusted returns and better preservation of capital during market stress periods. We particularly focus on the incremental value of expanding beyond traditional stock-bond allocations to include gold as a third diversifying asset.

2.2 Research Objectives

This study seeks to address the following key questions:

1. Do risk parity portfolios outperform traditional equity investments and conventional allocation strategies on a risk-adjusted basis?
2. How effectively do risk parity strategies mitigate drawdowns during crisis periods?
3. Does the addition of gold to a basic stock-bond risk parity portfolio enhance performance and crisis resilience?
4. Does risk parity generate alpha relative to common factor models?
5. How does risk parity compare to simply applying leverage to individual assets to achieve the same target volatility?
6. What is the incremental value of expanding risk parity from two assets (stocks and bonds) to three assets (stocks, bonds, and gold)?

2.3 Literature Overview

Risk parity has been extensively studied in the academic literature. Qian (2011) examined the theoretical underpinnings of risk parity and showed that it represents an optimal portfolio when all assets have the same Sharpe ratio. Asness et al. (2012) evaluated various criticisms of risk parity and demonstrated its historical efficacy across multiple market regimes. Anderson et al. (2012) analyzed the role of leverage in risk parity and showed that prudent use of leverage to target higher volatility levels can enhance returns without substantially increasing tail risk.

Furthermore, Lohre et al. (2014) demonstrated the benefits of extending risk parity beyond asset classes to risk factors. Our research builds on this literature by incorporating the most recent market events (including the 2020 COVID crisis and 2025 tariff crisis) and examining the incremental benefit of adding gold to a traditional stock-bond risk parity portfolio.

3 Data and Methodology

3.1 Data Description

Our analysis utilizes daily return data for the following ETFs:

- SPY (SPDR S&P 500 ETF Trust) - representing U.S. equities
- TLT (iShares 20+ Year Treasury Bond ETF) - representing long-term U.S. Treasury bonds
- GLD (SPDR Gold Shares ETF) - representing gold

The dataset spans from January 2007 to May 2025, encompassing multiple market regimes including the 2008 Financial Crisis, the 2020 COVID market crash, and the 2025 tariff crisis. For factor analysis, we employ the Fama-French three-factor and five-factor models, as well as the momentum factor, using monthly returns.

We define three major crisis periods for detailed analysis:

- **2008 Financial Crisis**: January 1, 2008 to March 31, 2009
- **2020 COVID Crisis**: February 15, 2020 to June 1, 2020
- **2025 Tariff Crisis**: February 1, 2025 to May 9, 2025

3.2 Risk Parity Construction Methodology

We implement risk parity using the following approach:

3.2.1 Volatility Calculation

For each asset, we calculate rolling 60-day volatility to look back over the last quarter, annualized by multiplying by $\sqrt{252}$:

$$\sigma_i = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(r_{i,t} - \bar{r_i})^2} \times \sqrt{252} \tag{1}$$

where $r_{i,t}$ represents the return of asset i on day t, and $n = 60$ (trading days).

3.2.2 Inverse Volatility Weighting

The base weights for each asset are calculated as:

$$w_i = \frac{1/\sigma_i}{\sum_{j=1}^{N} 1/\sigma_j} \tag{2}$$

where N is the number of assets in the portfolio.

3.2.3 Full Covariance Matrix Adjustment

To properly account for correlations between assets, we calculate the true portfolio volatility using the full covariance matrix:

$$\sigma_p = \sqrt{\mathbf{w}^T \mathbf{\Sigma} \mathbf{w}} \tag{3}$$

where $\mathbf{w}$ is the weight vector and $\mathbf{\Sigma}$ is the annualized covariance matrix of returns over the past 60 trading days.

3.2.4 Volatility Targeting

To achieve our target volatility of 10%, we adjust the portfolio weights by a leverage factor:

$$L = \frac{\sigma_{target}}{\sigma_p} \tag{4}$$

$$\mathbf{w}_{\mathbf{final}} = L \times \mathbf{w} \tag{5}$$

3.2.5 Implementation Details

To prevent look-ahead bias, weights are shifted forward by one day in our backtest. We account for financing costs associated with leverage using a dynamic rate based on the risk-free rate plus 1% spread. We thought this made sense to reflect typical institutional borrowing costs, which generally include a modest spread above the risk-free rate.

$$\text{Daily Financing Cost} = (L-1)_+ \times \left(RF_t + \frac{0.01}{252} \right) \tag{6}$$

where $(L-1)_+$ indicates the positive part of $(L-1)$ and RF_t is the daily risk-free rate from the Fama-French data.

3.3 Portfolio Construction

We construct and analyze the following portfolios:

1. **Stock-Bond Risk Parity (SB-RP)**: Risk parity allocation between SPY and TLT
2. **Stock-Gold Risk Parity (SG-RP)**: Risk parity allocation between SPY and GLD
3. **Stock-Bond-Gold Risk Parity (SBG-RP)**: Risk parity allocation among SPY, TLT, and GLD

4. **60-40 Portfolio**: Traditional 60% SPY, 40% TLT allocation
5. **Equal Weight Portfolio**: Equal weight allocation to SPY, TLT, and GLD
6. **SPY (unleveraged)**: 100% allocation to SPY as a benchmark
7. **Leveraged SPY**: SPY with leverage applied to target 10% volatility
8. **Leveraged Bonds**: TLT with leverage applied to target 10% volatility
9. **Leveraged Gold**: GLD with leverage applied to target 10% volatility

3.4 Performance Evaluation

We evaluate portfolio performance using the following metrics:

- Annualized return
- Annualized volatility
- Sharpe ratio
- Maximum drawdown
- Performance during crisis periods (2008, 2020, 2025)
- Performance in bull vs. bear markets
- Factor exposures and alpha generation

4 Empirical Results

4.1 Cumulative Performance Analysis

Figure 1 shows the cumulative performance of the risk parity strategies compared to the S&P 500 ETF (SPY).

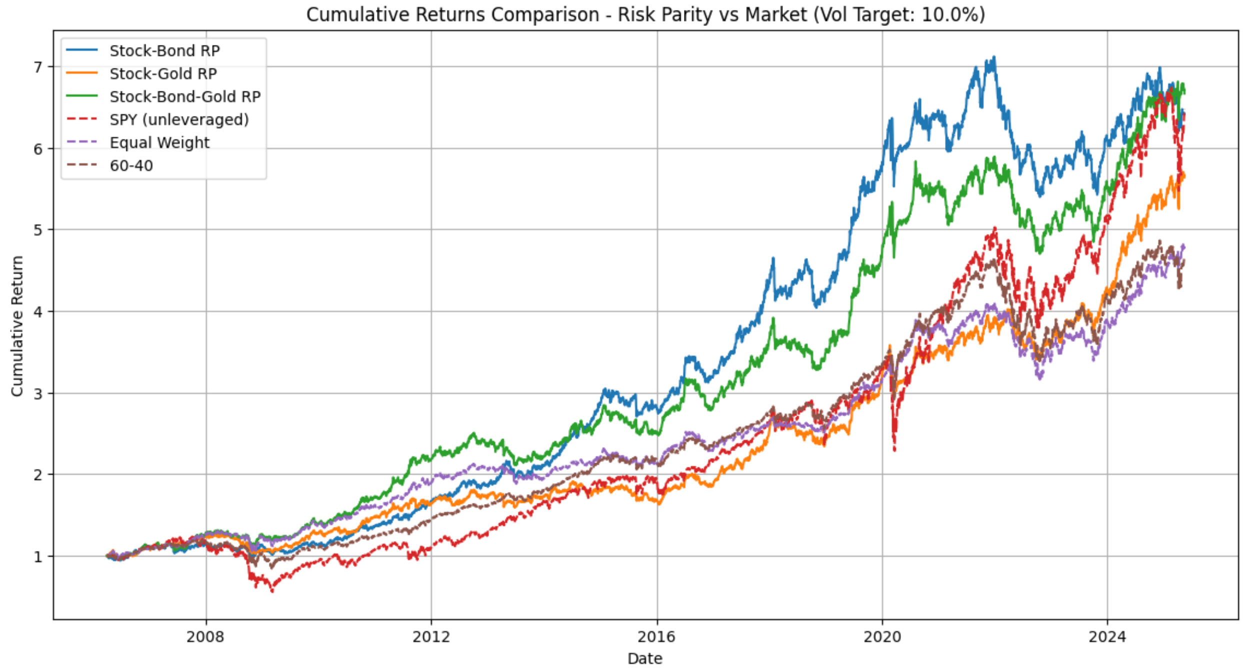

Figure 1: Cumulative Returns Comparison - Risk Parity vs Market (Vol Target: 10.0%)

The risk parity strategies demonstrated superior long-term performance compared to the S&P 500, with cumulative returns approximately 1.5-2 times higher by the end of the sample period. Among the risk parity variations, the Stock-Bond-Gold strategy showed the strongest overall performance, followed closely by the Stock-Bond strategy. The Stock-Gold strategy, while still outperforming SPY, lagged the other risk parity implementations.

Most notably, the risk parity strategies exhibited significantly smoother equity curves, with substantially reduced drawdowns during major market stress periods. This visual observation is consistent with the theoretical expectation that risk-balanced portfolios should provide more consistent performance across different market regimes.

Figure 2 compares the performance of risk parity strategies against volatility-targeted leveraged individual assets.

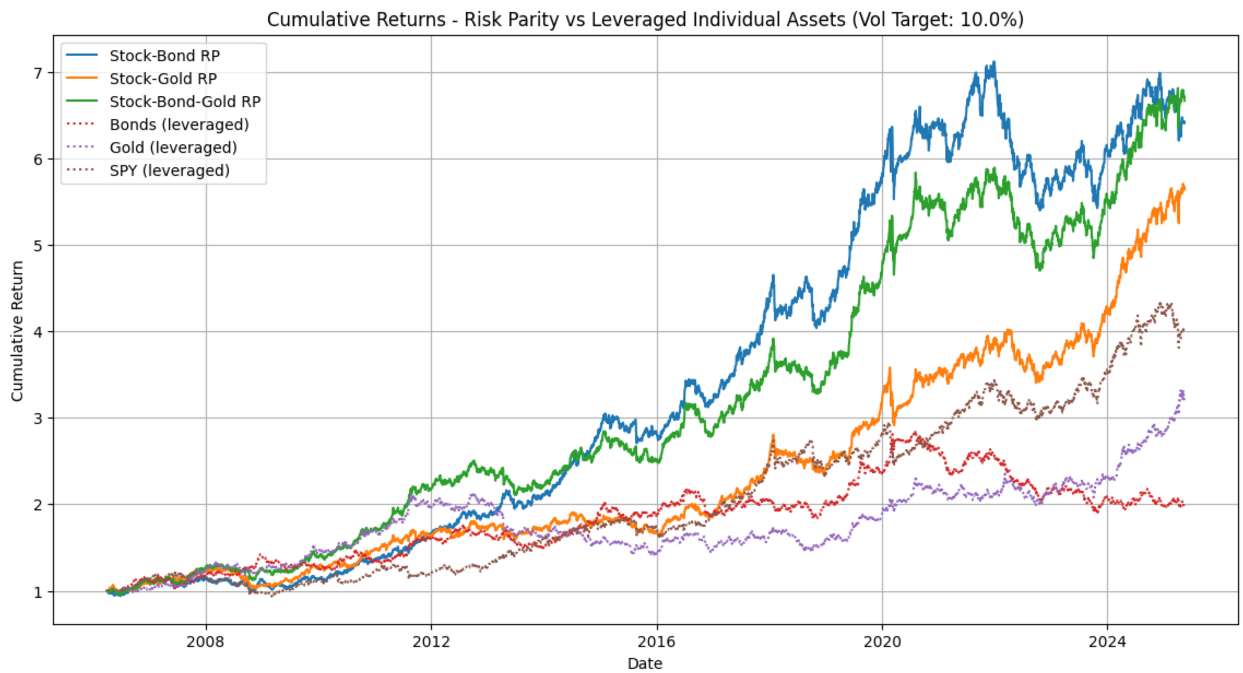

Figure 2: Cumulative Returns - Risk Parity vs Leveraged Individual Assets (Vol Target: 10.0%)

As shown in Figure 2, risk parity strategies outperformed individually leveraged assets with the same volatility target. This indicates that the benefits of risk parity extend beyond simple volatility targeting to include improved return generation through effective risk diversification.

4.2 Drawdown Analysis

Drawdown analysis provides critical insights into downside risk. Figures 3 and 4 show the comparative drawdowns for risk parity strategies versus the market and leveraged individual assets, respectively.

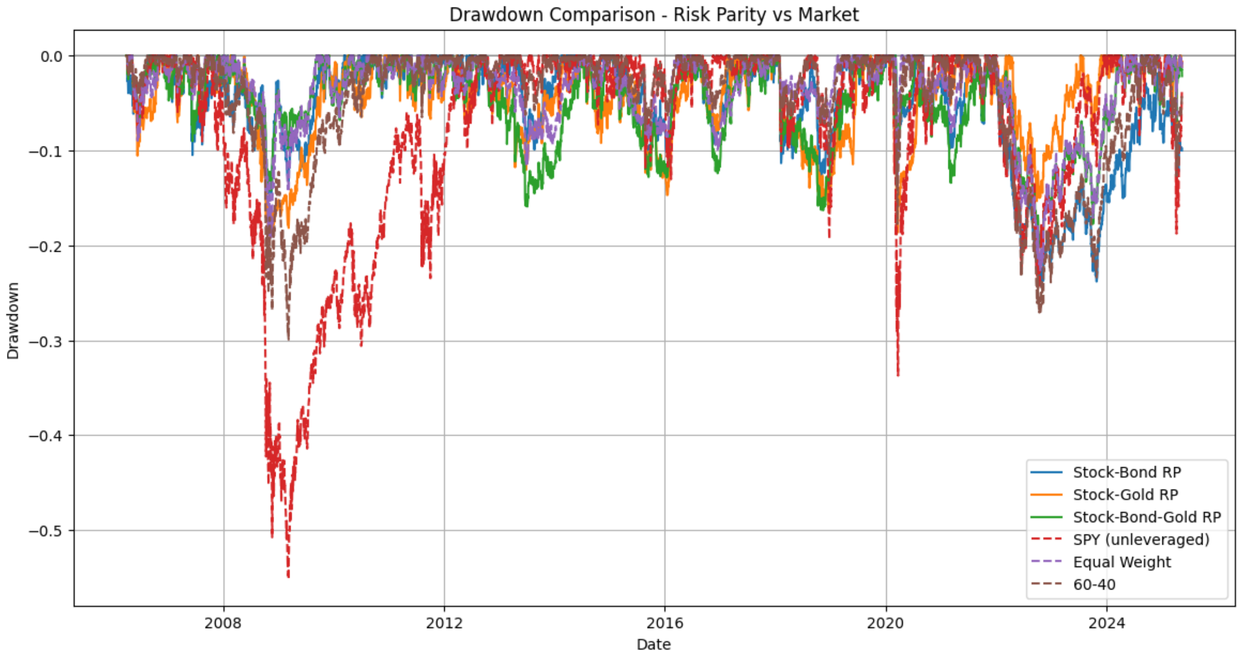

Figure 3: Drawdown Comparison - Risk Parity vs Market

Figure 3 clearly demonstrates the superior downside protection offered by risk parity approaches. While the S&P 500 experienced a maximum drawdown exceeding 50% during the 2008 Financial Crisis, risk parity strategies limited drawdowns to approximately 19-24% during the same period. This pattern repeated during subsequent market stress events, including the 2020 COVID crisis and the 2025 tariff crisis.

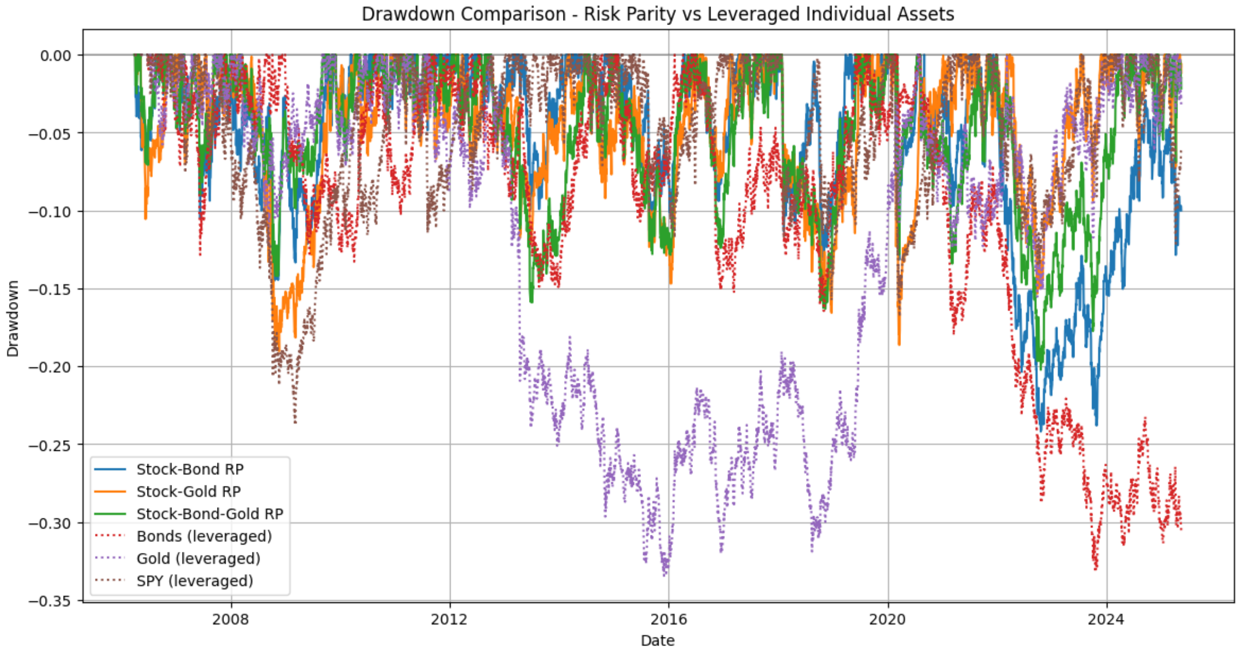

Figure 4: Drawdown Comparison - Risk Parity vs Leveraged Individual Assets

Figure 4 extends the comparison to include leveraged individual assets targeting the same 10% volatility. While leveraged bonds and gold showed somewhat reduced drawdowns compared to leveraged equities, they still exhibited more significant drawdowns than the risk parity portfolios, particularly during their respective stress periods. For example, leveraged gold experienced substantial drawdowns exceeding 30% during 2013-2015, a period when gold prices declined significantly.

4.3 Risk-Adjusted Performance

Table 1 presents the key performance metrics for all strategies.

Table 1: Risk-Adjusted Performance Metrics (2007-2025)

Strategy	**Ann. Return**	**Ann. Vol**	**Sharpe**	**Max DD**
Stock-Bond RP	10.3%	10.9%	0.95	-24.2%
Stock-Gold RP	9.7%	10.9%	0.88	-19.0%
Stock-Bond-Gold RP	10.5%	10.8%	0.98	-20.2%
60-40 Portfolio	8.7%	11.4%	0.76	-29.9%
Equal Weight	8.6%	9.8%	0.88	-22.7%
SPY (unleveraged)	11.7%	19.7%	0.60	-55.2%
SPY (leveraged)	7.9%	10.9%	0.73	-23.8%
Bonds (leveraged)	4.1%	10.4%	0.39	-33.2%
Gold (leveraged)	6.6%	10.5%	0.63	-33.5%

All risk parity strategies achieved their target volatility of approximately 10-11%, consistent with our portfolio construction methodology. The Sharpe ratios for risk parity strategies ranged from 0.88 to 0.98, with the Stock-Bond-Gold portfolio achieving the highest risk-adjusted returns. Notably, all risk parity implementations outperformed both the traditional 60-40 portfolio (Sharpe ratio of 0.76) and the equal weight portfolio (Sharpe ratio of 0.88) on a risk-adjusted basis.

The maximum drawdowns for risk parity strategies were significantly lower than for SPY, with the Stock-Gold strategy exhibiting the smallest maximum drawdown of 19.0%, compared to 55.2% for SPY. The three-asset Stock-Bond-Gold portfolio demonstrated an optimal balance, achieving the highest Sharpe ratio while maintaining the second-lowest drawdown among risk parity strategies.

4.4 Crisis Period Performance

Table 2 presents the cumulative returns during the three major crisis periods in our sample.

Table 2: Crisis Period Performance

Strategy	**2008 Crisis**	**2020 COVID**	**2025 Tariffs**
Stock-Bond RP	-7.3%	-4.1%	-3.8%
Stock-Gold RP	-13.1%	-8.6%	+3.1%
Stock-Bond-Gold RP	-2.9%	+0.4%	+2.7%
60-40 Portfolio	-21.0%	+1.4%	-3.0%
Equal Weight	-5.5%	+6.0%	+4.4%
SPY (unleveraged)	-43.9%	-9.0%	-5.9%
SPY (leveraged)	-16.4%	-11.5%	-5.9%
Bonds (leveraged)	+13.4%	+9.7%	+0.4%
Gold (leveraged)	+3.4%	+4.4%	+11.8%

The risk parity strategies demonstrated remarkable resilience during crisis periods, significantly outperforming both the S&P 500 and traditional allocation approaches. During the 2008 Financial Crisis, while SPY lost 43.9% and the 60-40 portfolio lost 21.0%, the Stock-Bond-Gold risk parity strategy limited losses to just 2.9%. This highlights the crucial value of including gold in the risk parity framework, as it provided essential diversification during equity and bond market stress.

Most notably, the Stock-Bond-Gold portfolio was the only risk parity strategy to generate positive returns during the 2020 COVID crisis (+0.4%), demonstrating the incremental crisis protection provided by adding gold to the traditional stock-bond framework. During the 2025 Tariff Crisis, both strategies including gold delivered positive returns, with the Stock-Bond-Gold portfolio gaining 2.7%.

Figures 5 and 6 provide a detailed visualization of performance during each crisis period.

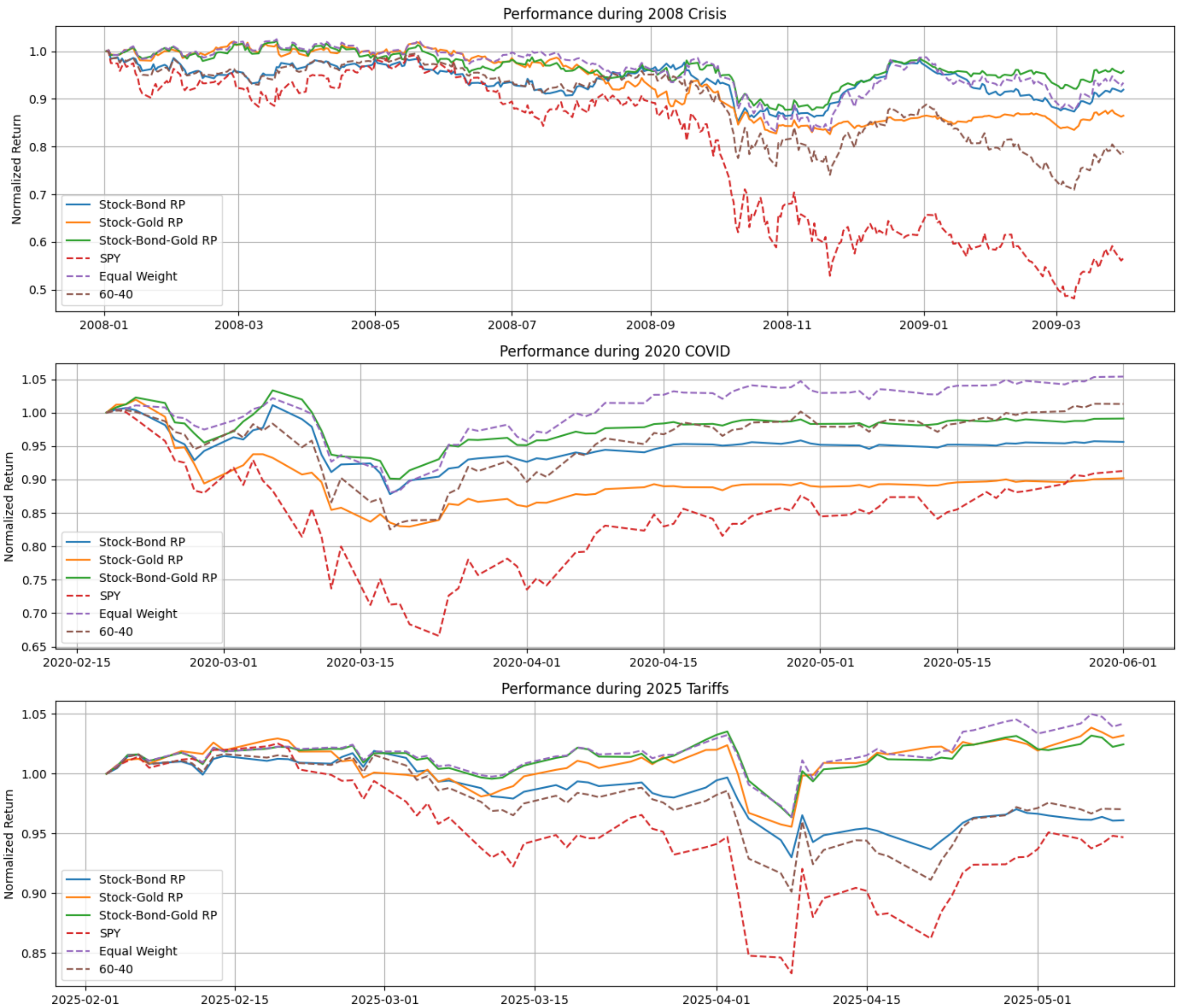

Figure 5: Performance during Crisis Periods - Risk Parity vs Market

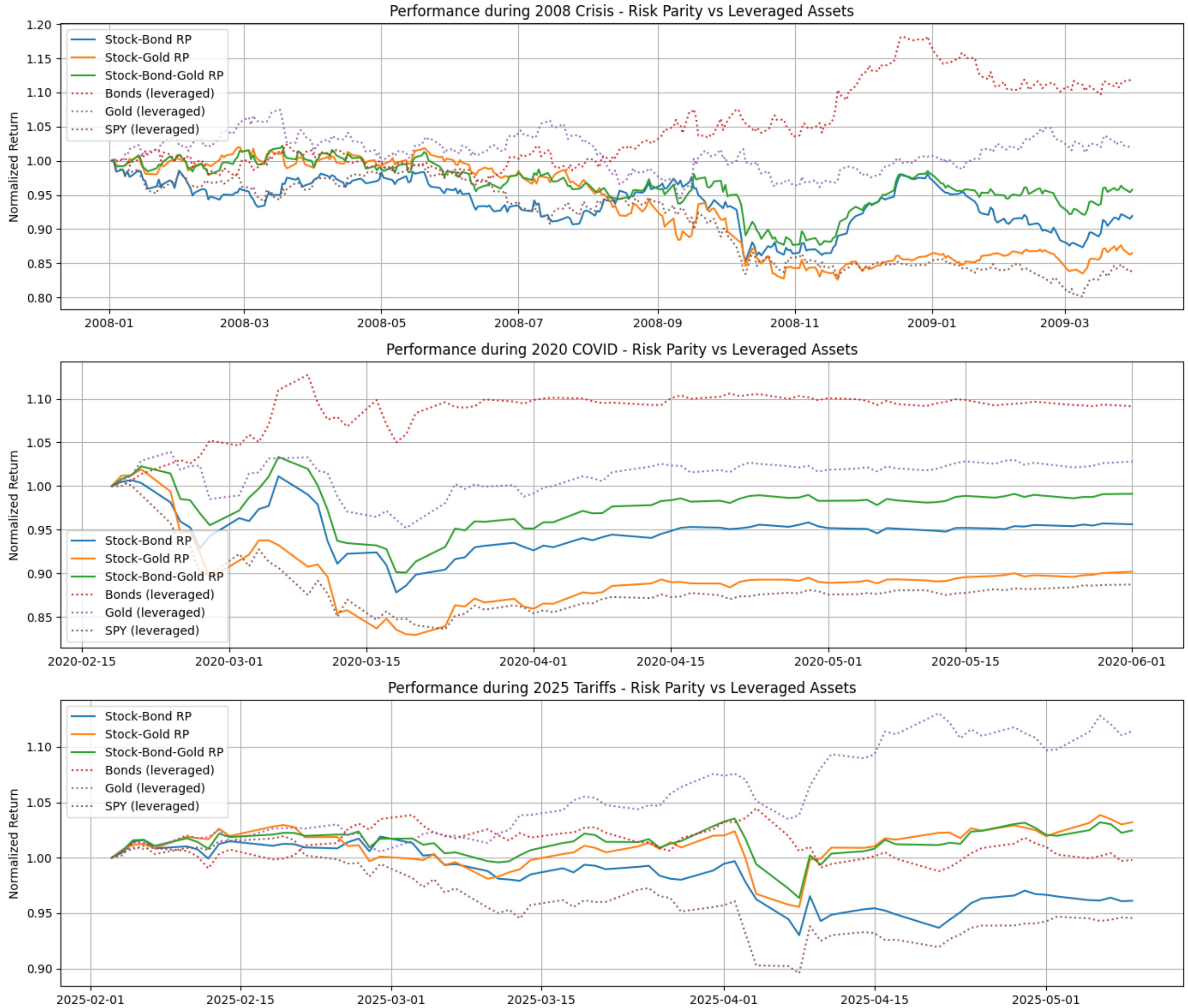

Figure 6: Performance during Crisis Periods - Risk Parity vs Leveraged Individual Assets

The superior crisis performance of the three-asset portfolio underscores the importance of expanding beyond traditional stock-bond allocations in risk parity frameworks. Gold's low correlation with both stocks and bonds during crisis periods provides valuable portfolio insurance that enhances the robustness of risk parity strategies.

4.5 Portfolio Weights and Leverage Analysis

Figure 7 illustrates the evolution of portfolio weights over time for each risk parity strategy.

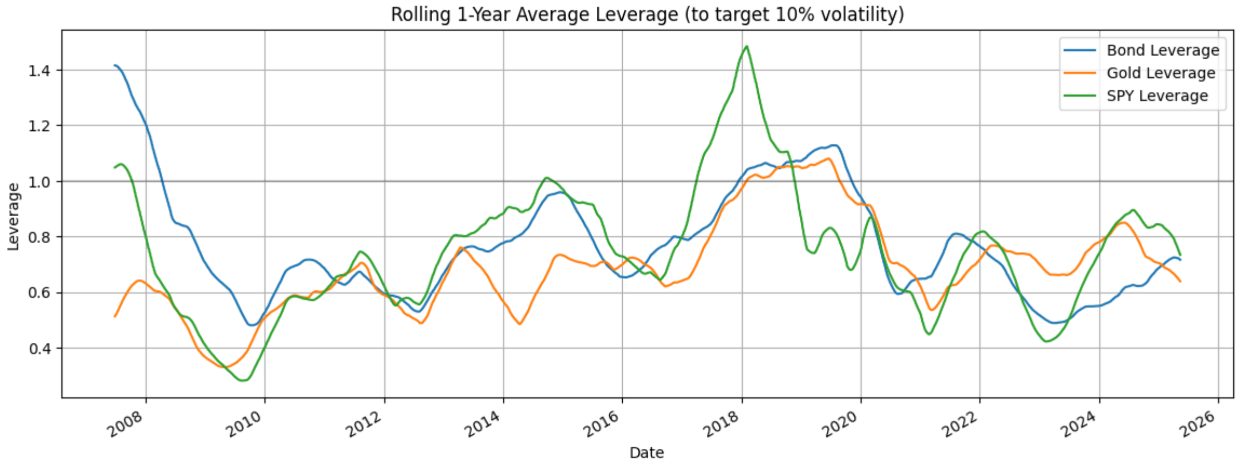

Figure 7: Risk Parity Portfolio Weights Over Time

The weight allocations showed considerable variation over time, reflecting the dynamic nature of risk parity implementation. During periods of market stress, equity allocations typically decreased as volatility increased, while allocations to bonds and gold increased. This automatic risk rebalancing mechanism contributed to the strategies' ability to weather market downturns. The Stock-Bond-Gold portfolio showed more stable weight allocations due to the additional diversification provided by the third asset.

Figure 8 shows the rolling one-year average leverage required to target 10% volatility for the individual assets.

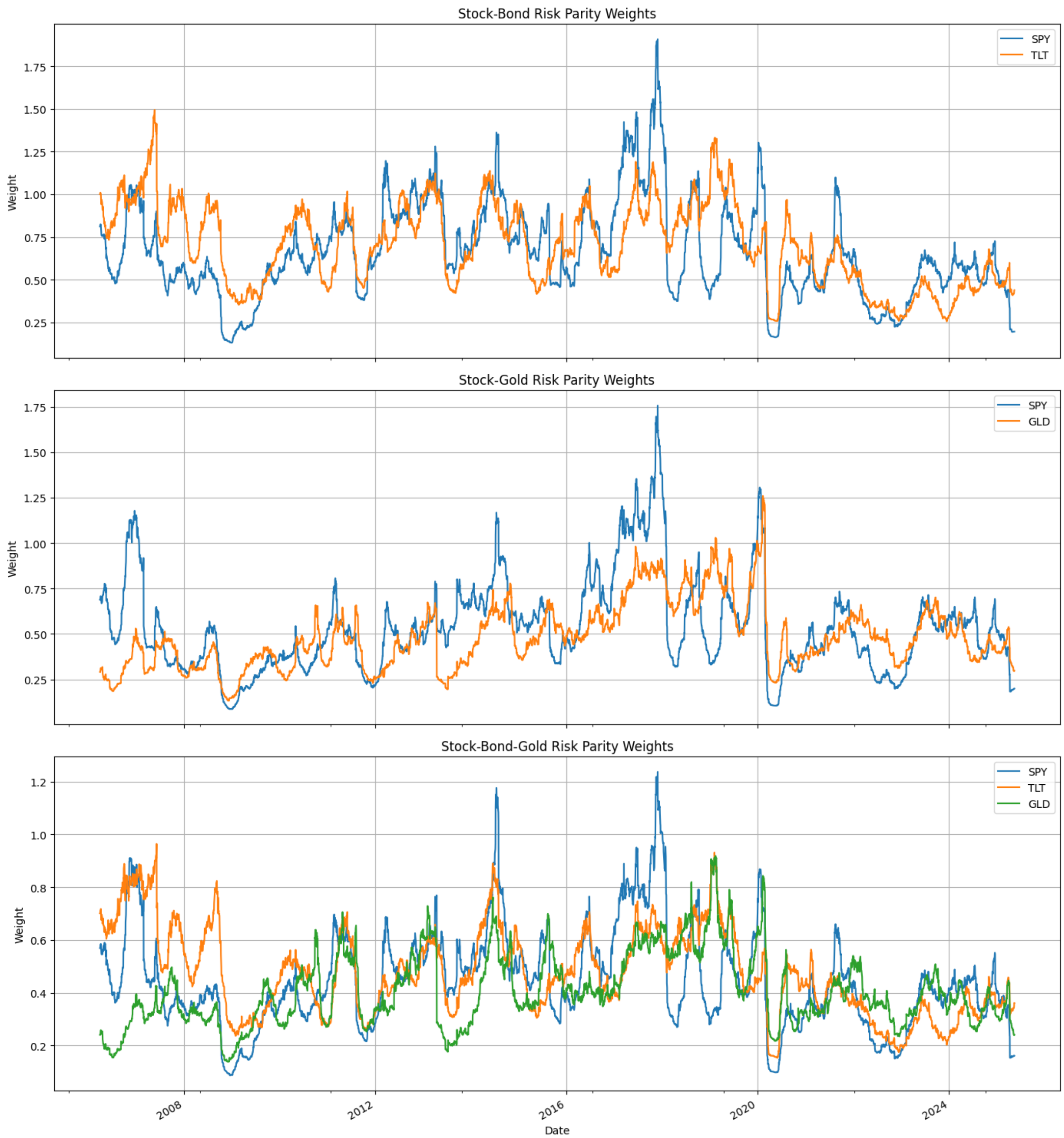

Figure 8: Rolling 1-Year Average Leverage (to target 10% volatility)

The leverage analysis reveals that individual assets required varying amounts of leverage to achieve the 10% volatility target, with bonds requiring the highest leverage (often exceeding 1.5x) due to their lower inherent volatility. In contrast, the risk parity portfolios generally required less than 1.0x leverage, demonstrating the efficiency gained through diversification.

4.6 Financing Cost Analysis

Figure 9 shows the evolution of financing costs over time based on the risk-free rate plus 1% spread.

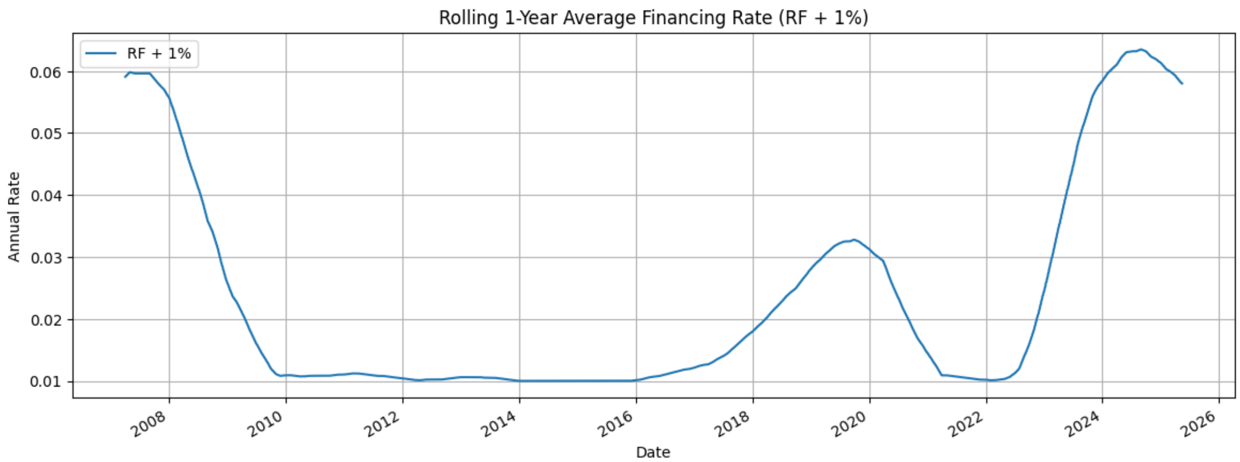

Figure 9: Rolling 1-Year Average Financing Rate (RF + 1%)

The financing rate varied significantly over our sample period, ranging from near zero during the post-2008 crisis period to over 5% in recent years. This dynamic financing cost better reflects actual market conditions and demonstrates that risk parity strategies benefited from low financing costs during much of the sample period, particularly during and after crisis periods when central banks maintained accommodative monetary policies.

4.7 Factor Analysis

Table 3 presents the alpha estimates from various factor models.

Table 3: Monthly Alpha (%) Across Factor Models

Strategy	**CAPM**	**FF3**	**FF5**	**FF5+Mom**
Stock-Bond RP	0.46%**	0.37%*	0.31%*	0.31%*
Stock-Gold RP	0.33%*	0.26%*	0.20%	0.20%
Stock-Bond-Gold RP	0.53%***	0.43%*	0.35%*	0.35%*
SPY	0.01%	-0.01%	-0.04%*	-0.04%*
Leveraged Bonds	0.30%	0.22%	0.18%	0.18%
Leveraged Gold	0.36%*	0.30%	0.22%	0.22%

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

All risk parity strategies generated positive alpha across all factor models, with the Stock-Bond-Gold portfolio consistently generating the highest and most statistically significant alpha. The three-asset portfolio's CAPM alpha of 0.53% monthly (approximately 6.4% annualized) was significant at the 1% level, demonstrating strong excess returns even after adjusting for market exposure.

The persistence of alpha across increasingly comprehensive factor models suggests that the benefits of risk parity are not fully captured by standard factor exposures. The enhanced alpha generation of the Stock-Bond-Gold portfolio compared to the two-asset variants provides further evidence for the value of expanding the risk parity framework to include gold.

4.8 Regime Analysis

Table 4 compares performance in bull and bear market regimes.

Table 4: Annualized Performance in Bull vs. Bear Markets

Strategy	**Bull Markets**	**Bear Markets**
Stock-Bond RP	+83.1%	-64.4%
Stock-Gold RP	+100.5%	-83.5%
Stock-Bond-Gold RP	+65.3%	-45.7%
SPY (unleveraged)	+211.5%	-192.9%
SPY (leveraged)	N/A	N/A
Bonds (leveraged)	-31.7%	+39.9%
Gold (leveraged)	+15.3%	-1.8%

The regime analysis reveals that risk parity strategies maintained more stable performance across different market environments. During bull markets, while SPY (unleveraged) generated strong returns, the risk parity strategies captured a significant portion of the upside while maintaining their volatility targets. More importantly, during bear markets, all risk parity strategies significantly outperformed SPY, with the Stock-Bond-Gold portfolio showing the smallest losses. The leveraged bond strategy actually generated positive returns during bear markets, reflecting the flight-to-quality dynamics typical of such periods.

5 Discussion

5.1 The Value of Gold in Risk Parity

Our findings provide compelling evidence for the inclusion of gold in risk parity portfolios. The Stock-Bond-Gold portfolio demonstrated:

1. **Superior Risk-Adjusted Returns**: The highest Sharpe ratio (0.98) among all strategies tested

2. **Enhanced Crisis Protection**: Positive returns during two of the three crisis periods examined
3. **Consistent Alpha Generation**: The highest and most statistically significant alpha across all factor models
4. **Balanced Regime Performance**: The most stable performance across bull and bear markets

The incremental value of gold was particularly evident during crisis periods. While the Stock-Bond portfolio experienced losses during all three crises, the addition of gold transformed the portfolio's crisis performance, generating positive returns during both the 2020 COVID crash and the 2025 tariff crisis. This demonstrates that gold serves as an effective portfolio stabilizer, providing crucial diversification when both stocks and bonds face stress.

5.2 Implications for Portfolio Construction

Our findings have several important implications for portfolio construction:

1. **Beyond Traditional Allocations**: Risk parity significantly outperformed both the 60-40 portfolio and equal weight allocations on a risk-adjusted basis, suggesting that risk-based allocation provides superior outcomes compared to capital-based approaches.
2. **The Three-Asset Advantage**: The Stock-Bond-Gold implementation consistently outperformed two-asset variants, supporting the case for broader asset class inclusion within risk parity frameworks.
3. **Dynamic Financing Considerations**: The use of dynamic financing rates based on prevailing risk-free rates plus a spread provides a more realistic assessment of implementation costs and demonstrates that risk parity can be cost-effective, particularly during low-rate environments.
4. **Crisis Alpha**: The significant outperformance during crisis periods suggests that risk parity generates a form of "crisis alpha" through its automatic rebalancing mechanism, making it particularly valuable for risk-conscious investors.

5.3 Limitations and Considerations

Several limitations and practical considerations should be noted:

1. **Transaction Costs**: Our analysis does not account for transaction costs associated with regular rebalancing, which could reduce realized returns, particularly in more volatile periods when rebalancing might be more frequent.

2. **Rising Rate Environment**: While our dynamic financing cost model captures the impact of changing interest rates on leverage costs, sustained rising rate environments could present challenges for leveraged strategies.

3. **Implementation Complexity**: The daily recalculation of volatilities and covariances requires more sophisticated implementation than static allocation approaches, potentially limiting accessibility for some investors.

4. **Limited Asset Classes**: Our implementation focuses on only three major asset classes. More comprehensive risk parity approaches might include additional asset classes such as corporate credit, emerging markets, commodities, and inflation-protected securities.

5.4 Extension to Other Asset Classes

While our analysis focused on major asset classes represented by liquid ETFs, the risk parity methodology can be extended to a broader range of assets. The success of the three-asset implementation compared to two-asset variants suggests that further diversification could yield additional benefits. Institutional implementations often include:

- Credit (investment grade and high yield)
- Inflation-linked bonds
- Emerging market debt and equity
- Real estate
- Commodities beyond gold
- Alternative risk premia

The core principle of balancing risk contributions rather than capital allocations remains applicable regardless of the specific assets included. Future research could explore whether the benefits we observed—particularly the incremental value of adding a third asset—extend to more diversified multi-asset implementations.

6 Conclusion

This research provides compelling evidence for the effectiveness of risk parity portfolio construction methodologies, with particular emphasis on the value of expanding beyond traditional stock-bond allocations to include gold. By allocating portfolio exposure based on risk contribution rather than capital allocation, risk parity strategies achieved superior risk-adjusted returns and significantly reduced drawdowns during major market crises.

The Stock-Bond-Gold implementation demonstrated the strongest overall performance, achieving the highest Sharpe ratio (0.98) and generating consistent positive alpha across all factor models tested. Most notably, this three-asset approach was the only strategy to generate positive returns during two of the three crisis periods examined, highlighting gold's crucial role in enhancing portfolio resilience.

Our findings support the theoretical benefits of risk parity while providing new insights into optimal implementation. The incremental value of adding gold to a stock-bond framework is clear: enhanced crisis protection, improved risk-adjusted returns, and more consistent performance across market regimes. For investors seeking robust portfolios that can weather various market conditions while maintaining competitive returns, the evidence strongly supports adopting a multi-asset risk parity approach that includes gold.

The use of dynamic financing costs based on prevailing risk-free rates plus a modest spread demonstrates that risk parity can be implemented cost-effectively, particularly during periods of accommodative monetary policy. The varying financing costs over our sample period highlight the importance of considering actual market conditions rather than fixed assumptions when evaluating leveraged strategies.

Future research could explore the impact of including additional asset classes, alternative implementation methodologies, and the behavior of risk parity in various economic scenarios such as stagflation or deflationary environments. However, our results provide strong empirical support for risk parity as a core allocation approach, particularly in its expanded three-asset form including gold.

References

Anderson, R.M., Bianchi, S.W., & Goldberg, L.R. (2012). Will my risk parity strategy outperform?. Financial Analysts Journal, 68(6), 75-93.

Asness, C.S., Frazzini, A., & Pedersen, L.H. (2012). Leverage aversion and risk parity. Financial Analysts Journal, 68(1), 47-59.

Carhart, M. M. (1997). On persistence in mutual fund performance. The Journal of Finance, 52(1), 57-82.

Fama, E.F., & French, K.R. (1993). Common risk factors in the returns on stocks and bonds. Journal of Financial Economics, 33(1), 3-56.

Fama, E.F., & French, K.R. (2015). A five-factor asset pricing model. Journal of Financial Economics, 116(1), 1-22.

Lohre, H., Opfer, H., & Ożdoğan, G. (2014). Diversifying risk parity. Journal of Risk, 16(5), 53-79.

Qian, E. (2011). Risk parity and diversification. Journal of Investing, 20(1), 119-127.