EFFECTIVE DIVERSIFICATION PRACTICES: INVESTING THROUGH UNCERTAIN ECONOMIC CONDITIONS

by

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A THESIS

Presented to the Department of Business Administration
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Science

June 2021

An Abstract of the Thesis of

Sean Silverman for the degree of Bachelor of Science
in the Department of Business Administration to be taken June 2021

Title: Effective Diversification Practices: Investing through Uncertain Economic Conditions

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The first iteration of risk parity, dubbed "All Weather" was introduced by Ray Dalio and his associates at Bridgewater Associates. The goal of the strategy is to create a diversified portfolio with equal risk distribution among asset classes so that high performance can be achieved through any period of economic uncertainty. The combination of risk-based allocation and use of leverage to boost expected returns has led to strong performance over long periods of time. After impressive performances during the modern day market crashes (2001 dot com bubble and 2008 financial crisis), the strategy gained in popularity among institutional investors. In this thesis, I will discuss the history of risk parity and its theoretical background versus other strategies, empirically analyze backtested risk parity portfolios, and discuss its performance during the COVID-19 market crash.

Acknowledgements

I would like to thank Dr. Zhi Jay Wang for serving as my primary advisor throughout the duration of this thesis. His support, expertise and guidance throughout the past year has allowed for the completion of this work. I would also like to extend my gratitude to Dr. Brandon Julio for agreeing to serve as my second reader. Dr. Julio, who also serves as the advisor to the UO Investment Group has provided countless moments of clarity for me since I joined UOIG through his wisdom and support. I would also like to thank Dr. Carol Paty for agreeing to serve as my Clark Honors College Representative and being there for a student in need. Finally, I would like to thank my family and friends who have supported me throughout this process. There have been countless moments in which you helped provide strength when I did not think I would make it and I will forever be grateful for that.

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Chapter 1: Understanding Risk Parity

On August 15, 1971, President Richard Nixon addressed the nation and announced that after twenty-seven years of monetary stability, the United States would break away from the Bretton Woods system of fixed exchange rates which tied the paper dollar's value to gold.[1] Ray Dalio, who worked as a clerk on the New York Stock Exchange at the time, had anticipated the news bringing absolute chaos into the financial markets leading to stocks falling; however, the Dow Jones Industrial Average ("DJIA"), which tracks the performance of thirty of the largest exchanges in the United States, experienced a 4% rally, which later became known as the Nixon rally. While Dalio was surprised by the market's reaction, he came to realize that while announcements of this magnitude were unfamiliar to him, they were not unprecedented. The disconnect between Dalio's expectations and the reality of the market influenced Dalio to dedicate himself to understanding the "timeless and universal relationships that both explain economic outcomes and repeat throughout history," later described as the economic machine.[2]

Dalio went on to found Bridgewater Associates, building the firm from a small risk management consulting business for corporate clients into nowadays, one of the largest asset management firms in the world. In his early work, it became evident that the company's competitive edge would be their creativity in breaking down returns. Dalio and his team effectively produced research that explained how returns could be

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[1] "Nixon and the End of the Bretton Woods System, 1971–1973." U.S. Department of State. U.S. Department of State. Accessed May 2, 2021. https://history.state.gov/milestones/1969-1976/nixon-shock.
[2] Podolsky, Paul, Ryan Johnson, and Owen Jennings. "The All Weather Story." Bridgewater. Bridgewater, May 21, 2020. https://www.bridgewater.com/research-and-insights/the-all-weather-story, 1.

simplified by analyzing each component and examining each individual driver of said components.[3] This came in its earliest form when Dalio devised a strategy to hedge the price of chicken by creating a synthetic future that would include the price of a chick, corn, and soymeal. It later followed by breaking down more traditional assets, such as treasury bond and corporate bond yields, as well as overall portfolio returns. He found that any portfolio return could be decomposed into three separate components: cash, beta (the compensation for bearing the market-wide systematic risk), and alpha (the additional value brought by the portfolio manager's selection skills). The risk parity strategy specifically is about understanding the drivers of the beta component of portfolio returns. In particular, Dalio and his associates set out to identify a consistent way of beta asset allocation (proportions of the portfolio allocated to stocks, bonds, commodities, etc.) that would perform well across all economic environments (e.g., the collapse of the Bretton Woods system).

[3] Ibid., 2.

Economic Shocks, Risk Balancing, and Performance of Asset Classes

In order to create a portfolio that delivered the best chance of generating above average returns over time regardless of economic environment, Dalio and his team needed to come up with an approach that fell outside the realm of traditional investment strategies. Instead of relying on correlations and volatility assumptions, Bridgewater Associates turned to the simple truths of assets:

1. Asset classes outperform cash over time.
2. Asset prices discount future economic scenarios.[4]

The first truth follows the basic principle of risk premium, which is the idea that a rational investor demands adequate compensation above the risk-free rate for taking on risk.[5] The second follows the pricing of assets, which are said to reflect the discounted value of the expected future cash flows. The discounted cash flow aims to estimate the present value of an asset based on its ability to return value to investors through increased future cash flow generation.[6]

Utilizing these two elements of pricing, Dalio and his associates set out to find the universal drivers causing the shifts in economic conditions. This is important because asset prices change due to unexpected shifts in market conditions and it is notoriously difficult to time the changes in the market. Although all risky assets deliver positive risk premia over the long run, different asset classes can have markedly

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[4] Bob Prince, "Risk Parity Is About Balance," Bridgewater (Bridgewater, January 6, 2021), https://www.bridgewater.com/research-and-insights/risk-parity-is-about-balance, 2.
[5] Chen, James. "Market Risk Premium." Investopedia. Investopedia, August 28, 2020. https://www.investopedia.com/terms/m/marketriskpremium.asp.
[6] Fernando, Jason. "Discounted Cash Flow (DCF)." Investopedia. Investopedia, April 20, 2021. https://www.investopedia.com/terms/d/dcf.asp#:~:text=Discounted%20cash%20flow%20(DCF)%20is,will%20generate%20in%20the%20future.

different reactions to any given economic shock over the short-term. To construct an effective diversified portfolio that could weather all market conditions, Dalio and his associates wanted to know how different asset classes would react to unexpected shifts in the market.

Built on the learning outcomes of managing assets and liabilities over the years, Dalio and his associates identified two main drivers causing the unexpected shifts in economic conditions: growth shocks and inflation shocks. They also discovered that combining asset classes together can effectively offset and balance the overall risk of a portfolio. For example, stocks tend to perform poorly in economic contractions (negative growth shocks); however, pairing stocks with nominal bonds can mostly offset the loss in stock returns. Although nominal bonds help to offset the risk of economic contractions, both stocks and nominal bonds perform poorly in highly inflationary environments. Commodities and inflation-linked bonds, on the other hand, perform well when inflation rises, and therefore, can be utilized to effectively hedge the risk of inflation shocks.[7] Combining these assets together creates a well-balanced portfolio. For illustration, the figure below displays the return correlation between three distinct asset classes (stock, treasury bonds, and commodities), demonstrating how balancing a portfolio centered around these assets can achieve high diversification benefits to minimize the effects of environmental shocks.[8]

[7] Lee Patridge and Roberto Croce, "Risk Parity for the Long Run: Building Portfolios Designed to Perform Across Economic Environment," Alternative Investment Analyst Review 1, no. 4 (2013): pp. 6-17, 11.
[8] Ibid., 9.

	Equity Returns	Commodity Returns	Treasury Returns
Equity Returns	1.00		
Commodity Returns	0.13	1.00	
Treasury Returns	0.16	-0.11	1.00

Figure 1: Correlation of Asset Returns 1958-2911.

The figure above shows a correlation matrix for monthly returns on equity, commodity, and treasury bonds.

The All Weather Portfolio

In 1996, twenty-five years after President Nixon's announcement, and twenty-one years after the founding of Bridgewater Associates, Dalio and his team put together a fully formed "All Weather" portfolio. The name reflected the original intent of the strategy (capturing the long-term positive risk premium while weathering the storms of short-term economic shocks). The portfolio includes a variety of risky asset classes that each would respond somewhat differently to growth or inflation shocks. The portfolio weights are dynamically adjusted to ensure that the portfolio mains an equal risk exposure to each asset class over time. The figure below demonstrates the original asset class allocations of the All Weather portfolio with the asset classes grouped together based on how they historically performed during growth and inflation environments.[9]

[9] Podolsky, Paul, Ryan Johnson, and Owen Jennings. "The All Weather Story.", 5.

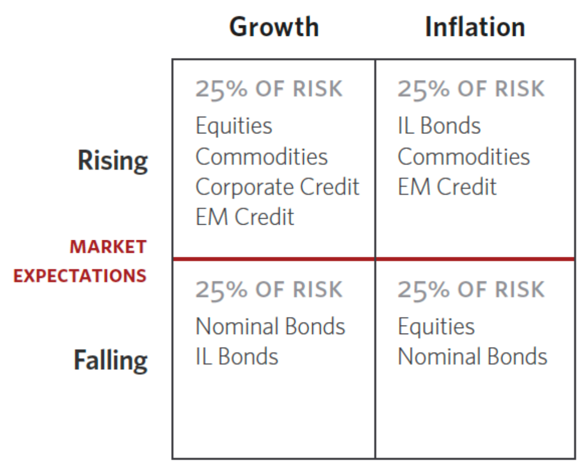

Figure 2: The "All Weather" Portfolio.

The figure above shows the allocations for the "All Weather" portfolio, broken down by asset type. The following assets are included: equities (stocks), commodities (raw materials), Corporate Credit (corporate bonds), EM Credit (emerging market bonds), IL Bonds (inflation-linked bonds), and nominal bonds (fixed-rate bonds).

This novel asset allocation approach delivered an impressive track record, especially during the 2001 dot com crash and the 2008 financial crisis. As a result, strategy increased in popularity and experienced rapid growth in assets under management. The strategy is now commonly referred to as Risk Parity.

Risk-Based vs. Dollar-Based Diversification

The key insight from Dalio's new diversification approach was the idea to allocate equally among asset classes in accordance to overall risk. This is a markedly different approach from the traditional dollar-based diversification strategy, which focuses on spreading capital across asset classes. For example, the widely popular 60/40 strategy implements dollar-based diversification, allocating 60% of capital to stocks and 40% to bonds. While there appears to be a benefit from a simplicity standpoint that favors the 60/40 strategy, the diversification benefit of the portfolio leaves much to be desired. The overall risk, measured by the volatility (standard deviation) of asset returns, shows that the large majority of risk is concentrated within equity. The inherent volatility of equity when compared to bonds leads to roughly 90% of risk being allocated in equity. The figure below shows the overall dollar and risk allocation of a more traditional portfolio following a strategy more closely aligned with 60/40.[10]

[10] Brian Hurst, Bryant W Johnson, and Yao Hua Ooi, "Understanding Risk Parity," AQR Capital Management, 2010, https://www.aqr.com/Insights/Research/White-Papers/Understanding-Risk-Parity, 2.

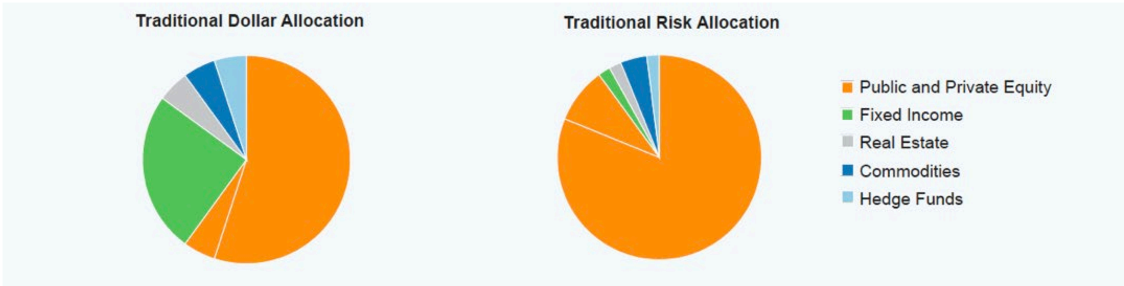

Figure 3: Traditional Portfolios Heavily Concentrated in Equity Risk.

The figure above illustrates an asset class allocation and corresponding risk allocation of a "traditional" portfolio.

Such a high concentration in equity risk makes sense only if the risk premium of stocks is significantly higher than that of bonds. Evidence, based on a long series of historical data, seems to suggest that the risk premia for stocks and bonds are actually comparable, meaning the dollar-based strategy tends to be heavily loaded in equity risk. Due to this observation, the strategy fails to achieve true diversification. The risk-based diversification strategy involved in risk parity ultimately ends up placing a much larger weight on non-equity assets in order to equalize the risk among asset classes. This split often results in an allocation more along the lines of 85/15, where 85% of the portfolio is held in bonds.

The Importance of Leverage

While the risk-based strategy produces a better risk-adjusted return than dollar-based strategies, demonstrated by its higher Sharpe ratio, the overall risk parity portfolio delivers a much lower return due to its larger allocation to non-equity asset classes. In order to achieve a higher return, leverage, defined as the level of assets utilized above the amount of total equity invested (or borrowing money to invest), is applied to increase the expected return (as well as the volatility of the portfolio).[11] A typical target volatility for the portfolio ranges from 10-15%, but can be set to match any level that is deemed fit by each individual's risk aversion. After determining the desired amount of leverage, the additional capital is applied to the portfolio, keeping the ratio between equity and non-equity the same as it was while unlevered.

Although it is difficult for retail investors to obtain leverage, it is widely used by institutional investors (e.g., hedge funds like Bridgewater Associates). The primary source of hedge fund leverage is through borrowing directly from prime brokers (e.g., Goldman Sachs), known as margin loans. Other ways include entering contractual agreements such as total return swaps, where one party agrees to make interest payments based on a set rate in return for another party committing to make payments based on the total return of the underlying assets.[12] These agreements are often made with a bank, where the set rate is determined by the London Inter-bank Offered Rate ("LIBOR") with an added premium.

[11] Kat Tretina, "What Is Leverage?," ed. Benjamin Curry, Forbes (Forbes Magazine, April 8, 2021), https://www.forbes.com/advisor/investing/what-is-leverage/.
[12] "Risk Parity Whitepaper," Wealthfront Investment Methodology White Paper | Wealthfront Whitepapers, accessed May 2, 2021, https://research.wealthfront.com/whitepapers/investment-methodology/, 7.

In this thesis, I construct several risk parity strategies with and without leverage based on two asset classes: stocks and treasury bonds. I use a long time series of historical data to backtest the performance of these portfolios and compare it to an all-stock and 60/40 portfolio. Through the analysis of the constructed portfolios, I find that the all-stock and 60/40 portfolios have higher average excess returns than the unlevered risk parity portfolio, but that the levered risk parity portfolios often achieve a higher excess return and Sharpe ratio with similar levels of volatility when compared the all-stock and the 60/40 portfolios. However, in the early stages of the COVID-19 Pandemic, the risk parity portfolios failed to live up to its name, ultimately failing to weather the unexpected economic storms. Although it experienced a quick recovery, the brief market crash proved that even with a long-term history of strong performance, risk parity not a perfect solution to every economic scenario.

Chapter 2: Theoretical Background - Risk Parity and the CAPM

The CAPM Model

The Capital Asset Pricing Model ("CAPM") was introduced by William Sharpe in 1964 and was built upon the work of Harry Markowitz' Portfolio Selection Model. The CAPM effectively turns an algebraic statement into a prediction showing the relationship between risk and expected return of any risky asset. It utilizes all available assets to create an efficient frontier to plot each combination of asset's risk-return relationship. Through this visualization, there exists an efficient frontier, which is the set of optimal portfolios that offer the highest expected return for any risk level targeted by the investor.[13] Along the efficient frontier is the optimal portfolio, known as the tangency portfolio, where the Sharpe ratio is maximized. In equilibrium, this tangency portfolio turns out to be the market portfolio, which consists of all available assets weighted in proportion to each asset's market capitalization.

Once the tangency portfolio is identified, a risk free asset is added into the equation. Connecting the risk-free asset to the tangency portfolio creates the Capital Market Line ("CML"), which captures all possible combinations between the risk-free asset and the tangency portfolio. While the exact optimal allocation for an individual investor depends on their risk preference, it is highly recommended that all investors following the CAPM model invest in some combination of the risk-free asset and the tangency portfolio that lies on the efficient frontier.

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[13] Akhilesh Ganti, "Efficient Frontier Definition," Investopedia (Investopedia, April 21, 2021), https://www.investopedia.com/terms/e/efficientfrontier.asp#:~:text=The%20efficient%20frontier%20is%20the,for%20the%20level%20of%20risk.

While the theory of CAPM sounds promising, it fails to live up to standards in reality. The historical performance of the market portfolio differs greatly from the actual tangency portfolio, resulting in a lower Sharpe ratio and general underperformance. The deviation between expectations and reality largely is recognized due to the unrealistic assumptions made under the CAPM. One assumption is that all investors have an unrestricted amount of borrowing and lending potential. This is clearly not true because even many institutions (i.e. mutual funds and pension funds) are either not allowed to utilize leverage, or are not willing to. Due to the leverage constraint, many investors overweigh high risk assets in their portfolio to increase the expected returns. Such demand leads to overpricing of high risk assets and underpricing of low risk assets relative to the CAPM predictions.

Opportunity for Investors with Leverage

As leverage-averse investors tilt away from the optimal allocation as prescribed by the CAPM model and invest more in riskier assets, such as stocks, to enhance their returns, the excess demand for riskier assets drives up current prices, lowering the expected future returns. The opposite occurs for safer assets, such as bonds. By trading in an opposite fashion to leverage-averse investors, those who have easy access to leverage can devise a portfolio underweighing equity and overweighing non-equity before applying leverage to reach their desired return and volatility targets. As the actual market portfolio continues to deviate away from the theorized allocation levels, investors who are willing and able to use leverage realize risk-adjusted returns much closer to the tangency portfolio through the means of a risk-parity inspired investment strategy. The figure below demonstrates an efficient frontier devised of annualized figures over the period 1926 through 2010.[14]

14 Clifford S. Asness, Andrea Frazzini, and Lasse H. Pedersen, "Leverage Aversion and Risk Parity," Financial Analysts Journal 68, no. 1 (2012): pp. 47-59, https://doi.org/10.2469/faj.v68.n1.1, 50.

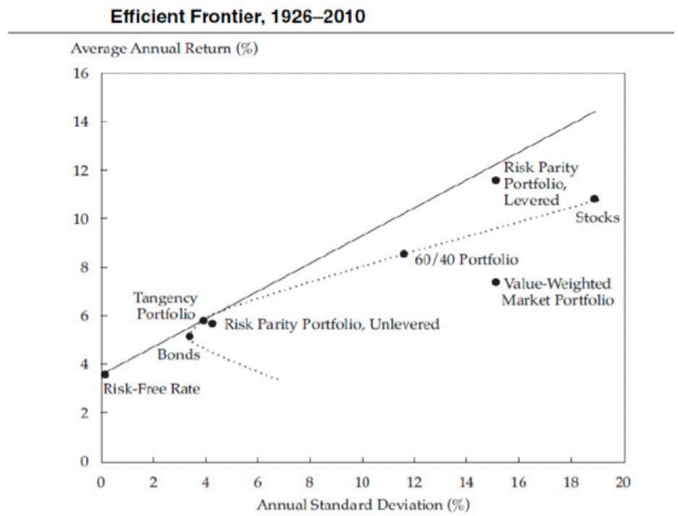

Figure 4: Efficient Frontier, 1926-2010.

The figure above shows the efficient frontier of portfolios of U.S. stocks and bonds over the period 1926-2010.

Chapter 3: Empirical Analysis – Backtesting a Simple Risk Parity Strategy

In this chapter, I construct a simple risk parity strategy and use historical data to backtest its performance. In an ideal world, a risk parity strategy would begin by identifying the tangency portfolio as described in CAPM. Unfortunately, doing this before knowing the actual returns are realized is impossible. To counter this, the risk parity model offers an approximation by dynamically allocating the same amount of risk to stocks and bonds. The resulting allocations have been shown to be quite close to the average tangency portfolio. In practice, a risk parity strategy can include many asset classes and employ fancier allocation methods, but the underlying principles remain similar. For the purpose of this thesis, the simple risk parity strategy will include only two asset classes: US stocks and US Treasury bonds.

Constructing the Simple Risk Parity Strategy: Methodology

The simple risk parity strategy determines the portfolio weights by calculating a percentage inversely proportional to each asset class' volatility, which serves as the estimation of risk. Specifically, I use the following equation to find the weight allocated to each asset class.[15]

$$w_{t,i} = k_t \, \hat{\sigma}_{t,i}^{-1},$$

Equation 1: Weight Allocation

w: the weight allocation for each asset within the portfolio

k: the amount of leverage to be applied

t: data up to month t-1within series under consideration

i: i = 1, 2, 3, …, n

ˆσ: standard deviation

The parameter, k, in the equation above represents a time varying variable that controls the amount of leverage applied to the risk parity portfolio. The calculation of k depends on whether you are creating an unleveraged or leveraged risk parity portfolio, although the overall logic behind the calculation remains the same. The formula below defines the calculation for k for an unleveraged portfolio, which is calculated as the inverse of the weighted average of volatility across all asset classes.[16]

[15] Ibid., 57.
[16] Ibid., 57.

$$k_t = \frac{1}{\sum_i \hat{\sigma}_{t,i}^{-1}},$$

Equation 2: Unleveraged k

The second component in need of calculation is the volatility, defined by the standard deviation. To accomplish this, we define the volatility as the annualized three-year monthly rolling standing deviation of excess returns. With this information now intact, we arrive at k by taking one divided by the sum of the inverse of the rolling standard deviations for each asset class.

For a leveraged portfolio, k is set such that the annualized portfolio volatility matches the realized volatility of the benchmark in which the risk parity portfolio is attempting to match. This is accomplished by finding the annualized standard deviation of the excess returns of the benchmark strategy, seen through the formula below:[17]

$$k_t = \bar{k}$$

Equation 3: Leveraged k

With the now calculated k, for both the unleveraged and leveraged portfolio, as well as the estimation of risk, the weight for each asset class can be finalized. Once that is achieved, the overall portfolio return can be calculated as the weighted average of excess returns across all asset classes. The formula to do so is seen below:[18]

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[17] Ibid., 57.
[18] Ibid., 57.

$$r_t^{RP} = \sum_i w_{t-1,i}\left(r_{t,i} - rf_t\right)$$

Equation 4: Portfolio Return

$r_{t,i}$: asset return

$w_{t-1,i}$: asset weight

rf_t: risk free rate

Based on the methodology described above, I created five unique risk parity portfolios. The first is the unlevered risk parity portfolio. The remaining risk parity portfolios are designed to match the volatility of specific portfolio allocations. Two are created to match an all-stock allocation. An additional two are designed to match the volatility of a 60/40 portfolio. Within both classifications, that being all-stock and 60/40, one of the models had the amount of leverage capped at 300% to align with the reality that unlimited leverage may not be attainable in practice.

Backtested Performance

To backtest the performance of the above mentioned five risk parity portfolios, I obtained monthly returns from 1930 to 2019 for the US Stock index returns and the US Treasury Bond index returns from the Center for Research in Security Prices ("CRSP"). The summary statistics that will be analyzed to generalize performance will be the average excess returns in combination with the average standard deviations of excess returns. These two summary statistics for each analyzed period will be utilized to calculate the Sharpe ratio for each portfolio. While the Sharpe ratio is not the end-all be-all metric to measure risk-adjusted performance, it has a sound theoretical foundation in the CAPM framework and is widely used by industry practitioners.

The Unlevered Risk Parity Model

Jan 1930 to Dec 2019	Mean	Standard Deviation	Sharpe Ratio	Average Leverage
RP Excess Returns (Unlevered)	2.39%	4.02%	0.5931	100%

Table 1: Unlevered Risk Parity Portfolio Statistics

The unlevered risk parity model expectedly had the lowest average excess returns and average volatility of all constructed portfolios; however, performance seen through the Sharpe ratio would indicate it outperforms the traditional dollar allocated portfolios, all-stock and 60/40. This unleveraged portfolio served as the baseline for all other constructed risk parity models.

The All-Stock Comparison

Jan 1930 to Dec 2019	Mean	Standard Deviation	Sharpe Ratio	Average Leverage
All Stock Returns	7.61%	18.40%	0.4139	100.00%
RP Excess Returns (Stock Volatility)	18.06%	29.72%	0.6076	975.46%
RP Excess Returns (Stock Volatility Maxed 3x)	7.16%	12.07%	0.5931	300.00%

Table 2: All-Stock Portfolio Comparison to Two Risk Parity Portfolios

The above findings demonstrate conflicting results. The average annualized excess returns for a portfolio weighted 100% equity from 1930 to 2019 was 7.61%, which represents an outperformance of the more attainable risk parity model capped at three times leverage from a pure return standpoint. However, when taking into account the portfolio volatility, the picture becomes more unclear. The All-Stock portfolio had an average standard deviation of 18.4%, which is 52.4% more volatile than the risk parity model. While it ultimately depends on each investor's tolerance for risk, the risk parity model delivered similar returns for substantially less risk, achieving a Sharpe ratio of 0.5931, representing a 43.3% outperformance of the generic All-Stock portfolio.

Although unrealistic to attain, the uncapped risk parity portfolio greatly outperformed both the capped risk parity and generic all-stock portfolios from a return standpoint; however, it had 146.2% and 61.5% more volatility, respectively, than the all-stock and capped risk parity models. While visualized as achieving a higher Sharpe ratio, the slight difference between the two leveraged risk parity portfolios can be explained by estimation error. The amount of leverage should not influence the realized Sharpe ratio.

The charts seen below will show visual representation of the three portfolios performance through average excess returns, average standard deviation, average

Sharpe ratio, average stock allocation, and average bond allocation in increments of ten year periods.

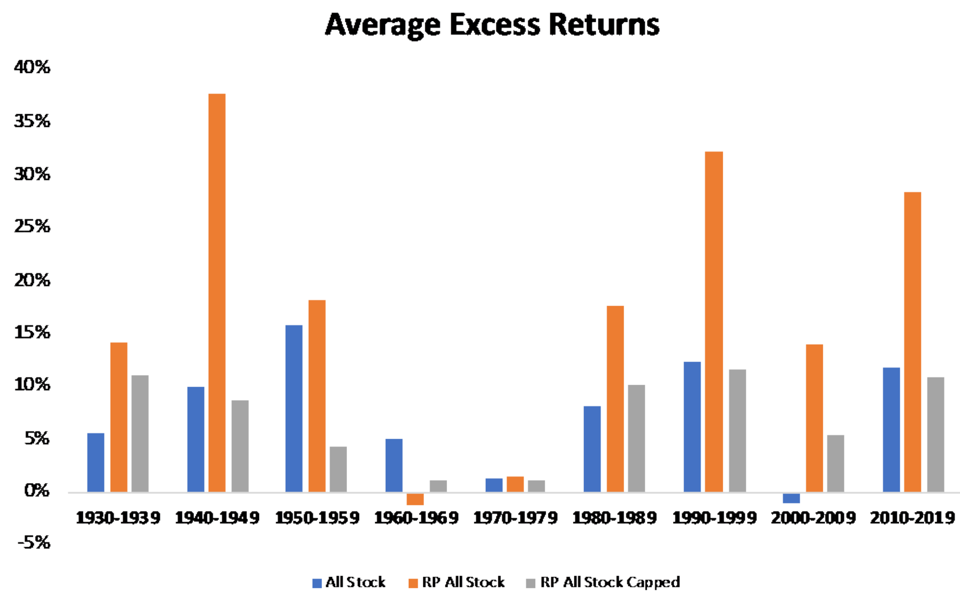

Figure 5: Average Excess Returns Comparison, All-Stock vs. Risk Parity Portfolios

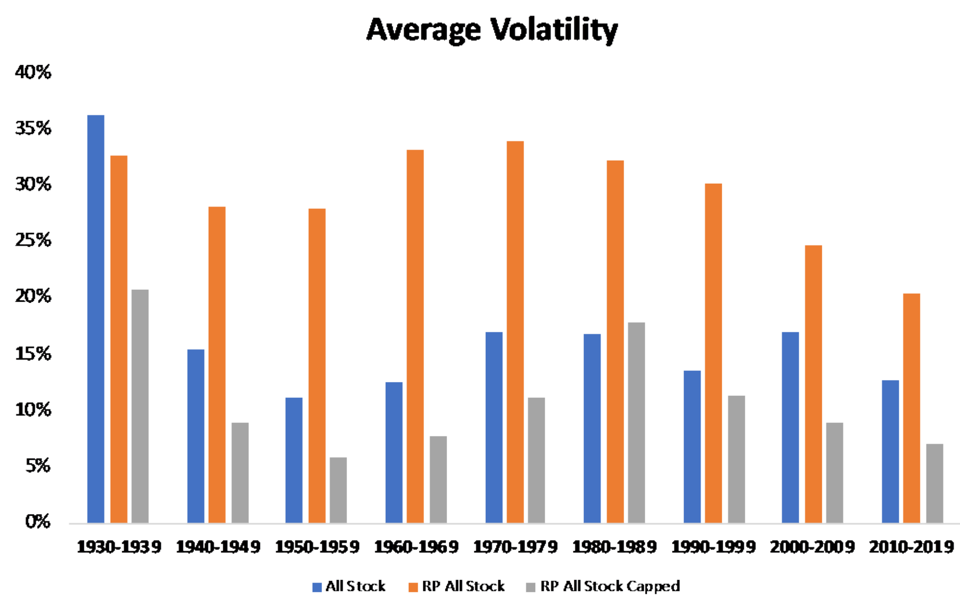

Figure 6: Average Volatility Comparison, All-Stock vs. Risk Parity Portfolios

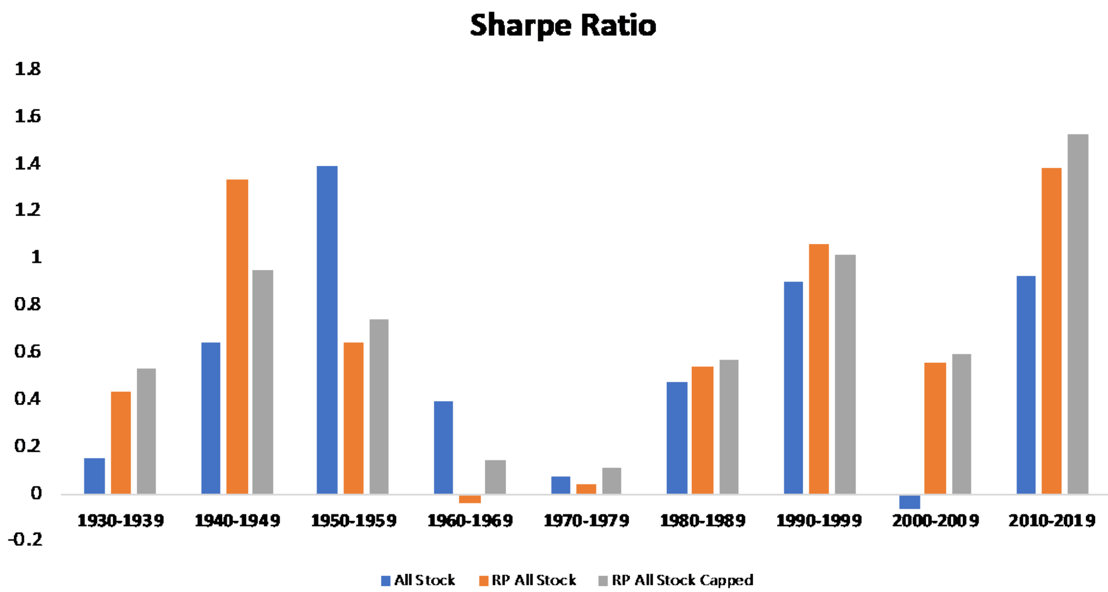

Figure 7: Average Sharpe Ratio Comparison, All-Stock vs. Risk Parity Portfolios

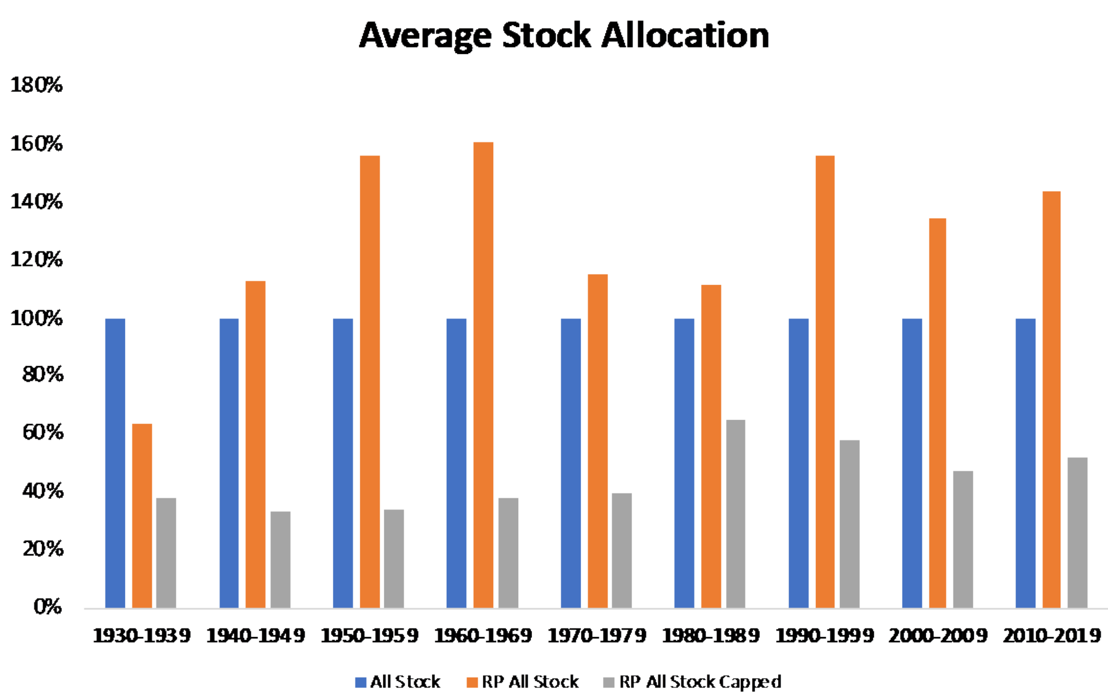

Figure 8: Average Stock Allocation Comparison, All-Stock vs. Risk Parity Portfolios

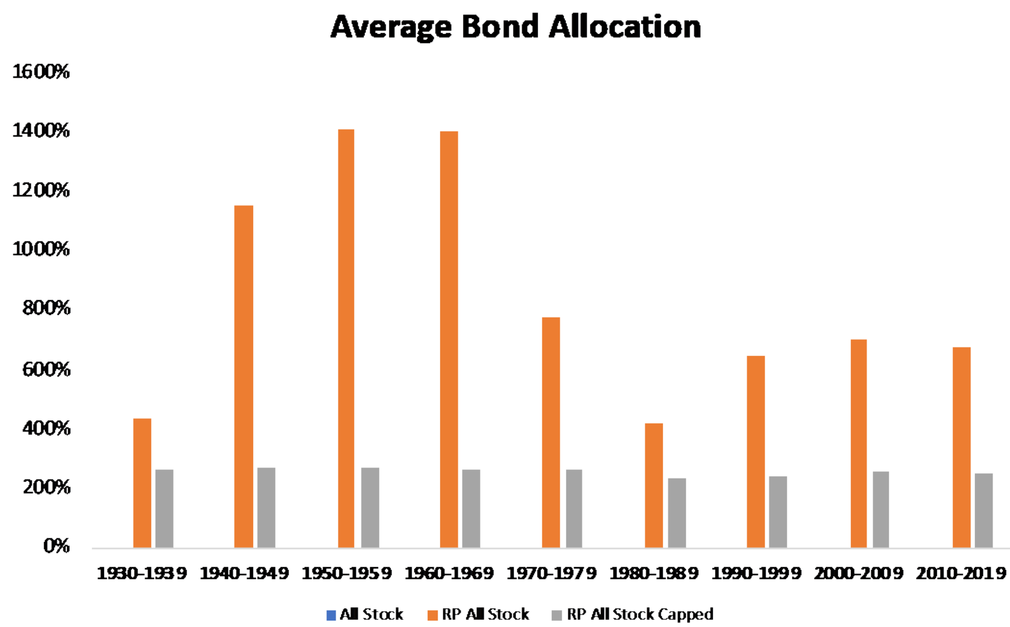

Figure 9: Average Bond Allocation, All-Stock vs. Risk Parity Portfolios

The ten-year subperiod performances as seen above demonstrate the risk parity portfolio's ability to perform well over the long haul. Although it did not beat the all-stock portfolio for every ten-year period, from 1930-2019, there were four sub-periods in which the capped risk parity portfolio achieved higher excess returns. Over the same period, there was only one instance in which the volatility for the capped risk parity portfolio was higher than the all-stock portfolio. This leads to a higher Sharpe ratio for the capped risk parity portfolio in seven of the nine analyzed sub-periods.

Since the release of the All Weather portfolio in 1996, the risk parity strategy has outperformed the all-stock portfolio. Looking at the 2000-2009 sub-period in which the United States suffered two market crashes (2001 dot com bubble and 2008 financial crisis), the risk parity portfolio achieved positive excess returns as opposed to the all-stock portfolio which realized negative excess returns. The portfolio achieved this while realizing a lower average volatility and higher Sharpe ratio.

The 60/40 Comparison

Jan 1930 to Dec 2019	Mean	Standard Deviation	Sharpe Ratio	Average Leverage
60/40 Returns	5.20%	11.26%	0.4623	100.00%
RP Excess Returns (60/40 Volatility)	11.05%	18.19%	0.6076	596.81%
RP Excess Returns (60/40 Maxed 3x)	6.71%	11.30%	0.5938	293.95%

Table 3: 60/40 Portfolio Comparison to Two Risk Parity Portfolios

Differing from the All-Stock comparisons, the above findings demonstrate a more clear-cut picture from a performance standpoint. The average annualized excess returns for a portfolio weighted 60% stock and 40% bond from 1930 to 2019 was 5.2%, which represents an underperformance of the more attainable risk parity model capped at three times leverage from a pure return standpoint. When taking a broader lens and incorporating the portfolio volatility, the picture remains clear. With an average annualized standard deviation of 11.26%, the generic 60/40 portfolio is only four basis points less volatile than the capped risk parity model. For a similar volatility, the capped risk parity model delivered a 6.71% annualized return, representing a 29.0% outperformance of the generic 60/40 portfolio. From a risk-return basis, the capped risk parity portfolio delivered with a Sharpe ratio of 0.5938, representing a 28.4% increase from the generic portfolio.

Although unrealistic, the uncapped risk parity portfolio greatly outperformed both the capped risk parity and generic 60/40 portfolios from a return standpoint; however, it had 61.0% and 61.5% more volatility, respectively, than the generic all-stock and capped risk parity models. While visualized as achieving a higher Sharpe ratio, the slight difference between the two leveraged risk parity portfolios can be explained by estimation error. The amount of leverage should not influence the realized Sharpe ratio.

The charts seen below will show visual representation of the three portfolio's performance through average excess returns, average standard deviation, average Sharpe ratio, average stock allocation, and average bond allocation in increments of ten year periods.

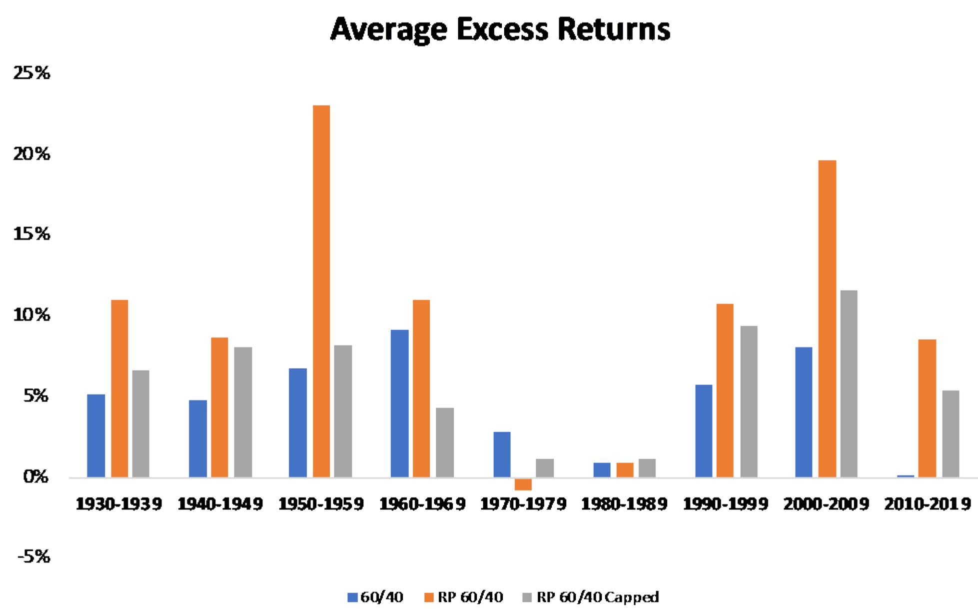

Figure 10: Average Excess Returns Comparison, 60/40 vs. Risk Parity Portfolios

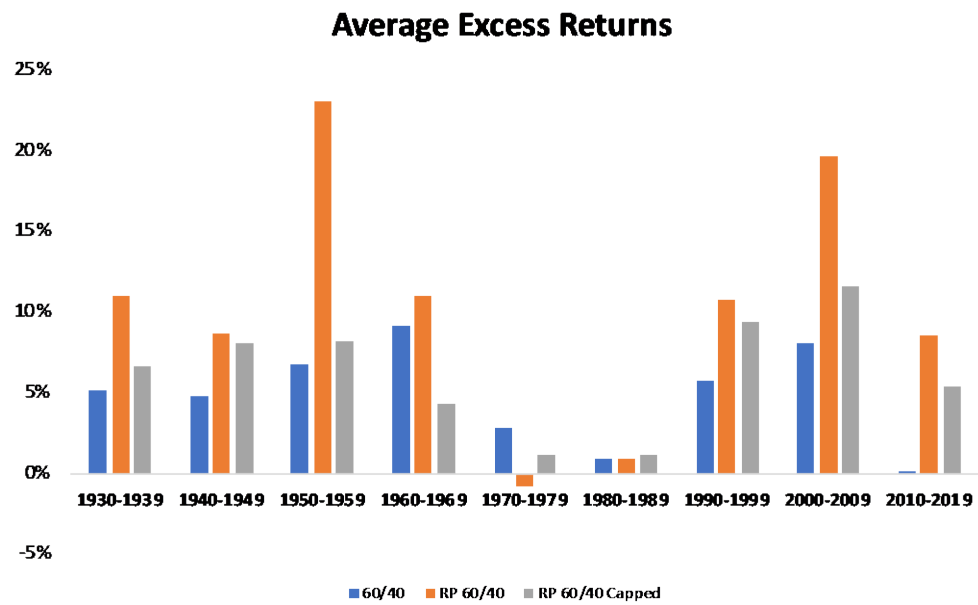

Figure 10: Average Excess Returns Comparison, 60/40 vs. Risk Parity Portfolios

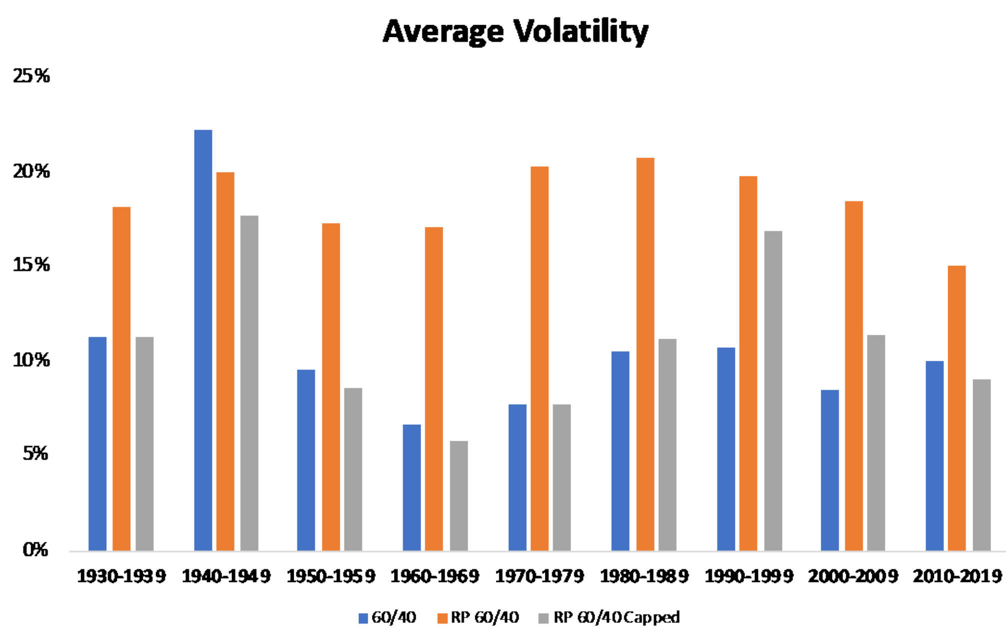

Figure 11: Average Volatility Comparison, 60/40 vs. Risk Parity Portfolios

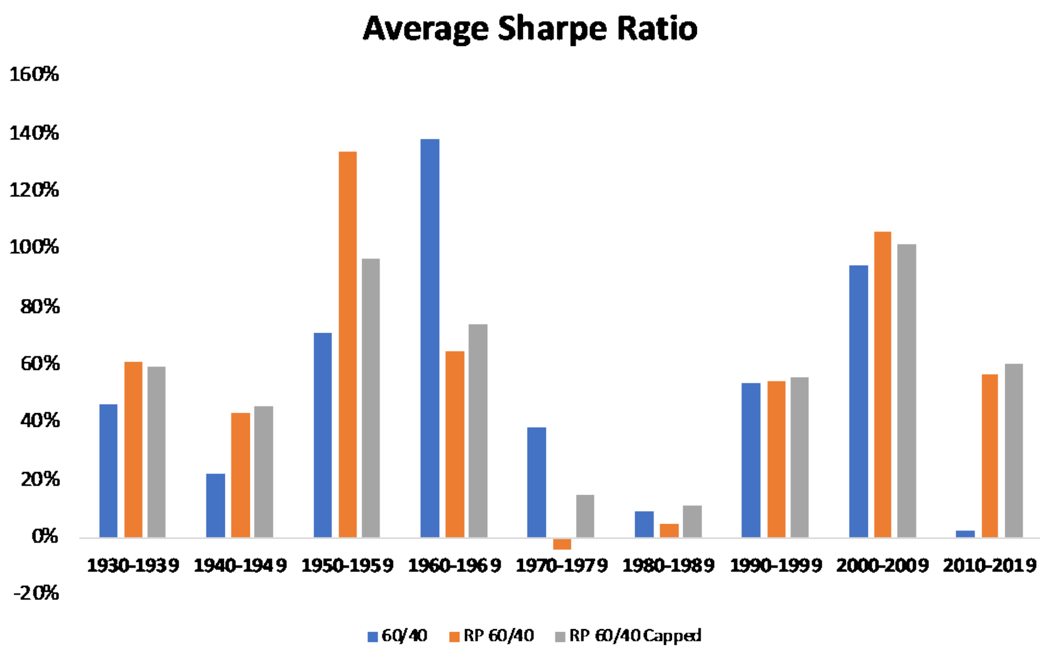

Figure 12: Average Sharpe Ratio, 60/40 vs. Risk Parity Portfolios

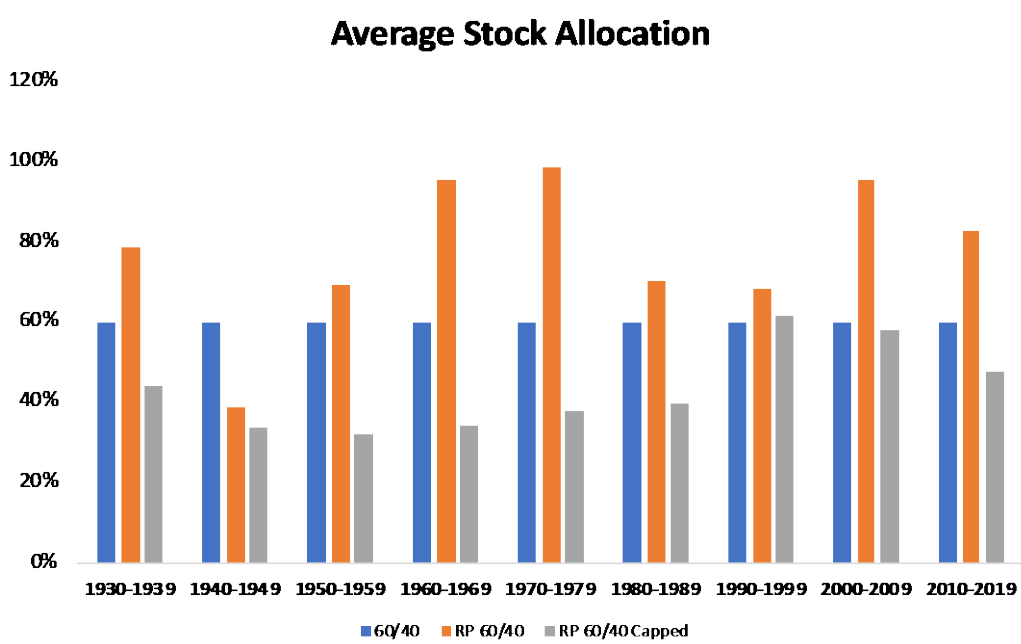

Figure 13: Average Stock Allocation Comparison, 60/40 vs. Risk Parity Portfolios

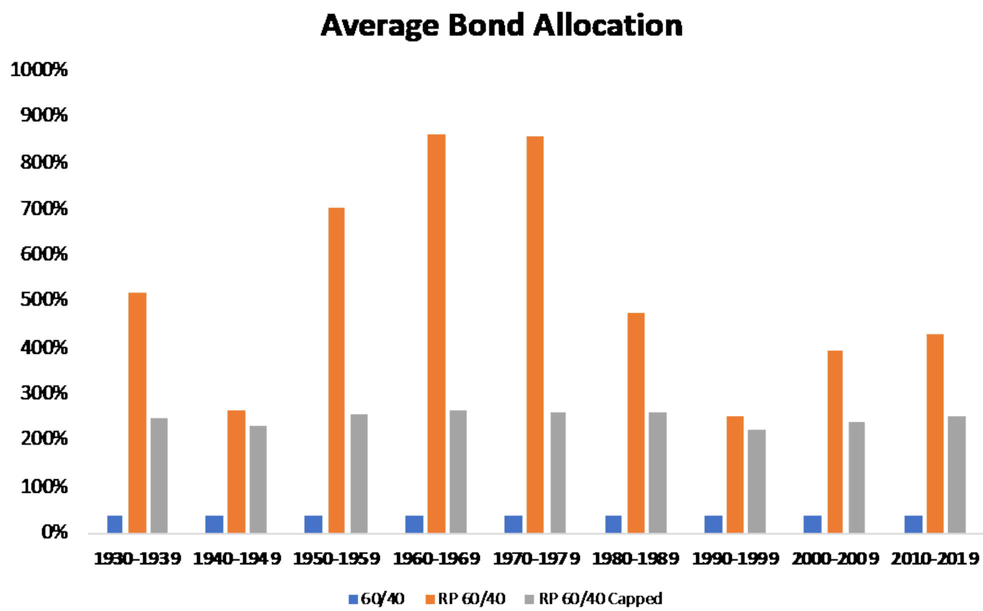

Figure 14: Average Bond Allocation Comparison, 60/40 vs. Risk Parity Portfolios

The ten-year subperiod performances as seen above demonstrate the risk parity portfolio's ability to perform well over the long haul. Although it did not beat the 60/40 portfolio for every ten-year period, from 1930-2019, there were seven sub-periods in which the capped risk parity portfolio achieved higher excess returns. Over the same period, there were three instances in which the volatility for the capped risk parity portfolio was higher than the all-stock portfolio. This led to a higher Sharpe ratio for the capped risk parity portfolio in seven of the nine analyzed sub-periods.

Since the release of the All Weather portfolio in 1996, the risk parity strategy has outperformed the 60/40 portfolio, achieving higher excess returns on lower volatility and a higher Sharpe ratio. The overall consistency of the risk parity portfolio proves that the performance can be stable over time and is not entirely driven by one, or a few, strong sub-period(s).

Chapter 4: COVID-19 Pandemic Performance

The outbreak of COVID-19 was officially declared a global pandemic on March 11, 2020 by the World Health Organization. The market, realizing the potential chaos it could cause, started to react about three weeks prior, beginning the COVID-19 market sell-off on February 20, 2020. Over the course of a one month period from February 20 to March 20, 2020, the DIJA index plummeted just under 34%. Most of the activity occurred over three days, Black Monday (March 9), Black Thursday (March 12), and Black Monday II (March 16) where the DIJA dropped 7.79%, 9.99%, and 12.93%, respectively.[19] Much of the sell-off was fear driven as the United States imposed quarantines on the population and ordered shut-downs of business activity as a means of safeguarding the public. At the time, these decisions led to a drastic rise in the rate of unemployment, reaching heights above 20%, directly contributing to sharp declines in GDP of 5.0% and 31.7% over quarter one and quarter two of 2020.[20]

As stocks were plummeting, it was assumed that the treasury bond market would pick up steam due to is historical status of being one of the most liquid and safe assets in the world. The negative beta of Treasury bonds over recent decades made that assumption feel like a certainty; however, the reality of the situation differed greatly. The events during March 2020 did not follow the traditional reactions seen in previous

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[19] Mieszko Mazur, Man Dang, and Miguel Vega, "COVID-19 and the March 2020 Stock Market Crash. Evidence from S&P1500," Finance research letters (Elsevier Inc., January 2021), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7343658/#cit_3.

20 "Gross Domestic Product, 2nd Quarter 2020 (Second Estimate); Corporate Profits, 2nd Quarter 2020 (Preliminary Estimate)," U.S. Bureau of Economic Analysis (BEA), August 27, 2020, https://www.bea.gov/news/2020/gross-domestic-product-2nd-quarter-2020-second-estimate-corporate-profits-2nd-quarter#:~:text=Real%20gross%20domestic%20product%20(GDP,real%20GDP%20decreased%205.0%20percent.

market crashes. In this short period of time, the stock market fell dramatically, the volatility index (VIX) spiked, credit spreads widened, the dollar appreciated, and prime money market funds experienced outflows.[21] The price of long-term Treasury securities fell sharply as the Treasury yield increased 60 basis points, resulting in an unusual positive correlation between the stock and bond market returns.

As stock and bonds both fell, a large majority of commodities followed suit. The sudden halt of economic activity with expected threats of global slowdown caused commodities linked to energy, metals, transportation, and agriculture to fall.[22] The stoppage of the economy played hand-in-hand with supply chain issues and government intervention.

Combined, the three asset classes all performed poorly. The risk parity model, designed to withstand major disruptions to the economy regardless of uncertainty, failed to live up to expectations. The table below demonstrates the performance of different risk parity mutual funds, as well as domestic and global 60/40 portfolios during the peak of the COVID-19 market crash.[23]

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[21] He, Zhiguo, Stefan Nagel, and Zhaogang Song. "Treasury Inconvenience Yields during the COVID-19 Crisis." NBER working paper, June 2020, 1.
[22] "Most Commodity Prices to Drop in 2020 As Coronavirus Depresses Demand and Disrupts Supply," World Bank, April 23, 2020, https://www.worldbank.org/en/news/press-release/2020/04/23/most-commodity-prices-to-drop-in-2020-as-coronavirus-depresses-demand-and-disrupts-supply.
[23] "Quant Funds in the Coronavirus Market Rout: Risk Parity," Quant Funds in COVID Market Rout | Markov Processes International, April 20, 2020, https://www.markovprocesses.com/blog/risk-parity-funds-in-the-coronavirus-market-rout/.

Name	Ticker	Max Drawdown Loss, %	Annualized Trailing Return as of April 9th, 2020			
			YTD	1 Year	3 Years	5 Years
AB Global Risk Allocation A	CABNX	-24.5	-12.1	-7.7	-0.2	0.4
AMG FQ Global Risk-Balanced	MMAFX	-29.4	-18.2	-11.6	-1.4	0.8
AQR Risk Parity	QRMIX	-16.4	-8.8	0.0	4.2	2.1
AQR Multi-Asset I	AQRIX	-17.7	-10.4	-1.6	3.6	2.3
Columbia Adaptive Risk	CRAAX	-13.4	-5.7	0.7	4.7	4.3
Invesco Balanced-Risk Allocation	ABRZX	-20.3	-10.1	-5.7	0.8	1.5
Putnam Dynamic Risk Allocation	PDREX	-20.4	-11.4	-8.8	-0.4	0.2
Putnam PanAgora Risk Parity	PPRWX	-15.8	-4.8	2.6	-	-
RPAR Risk Parity ETF	RPAR	-20.5	-0.1	-	-	-
Wealthfront Risk Parity	WFRPX	-42.8	-18.8	-5.7	-	-
Domestic 60/40		-20.9	-5.9	2.6	7.0	6.7
Global 60/40		-21.5	-9.3	-2.6	3.7	3.5
S&P Risk Parity 12%		-29.1	-14.1	-3.7	3.7	3.5
S&P Risk Parity 10%		-24.4	-11.6	-2.5	3.5	3.2

Figure 15: Risk Parity Indices Performance During COVID-19 Pandemic

This shows that there are still unforeseen economic shocks that can break down the presumed correlation patterns between asset classes. The lesson learned from this, is that despite the stellar historical performance of risk parity portfolios, it is still not a perfect strategy that effectively weathers all of the storms. We still have a long way to go in order to reach a true “All Weather” portfolio.

Chapter 5: Conclusion

After years of studying the makeup of the economic machine, Ray Dalio and his associates released the first edition of a risk parity portfolio, known as "All Weather". By utilizing a risk-allocation as opposed to a dollar-allocation, the risk parity model achieves true diversification. This allocation based on risk results in a portfolio heavily dominated in inherently less risky assets. While this leads to high performance from a maximization of Sharpe ratio standpoint, the actual returns of an unleveraged portfolio fail to impress. By applying leverage to match the desired volatility of an investor, the risk parity model generates higher risk-adjusted returns than other portfolio compositions.

Designed to weather the storms of any economic uncertainty, the risk parity portfolio failed to live up to its name during the COVID-19 market crash. The break down between stock and bond correlations in the early stages of the pandemic posed a challenge unforeseen to investors. Although it was quick to recover, along with much of the market, the underperformance led many to question its viability for future market downturns; however, with a long-term focus, it is easy to understand just how beneficial following the strategy can be.

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