# PORTFOLIO OPTIMIZATION IN A HIGHER-FOR-LONGER INTEREST RATES ENVIRONMENT

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# Executive Summary

While major developed economies seem to be headed towards recession, global inflation dampens but central banks believe that upside risks remain strong and signal for higher-for-longer interest rates. The higher-rate regime will be one of the main characters in the portfolio allocation stories for the next year.

Investors across all asset classes face a highly uncertain macroeconomic environment. This report elaborates a macro-based equity portfolio optimization strategy to help investors navigate the current uncertainty.

We provide an overview of the current macroeconomic context surveying the most relevant data. This gives us a useful snapshot to be kept in mind for the following asset classes analysis. We scrutinize how the higher-for-longer central banks narrative and of the market expectations about future macroeconomic developments impacts the performance of several asset classes. This analysis encompasses fixed income, considering both government and corporate bonds; equities, conducting comparisons by sector, by type of stock (growth vs value) and by company size; alternatives, including ETFs, commodities, real estate and private equity.

We then conduct a quantitative analysis aimed at recommending an equity portfolio strategy to endure the current macroeconomic volatility. After a macro-based stock selection, we construct a mean-variance and a risk-parity portfolio. Finally, we conclude that a risk-parity strategy might be more fit, effectively distributing investments among diverse assets and reducing risks specific to particular sectors.

# 1 Overview of Macroeconomic Environment and Future Outlook

## 1.1 Current Macroeconomic Context

A few important economic metrics, the most well-known of which is inflation, best describe the macroeconomic conditions of the Euro area, the US, and the UK as of Q3 2023.

The annual inflation rate in the Euro area was predicted to drop from 2.9% in October 2023 to 2.4% in November 2023. Additionally, key industries including food, alcohol, and tobacco had a Q3 inflation of 6.9%, 4.0% on services, non-energy industrial products at 2.9% inflation, and energy inflation had significantly decreased by -11.5%. Services led the list of expenditures with 43.5% annual inflation in 2023, followed by non-energy industrial products at 26.3%, food, drink, and tobacco at 20.0%, and energy at 10.2%.

A similar situation occurred in the United States, where the annual inflation rate for the year ending October 2023 dropped to 3.2%, a considerable decline from the rate of 3.7% for the preceding year and far lower than the average inflation rate of 8.0% in 2022. In the meantime, there was a decrease from 6.3% in September to 4.7% in the UK's Consumer Prices Index including owner occupiers' housing expenses (CPIH) for the 12 months ending in October 2023. Comparably, within the same time frame, the US Consumer Prices Index (CPI) increased by 4.6% in October, down from 6.7% the month before.
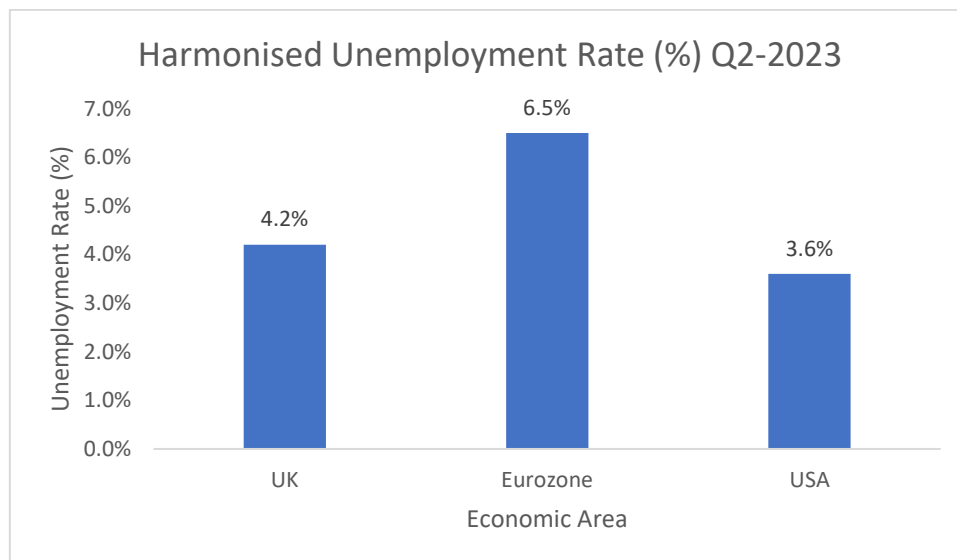


The unemployment scenario further highlighted the varied economic conditions. The UK's harmonized unemployment rate rose from 3.9% in Q1 to 4.2% in Q2 2023, surpassing Germany's 3.0% but falling short of France's 7.3%. In Q3 2023, the total unemployment rate in the Eurozone remained steady at 6.5%. Following the coronavirus pandemic, unemployment rates varied greatly around the world; Spain had the highest rate, 12.0%, while South Korea and Japan had the lowest, 2.6%. Concerns over youth unemployment persisted, especially in nations like Greece (25.9%), Costa Rica (26.4%), and Spain (27.8%), whilst the UK reported a figure of 12.3% for the second quarter of 2023.

**Real GDP Growth by Quarter**
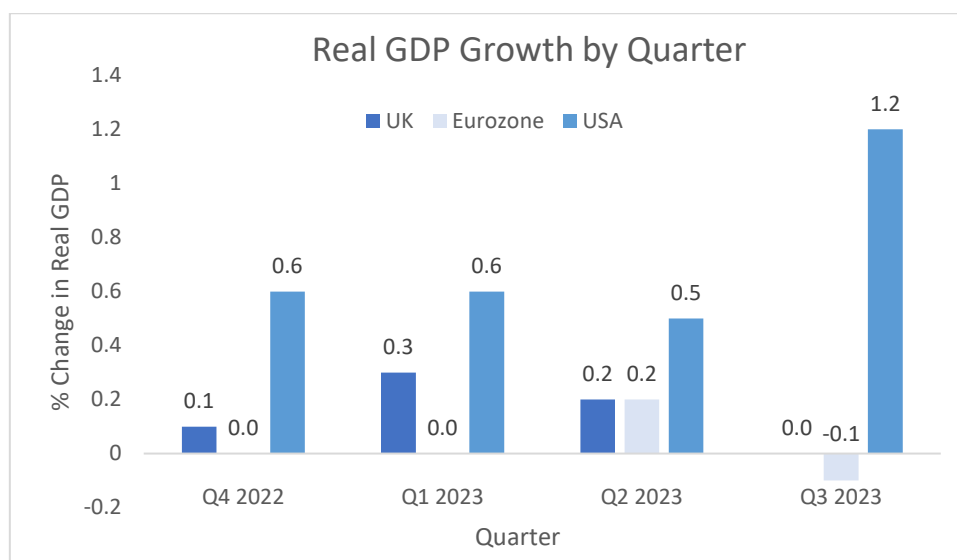
In Q3 2023, GDP growth for the UK was unchanged from the previous quarter, while Germany and the Eurozone had a 0.1% decline. In contrast, the US had a 1.2% increase in GDP during the same quarter. GDP changes from year to year were 2.9%, 0.6%, and 0.1% for the US, the UK, and the Eurozone, respectively. While the EU's GDP remained stable overall in Q3 2023, there were variations in different sectors. The service sector showed upward growth trends, while industrial production declined. Retail trade, despite a decrease, remained above pre-pandemic levels, indicating strong consumer spending.

The International Monetary Fund's (IMF) World Economic Outlook report from October 2023 shows forecasts of slowdown in global growth from 3.5 percent in 2022 to 3.0 percent in 2023 and 2.9 percent in 2024. Advanced economies are expected to experience a more significant slowdown, from 2.6 percent in 2022 to 1.5 percent in 2023 and 1.4 percent in 2024, as the tightening of policies begins to have a more meaningful impact. This report highlights the widening divergences among countries and regions, complicating efforts for some to achieve higher living standards.

Central banks in major economies have taken a "higher for longer" approach to maintaining interest rates to curb inflation, still well above the ideal target of 2%. Such persistent inflation emphasizes the need for continued program strengthening. Furthermore, labor market fluctuations, especially in the US and Europe, might allow a "soft landing" for the global economy despite uncertainty about the true strength of the global economy. Structural changes in the economy, such as greater demand for investments compared to saving, and uncertainty including interest rate insensitivity in businesses and potential new labor shortages due to shifts in manufacturing, further complicate the economic outlook.

The result of this is that the housing sector has experienced a significant impact due to the rise in mortgage rates, which approached 8% in 2022, the highest in over two decades. This substantial increase in mortgage rates, as reported by U.S. Bank, has led to a cooling of the housing market, resulting in a brief decline in average home prices in the U.S. Additionally, a study highlighted by the National Association of Home Builders (NAHB) demonstrates how even a modest quarter percentage point increase in interest rates can price out approximately 1.1 million households from the new home market, based on the 2022 median home price of $412,506. This shows the sensitivity of the housing market to interest rate changes and their direct impact on affordable housing. In addition, rising interest rates have a clear impact on consumer spending. According to a paper by Roman Kozlov at the NHH Norwegian School of Economics, higher interest rates increase household loan and borrowing costs, directly affecting household consumption. This is particularly important considering the high level of reliance on household debt in recent years. Other sources, such as the Richmond Fed and Deloitte Insights, support that higher interest rates have pushed up borrowing costs, affected non-capital corporate spending, and reduced consumer spending, especially on purchases based on loans such as for automobiles and large appliances. This reduction in consumer spending is critical as it's a primary driver of economic growth. For businesses, the increase in borrowing costs due to higher interest rates is a significant barrier. A study by Saba Mustaq at the

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University of Karachi and one by Augustine Tarkom from Texas A&M University highlight a negative relationship between private investment and real interest rates beyond a certain threshold. This relationship implies that as interest rates rise, firms' resource allocation and tactical decision-making decreases, leading to a decrease in private investment. This, in turn, affects aggregate demand in the economy, causing a decline in both consumption and investment.

## 1.2 Future Outlook

In terms of yield environment projections, the UK economy, a significant player in the global financial market, is experiencing a mild recession, influencing medium-term yield projections. In the long term, global economic growth is expected to ease further, with possibilities of mild recessions in Europe and the UK, while the US is expected to achieve a soft landing. China's growth is seen weakening, impacted by companies seeking alternative production destinations. The global economy is forecasted to grow by 2.9% this year, with growth slowing to 2.6% next year.

Interest rate trends in the largest economies are predicted to fluctuate starting in 2024. Rate cuts in the third quarter of 2024 are widely expected in the UK and the Euro area as a response to the necessity of boosting economic activity to prevent minor recessions. In contrast, rate cuts are surely in line for the United States, which is expected to see greater growth and are expected in the fourth quarter of 2024. Experts predict higher long-term rates in the main developed economies when considering the longer-term outlook. This tendency is linked to increased public debt levels as well as an AI-driven productivity boom that supports economic development. These elements point to a changing economic environment in which longer-term structural shifts and technology innovations are interconnected with short-term policy decisions.

# 2 Impact on Asset Classes

## 2.1 Fixed Income

Bonds have always served as a powerful instrument for portfolio diversification, risk mitigation and potential capital preservation. With the highest interest rates in the USA and Europe in 22 years, fixed income assets start to play even more important role in portfolios, offering increased incomes, which can be fully realized after inflation and prices fall. However, from the other perspective, as the bonds prices have inverse relationship with interest rates, investors are exposed to interest rate risks and erosion of the value of their assets, which paved the way for Silicon Valey Bank bankruptcy this year. Thus, with all the riches of the bond universe, investors should clearly identify their goals and make compromise between long-term return and potential market volatility.

In conditions of interest rates hikes, no matter how stable and responsible the issuer is, all fixed income investors will still be influenced by interest rate risks. Thus, from the table we may see that during the last 6 major period of increased interest rates all 4 main classes of bonds have experienced at least one period of negative returns. Essentially, the scale of this negative influence is linked to such metrics of bonds as maturity, coupon rates and yields with the general rule that long-term bonds have a greater sensitivity to the rise in rates. In this way, long-term U.S. Treasuries suffered the largest decline among all bond types with the measure of -29,3%. And despite successful periods of high interest rates as 2004-2006 for high-yield and emerging markets, all bonds mostly benefit from the conditions of declining interest rates.

|  | U.S. Bond Market | Global High Yield | Emerging Markets | Global Bond Ex-U.S. |
|---|---|---|---|---|
| February 1994–February 1995 | 0,01% | -7,82% | -24,13% | 8,75% |
| June 1999–May 2000 | 2,11% | 5,03% | 14,67% | -6,24% |
| June 2004–June 2006 | 3,09% | 10,40% | 11,83% | 4,31% |
| July 2012–December 2013 | -0,17% | 12,43% | 2,57% | 0,07% |
| December 2015–December 2018 | 1,89% | 5,72% | 4,54% | 3,48% |
| April 2022 - November 2023 | -6,85% | 1,23% | -5,18% | 1,23% |

Nevertheless, historically and by construction, short-term bonds have been more immune to interest rate risks and one of the main indexes which tracks the performance of short-term bonds, ICE Indices U.S. Treasury Short Bond Index (IDCOTS) have shown almost no declines in its values since its inception date of tracking in 2005. All this made ultra-short income investment strategies one of the most popular in 2022, however offering just about 1% of return.

Investors should understand that in case of massive investment in short-term bonds they lose returns of newly issued long-term instruments which generally drive the performance of investor's portfolios and support funding for long-term goals. Looking at current inverted yield curve, many fixed income securities with shorter maturity and higher rates may still seem to be more preferable, but with the potential end of quantitative tightening reinvestment risk of classical bond classes becomes more relevant.

The class of bonds, which clearly demonstrates increased performance in times of rate hikes and inversed yield curve are high-yield bonds, which usually have shorter duration and higher coupon rates than high-quality corporate bonds, making it less sensitive to the hikes. (on November 22nd 2023 weighted average maturity of iShares iBoxx High Yield Corporate Bond ETF was 4,67 years in comparison with 7,39 years for iShares 5-10 Year Investment Grade Corporate Bond ETF). At the moment The Bloomberg US Corporate High-Yield Bond Index offers an average yield of roughly 8.5% and standard deviation of 8,69%.

Usually in period of rate hikes High-Yield Bonds have lower Treasury Spread, but reach unprecedented levels of Yield to Worst. Despite the fact, that global corporate default tally rose to 127 through Oct. 31, the share of BB-rated bonds now is the largest in the decade at 50%, with its duration making it a more attractive investment then before, especially at the end of tightening cycles. Investing in this category could be considered as an example of hedging when you invest in portfolios of high-yield bonds and include a built-in hedge of short duration products to mitigate the impact of rising rates.

Combining the qualities of both equities and fixed income, convertible bonds historically have performed well in an environment of high interest rates. The convexity of convertibles makes it possible to mitigate risks as well as to get additional exposure during market rally. Thus, in the last 20 years, during the periods when interest rate when the 10-year Treasury yield rose more than 100 basis points, convertibles (ON THE example of ICE BofA All US Convertibles Index) showed their best results and considerably outperformed traditional bonds with average results for such periods of 12,7%. Conditions of rising rate environment creates an entry-point for this asset class, which returns are driven by market volatility and widened credit spreads.

Bond markets of emerging markets historically have been heavily influenced by rate hikes in developed countries with the result of massive underfinancing (about $100 billion of predicted borrowing for EM investors in 2023 in comparison with annual average of $ 150 billion within 2016-2019) and increased uncertainty of this asset class. Nevertheless, EM bonds always overperformed after the finish of hawkish policies with 11% on average return the respective post-hiking cycle period compared to 8% average performance for other years. For instance, The JP Morgan EMBI Global Core index composed of U.S. dollar-denominated, emerging market bonds, showed the best performance in 2019 with 16,09% of annual return, following the end of high rates. In this way, if historical trend continues, the period of transition to dovish policy and resilient growth may become good entry-point for EM bonds. Specifically, a number of factors are now having a more favorable impact on the recovery of China's debt securities market, which make up a significant portion of emerging market bond indices. At the same time, many emerging countries that depend on Chinese demand will also benefit from additional growth and can guarantee more stability in this direction of bond investments. Positive bond investment strategies are also linked to record yields on corporate bonds. After hitting lows in 2021, interest rates have risen significantly, with the Morningstar U.S. Corporate Bond Index at 5.16%,

Special place in the spectrum of fixed income investments during high inflation and rising interest rates plat inflation-linked bonds, which, as it's clear from the name, are designed to protect investors from increasing inflation and are linked to a specific measure of inflation, as CPI in the USA, for instance. This type of investment usually matches the investors, whose expectations about inflation are higher, than its final realization. During tight monetary policies of central banks, real yields rise, making realized inflation to fall and negatively influencing the performance of inflation-linked securities in this way. Observing current diligent efforts of central banks to combat inflation, it's logical to see the performance of inflation-linked bonds on the example of Bloomberg World Government Inflation-Linked Bond Index within the period of April 2022 – November 2023 at -17,6%, representing an unattractive investment opportunity despite overall market hype on it. For instance, the portion of US TIPS which was issued on November 21, 2023 had a real yield to maturity of 2.180%. With the 10 Year Treasury Rate of 4,41% on the same date and target of 4% for inflation, this premium seems insufficient for many investors, which was proved by the bid-to-cover ratio of 2.32, indicating fairly weak demand.

## 2.2 Equities

Equities can be described as an asset class which experiences a very specific influence of high interest rates. From one perspective, as high interest rates are connected with inflation, companies should benefit it, realizing their ability to pass higher costs on consumers and maintain their growth. On the other side, many equities begin to be subject to underfinancing problem, functioning in conditions of economic slowing as well as to higher uncertainty and decreased investment demand due to high potential returns of bonds.

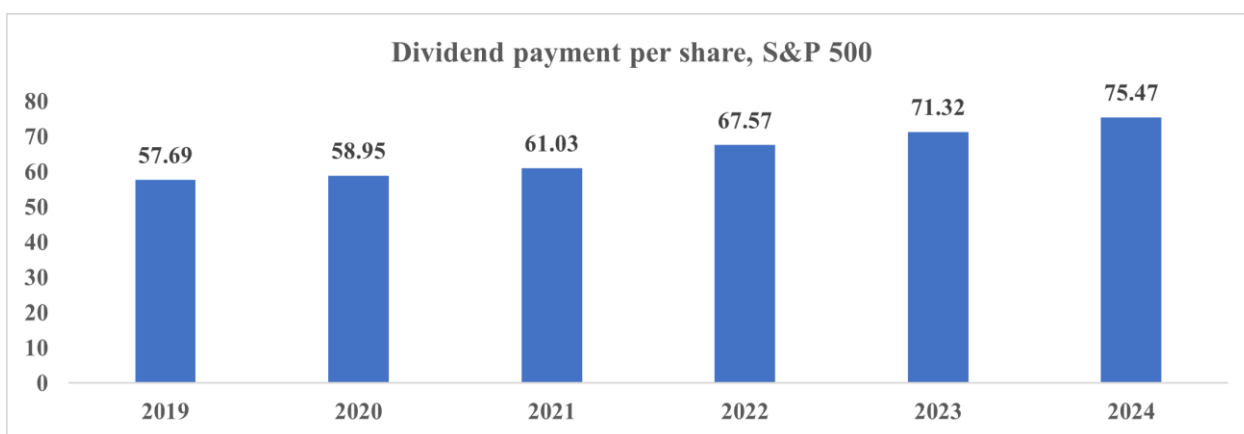| Decade | Annual inflation (% p.a.) | Change in inflation (% p.a.) | Volatility (% p.a.) | US Equity Returns 1950-2010 (% p.a) |
|--------|--------------------------|------------------------------|---------------------|-------------------------------------|
| 1950s | 2 | 3,4 | 3,8 | 14,3 |
| 1960s | 2,3 | 4,3 | 1,3 | 8,8 |
| 1970s | 6,9 | 6,1 | 2,9 | 4,7 |
| 1980s | 5,6 | -8,1 | 3 | 17,2 |
| 1990s | 3 | -2,1 | 1,2 | 18,1 |
| 2000s | 2,6 | -2,8 | 2,5 | -1,7 |

From the table we may see that historically stocks could be considered as a poor hedge against inflation and corresponding high interest rates, which was especially seen during the 1970-s and 2000-s, when U.S. Equity Returns were insufficient in comparison with annual inflation. Also, according to the study "Stocks as a Hedge against Inflation: Does Corporate Profitability Keep Up with Inflation?," published in the August 2023 equities could not have been considered as a hedge in tightening environment. That's connected with the fact that the relationship between corporate profitability and inflation was too unstable, and could lead both to favorable and unfavorable consequences, especially in short time intervals. That's why potential success of equity investing also depends on the rights choice of subcategories in terms of sectors or styles, but not the equity universe as a whole.

As was mentioned earlier, returns and bonds prices move in a different direction, so in condition of high interest rates, sectors which negative beta relative to the Treasuries should show positive results during tightening, In this way, ranging from -0,2 to -1 Communication Services, Materials, Industrial, Energy and Financials are 5 sectors which usually are strong during high interest rates. Also, historically, during the 5-year cycles of rising interest rates in 1994,1997, 1999, 2004 and 2015 six of the 11 market sectors have outperformed the broader market in the year following an initial rate increase: Communication Services, Energy, Financials, Health Care, Information Technology, and Utilities, while Real Estate was the sector which performed the worst. According to the data of US Sectors' performance during the recent cycle of rises, there was a similar range distribution, except from healthcare, materials and utilities, which clearly underperformed. This variation proves the statement, that the performance of stocks in tight environment tends to be too volatile and erratic, as inflationary environment evokes shrinking returns due to higher costs, even for such defensive industries as consumer staples, which has negative returns of -2,42% in the last 1,5 years. While energy benefits from increased prices and information technologies with communication services are still able to maintain growth due to cash balances from previous years and the development of new technologies.



April 2022 - November 2023
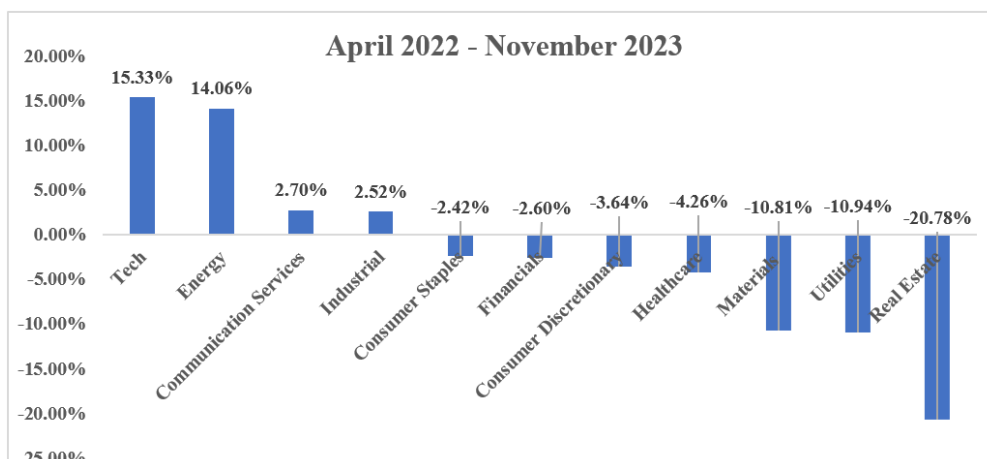
As sector investing results may seem to be too volatile to analyze past trends and make investment recommendations, the analysis of stocks according to traditional Fama-French components may excel.

Comparing value and growth stocks, it's clear that value equities have a tendency to outperform growth during the period of high interest rates, as they mostly rely on the cash flows which are produced currently, while the growth stocks are connected with future cash flows, which are as a result discounted with higher interest rates. Secondly, value companies usually experience excess demand during high interest rates, extracting benefits from ongoing inflation. Thus, from 1970 till 2022 the correlation between Fed Rate and HML component was 0,06, indicating a weak but positive relationship between value stocks and rates. In the United States, whenever the 10-year treasury rate increased by 0,10% during the month in the period of 1980 and 2021 value stocks outperformed growth equities approximately by 113 bps, what highlights the befits of value during tightening. Moreover, according to BlackRock estimates current exposure of portfolios from 16000 advisors to value stocks is 8% lower, than expected, which can create additional demand and excess returns in the future. However, the overall condition should be carefully monitored, as although value tend to overperform growth during recovery periods, in case of recessions and slowdowns growth companies which not so heavily depend on current economic trend win. In addition to that with the change of economic environment investors start to appeal to high dividend stocks, as possible hedge instruments for their portfolios with the ability to generate stable income, as the change of dividend policy is reluctant by the majority of companies (historically dividends are sticky for more than 60% of US companies). According to Global X Management Company during the period of 1960-2017 in 7 out of the 10 rising interest rates environments high dividend stocks outperformed the S&P 500 Index. And at the moment despite the fact that since April 2022 return of High Dividends Stocks accounted at -2,66%, investors may expect potential excess returns, as with the possibility of following recession, dividend companies may have a tendency to increase their dividend payout ratio in order to align with their average absolute numbers, benefiting stockholders. Current Bloomberg data indicates that the dividend payments from S&P500 Index constituents will total 71,32 USD per share in 2023 and 75,47 USD per share in 2024 accordingly, reaching the record high values and continuing the trend of constant growth.



**Dividend payment per share, S&P 500**

| Year | Value |
|------|-------|
| 2019 | 57.69 |
| 2020 | 58.95 |
| 2021 | 61.03 |
| 2022 | 67.57 |
| 2023 | 71.32 |
| 2024 | 75.47 |

The second major factor of Fama-French Model – the size of the company, points out that small-caps historically showed better results in periods, following the rise of interest rates.

RUSSELL 2000 INDEX RETURNS FOLLOWING FED FUNDS RATE INCREASE

| Hike Date | 3 months after | 12 months after | 18 months after | 36 months after |
|---|---|---|---|---|
| 2/1/83 | n/a | 26.97% | 5.20% | 49.22% |
| 10/1/86 | 1.75% | 29.02% | 7.47% | 40.02% |
| 2/4/94 | -2.54% | -2.69% | 16.85% | 47.57% |
| 6/30/99 | -6.32% | 14.32% | 7.60% | 1.71% |
| 6/30/04 | -2.86% | 9.45% | 15.88% | 48.00% |
| 12/15/15 | -5.36 % | 22.63% | 17.55% | 9.14% |
| Averages | -3.07% | 16.62% | 11.76% | 32.61% |

In this way, companies from Russell 2000 index, which tracks the performance of 2000 smallest companied from the index Russell 3000, usually showed negative performance just after the first months of tightening, while in mid-term perspective the performance was high enough, on average earning 16,62% of annual return 12 months after the Fed Funds Rate was increased, which also align with positive correlation of 0,04 of SMB component of Fama-French Model. However currently small-caps stocks experience one of the largest pression in history, as their weak balance sheet have become the risks with the serious rate increase and 30 per cent of their debt stock being floating-rate. So, since the start of current increase of rates in April 2022 Russell 2000 Return has been -11,55%, while the return of S&P 500 Index amounted to 2,92% and is remarkably stronger. In parallel to that, P/B ratio of Russell 2000 was 1,73 as of November 29, 2023 in comparison with 4,3 of S&P 500, making it considerably more preferable for value investors.

At the same time looking at geographical diversification of portfolios many equities may seem to be appealing, as with the growth of rates companies start to benefit from weaker currencies and higher potential profits from export. However, according to the research of the World Bank with the increase of 2-year yield in the US lead to the increase of the probability of crisis in emerging markets from 3,5 to 6,5 percent, negatively influencing the demand and attitude to risks. Moreover, equity index of emerging markets outperformed classical S&P 500 during the period of 2004-2010, while after that period had losing results in all the years, except 2017, as effects of globalization premia started to disappear for this asset class.

## 2.3   Alternatives

In the modern conditions alternatives start to play more important role in the portfolios of investors, as classical mix of equities and bonds doesn't provide full diversification and potential excess returns. Firstly, we should mention, how ETF-funds market was influence by the growth of inflation and rising interest rates. In this macroenvironment, the most significant was the raise of Pacer Cash Cows ETF funds, which track the performance of high-quality equities with the best high free cash flow yield on different markets and segments: Pacer US Cash Cows 100 ETF, Pacer Emerging Markets Cash Cows 100 ETF, Pacer Developed Markets International Cash Cows 100 ETF, which accumulate more than 30 billion dollars of AUM under current economic conditions. Particularly, we should highlight the growth of AUM of Pacer US Cash Cows 100 ETF from 1,25 billion USD at the beginning of 2022 to 16,3 billion USD in November 2023, while others funds had smaller absolute number, but tremendous percentage growth from 77% to 300% during 2023. At the same time the return of Pacer US Cash Cows 100 ETF and Pacer Developed Markets International Cash Cows 100 ETF (P/B ratio of 1,03) reached average annual numbers of 23,56% and 12,9% accordingly for the last 3 years, which in turn were very tough for the economy. That's why we may see that during similar situations, these strategies may be highly appealing, both due fundamental value drivers and market interest.

According to the research of Vanguard commodities have always been an instrument which showed high results during inflation. Having low correlation with inflation of 0,34 commodity as a class has had a very significant

inflation beta of 7,6 for the last 3 decades (the highest among all asset classes) and according to historical estimates the growth of inflation of 1% was followed by 7%-9% growth of commodities' prices. However actual for inflation high interest rates have been one of the worst influencers for prices of commodities, increasing volatility and surpassing trading volumes. Slowing economy translates to less demand from the market and higher production costs. That's why gold, as one of the main assets overall, has always been negatively associated with raising rates. The same situation is actual for other metals, energy resources and agricultural products. So S&P GSCI(R) Index, which gives exposure to the whole market of commodities, has showed the return of -7,1% since April 2022, while during the previous tight period of December 2015-December 2018 performed at -7,7%. Potential declines of commodities pricing are also connected with more appealing fixed income returns for part of conservative investors.

As mortgage rates have a high influence on property values, real estate has historically been highly impacted by changes in policies of central banks. During 6 periods of interest rate rised in the US from 1970 till 2018 US REITs performed positively 4 times and outperformed S&P 500 3 times, with the highest return of 35,6% during the period of January 1983-June 1984, that can be connected with increased rent return and high economic growth (in 1983 the growth of the US GDP was 4,6%). At the same time according to the Vector Error Correction Model inflation-driven increase of interest rates lead to the 15% decline of property values during the next 5 years. That' why correct influence of interest rates on RE prices is highly connected with other macro variables, as inflation, disposable income, GDP growth, rent rates. Thus, JPMorgan Asset Management shows that the ratio of disposable income to US house price is a good indicator for observing house prices, as 2 historical declined of property prices were preceded by the indicator achieving value above 1 (which also happened during the periods of 1970-1980 and 2004-2006). As the indicator this year is on its record level of 1,06, we also observed the 3rd historical decline of historical prices after Q4 2022.



Exhibit 3: US house price index vs house price to personal disposable income ratio*
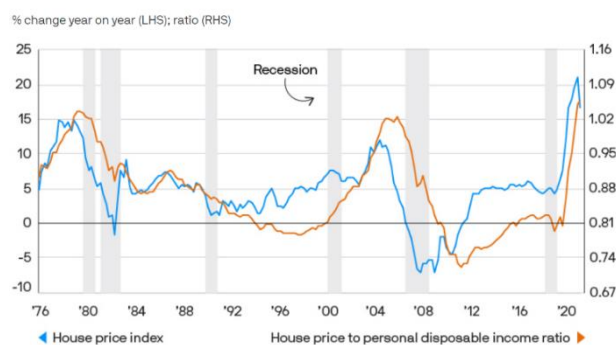
This is why traditional real estate investing may both be a successful strategy now, while investors may focus on more specific and demanded property types: hotels, medical and data centers spaces or student facilities.

Private capital markets, meanwhile, are highly dependent on interest rates, as one of their main forms of investment on them are LBO. Thus, after the start of hikes last year investments in companies from private markets decreased from 1 trillion dollars in 2021 to 654 billion dollars in 2022. In parallel from 4 largest private investors in the world: Blackstone, KKR, Apollo и Carlyle 2 outperformed S&P 500 in 2022 and ended the year with net profit. That can been explained by historically more accurate approach to valuation and asset allocation with focus on resilient industries and cash-generating units. In addition to that, average rates of private credits increased from historical 6%-7% to 11%-12% with considerably greater spread to government securities. That's why during hiking rates with a reasonable approach to asset picking, private markets can be highly beneficial for portfolios.

# 3 Portfolio Optimization and Quantitative Analysis

## 3.1 Macro-based Stock Selection

Current trends in GDP growth, inflation, interest rates, and geopolitical events play a pivotal role in sector performance. For instance, sectors like consumer staples and healthcare often demonstrate resilience in high inflation scenarios, whereas luxury goods and technology might underperform. In the context of the prevailing macroeconomic conditions, characterized by a robust annual GDP growth rate of 4.9% in the third quarter of 2023, an effective federal funds rate of 5.33% as of December 2023, and an annual inflation rate of 3.2%, our stock selection has been tailored to capitalize on sectors that historically demonstrate resilience and growth potential in such an economic climate. Our strategy pivots on diversification, spreading investments across multiple sectors to create a robust financial ecosystem. We handpick companies that not only exhibit robust fundamentals but also demonstrate promising growth trajectories and a steadfast resilience against market volatility.

In particular each stock was carefully chosen out of a huge pool, dissecting their returns, volatility, and risk-adjusted performance ratios (table next page). The stocks daily data were gathered through the use of Yahoo Finance from the following period: December 3rd, 2018, to December 3rd, 2023. A timeframe of 5 years is sufficient to assess the performance in order to conduct accurate stock picking and the various portfolio optimization techniques.

| Stock | Return (%) | Volatility (%) | Sharpe Ratio | Sortino Ratio | Drawdown (%) |
|-------|-----------|----------------|--------------|---------------|--------------|
| AAPL  | 31.62     | 32.62          | 1.01         | 1.68          | −31.43       |
| MSFT  | 26.35     | 30.87          | 0.91         | 1.53          | −37.12       |
| NVDA  | 40.81     | 55.95          | 0.89         | 1.68          | −66.33       |
| GS    | 13.46     | 32.83          | 0.55         | 0.92          | −45.45       |
| CAT   | 13.80     | 32.79          | 0.56         | 0.92          | −38.52       |
| GE    | 12.94     | 42.50          | 0.50         | 0.83          | −58.22       |
| AMZN  | 8.73      | 35.86          | 0.41         | 0.69          | −56.03       |
| GOOGL | 5.91      | 33.21          | 0.34         | 0.55          | −31.73       |
| CVX   | 6.41      | 35.58          | 0.35         | 0.56          | −55.65       |
| NKE   | 6.97      | 33.08          | 0.37         | 0.62          | −52.67       |

In detail, our investment selection process is based on their historical performance, risk metrics, and diversification benefits. At the same time, it is deeply intertwined with the macroeconomic landscape. For example, our focus on the technology sector aligns with its potential for robust growth in a thriving economy. In contrast, our selection of financial stocks, such as Goldman Sachs (GS), is based on their potential to benefit from rising interest rates in a growing economic environment. Each stock in our portfolio is influenced by specific macroeconomic factors. For instance:

- Apple (AAPL): exceptional annualized excess return with a solid Sharpe ratio, indicating strong risk-adjusted returns. This technology giant's performance is sensitive to consumer spending trends and global supply chain dynamics, which are in turn influenced by broader economic conditions.
- Microsoft (MSFT): high annualized excess return and favorable Sharpe ratio, showcasing strong performance with relative stability. Microsoft's performance is often linked to business spending on technology and software, which can fluctuate with corporate profits and economic cycles. In periods of economic expansion, increased business investment can lead to higher demand for Microsoft's products and services.

- NVIDIA (NVDA): highest annualized excess return in the selection, albeit with higher volatility. NVIDIA, known for its graphics processing units (GPUs), is impacted by trends in gaming, data centers, artificial intelligence, and cryptocurrency mining. Economic conditions that favor technological advancement and digital transformation can drive demand for its products.
- Goldman Sachs (GS): strong annualized returns with a moderate Sharpe ratio, representing the financial sector. As a leading financial institution, its performance is closely tied to interest rate changes and banking regulations. In a rising interest rate environment, GS may benefit from wider net interest margins, boosting profitability.
- Caterpillar (CAT): robust returns and a good Sharpe ratio, providing industrial sector exposure. Caterpillar is a bellwether for global industrial activity, with its performance linked to construction, mining, and infrastructure development. Economic growth drives demand for construction and mining equipment, benefiting CAT.
- General Electric (GE): solid annualized returns and a decent Sharpe ratio, di- versifying into the industrial sector. GE's diverse operations in aviation, health- care, power, and renewable energy make its performance sensitive to economic cycles, government policies, and technological advances in these sectors.
- Amazon (AMZN): good return profile and represents significant e-commerce and cloud computing exposure. Amazon's dual roles in e-commerce and cloud computing make its performance sensitive to consumer spending, digital trans- formation trends, and the overall health of the tech sector.
- Alphabet (GOOGL): offers tech and communication sector exposure with balanced returns and risk profile. As the parent company of Google, Alphabet's performance is linked to online advertising, digital services, and technological innovation. Its revenue, largely derived from advertising, can be sensitive to economic cycles affecting business and consumer spending.
- Chevron (CVX): represents the energy sector with decent returns and con- tributes to diversification. Chevron's performance is highly dependent on global oil and gas prices, which are influenced by geopolitical events, supply-demand dynamics, and global economic trends. Economic growth can lead to higher energy demand and prices, positively impacting CVX.
- Nike (NKE): adds consumer goods exposure with reasonable returns and risk metrics. Nike's performance is influenced by global consumer spending, fashion trends, and sports events. Economic prosperity typically leads to increased consumer spending on branded apparel and footwear, benefiting this company.

## 3.2 Portfolio Optimization Framework

Another crucial facet of our study revolves around analyzing portfolios created using known portfolio optimization techniques. Strategies such as the mean-variance and risk parity approaches, are designed with an eye on the macroeconomic climate. In volatile markets, a risk parity strategy might be more apt, balancing the portfolio across diverse assets and mitigating sector-specific risks.

### 3.2.1 Mean-Variance Portfolio

Leveraging five years of daily data up to December 3rd, 2023, we calculated expected returns and the covariance matrix of returns. Subsequently, we delineated the Markowitz mean-variance efficient frontier for the aforementioned stocks, subject to a standardized set of constraints, to find the optimal asset allocation.

First of all, the total of all asset weights is required to equal 100%:

$$\sum_{i=1}^{n} w_i = 1$$

In the context of these portfolios, $n$ represents the total number of assets within a given universe, while $w_i$ stands for the weight of asset $i$, the exact value of which is yet to be determined. To facilitate an equitable comparison across all portfolios, we've implemented boundary constraints where each weight $w_i$ is confined within a lower limit $l$ and an upper limit $u$.

$$l \leq w \leq u$$

Standard boundary constraints typically include no short selling, which is characterized by setting $l$ to 0 and $u$ to 1.

The task of optimizing a portfolio to find the mean-variance efficient frontier can be formulated as follows. First, let

$$X = \{w \in R^n \mid \sum_{i=1}^{n} w_i = 1, 0 \leq w \leq 1 \}$$

The minimization problem is the following:

$$\min_{w} w^T \cdot \Sigma \cdot w$$

$$s.t. \quad \mu^T \cdot w \geq \mu_0$$

$$w \in X$$

In this context, $\mu$ represents the vector of expected return rates, while $\Sigma$ denotes the matrix of return covariances. By varying the hyperparameter $\mu_0$ — the desired expected return — we can determine the mean-variance efficient frontier.
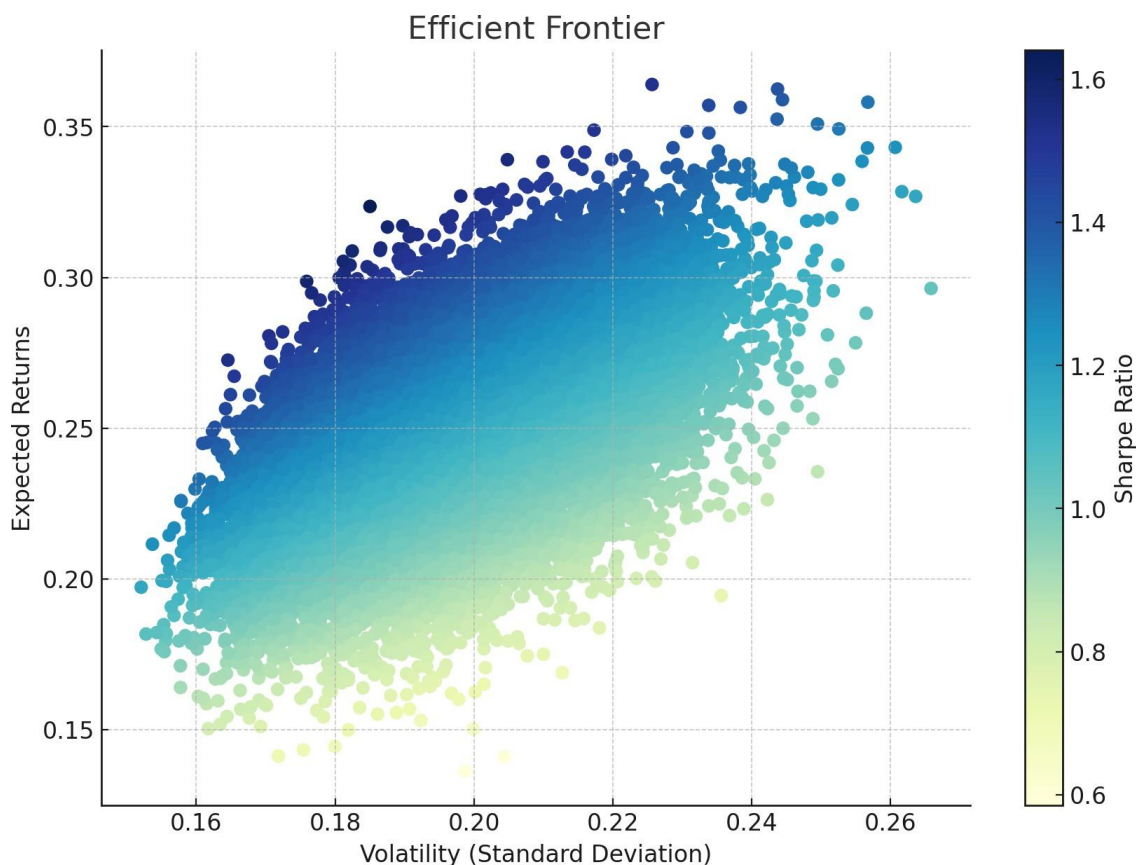


The efficient frontier graphically represents the set of optimal portfolios that offer the highest expected return for a given level of risk or the lowest risk for a given level of expected return. Points along the curve represent the optimal mix of risk and return. Each point on the graph is obtained by a specific combination of the weights of the stocks in the portfolio. Finally, the Sharpe ratio, indicated by the color gradient, shows the risk-adjusted return of the portfolios: the higher the Sharpe ratio, the better the portfolio's risk-adjusted performance.

The mean-variance optimization for the portfolio comprising the stocks GS, NVDA, AAPL, NKE, CVX, GOOGL, AMZN, GE, MSFT, and CAT, based on their daily historical data from December 3rd, 2018, to December 3rd, 2023, yields the following optimized weights:

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| Stock | Weight (%) |
|-------|-----------|
| GS | 4.57 |
| NVDA | 0.00 |
| AAPL | 6.34 |
| NKE | 9.01 |
| CVX | 10.37 |
| GOOGL | 5.57 |
| AMZN | 6.71 |
| GE | 2.37 |
| MSFT | 10.30 |
| CAT | 44.76 |

These weights represent the proportion of each stock in the optimized portfolio, aiming to minimize volatility while maximizing the returns. It's noteworthy that NVDA has a weight of 0%, indicating its exclusion from the optimized portfolio under these parameters, while CAT has the largest share, making up almost 45% of the portfolio.

The only way to check the reliability and the performance of this portfolio is to backtest portfolio returns, risk characteristics, style exposures, and drawdowns, and compare the results with an established market index.

| Portfolio | CAGR (%) | Stdev (%) | Max. Drawdown (%) | Sharpe Ratio | Sortino Ratio | Market Correlation |
|-----------|----------|-----------|-------------------|--------------|---------------|-------------------|
| Optimal Portfolio | 19.65 | 23.82 | –23.99 | 0.80 | 1.35 | 0.88 |
| Vanguard 500 Index Investor | 12.36 | 19.04 | –23.95 | 0.61 | 0.94 | 1.00 |

The optimal portfolio is compared to the Vanguard 500 Index, a proxy to represent the whole market. The backtest performance analysis was conducted over the period spanning from 3/12/2018 to 3/12/2023. As displayed in the table, the tangency portfolio achieved a compound annual growth rate (CAGR) of 19.65%, while the Vanguard 500 Index Investor has a CAGR of 12.36%.

In addition, the optimal portfolio exhibited a higher standard deviation of 23.82% compared to 19.04% for the Vanguard 500 Index Investor, implying greater volatility. Despite this, its maximum drawdown was -23.99%, slightly less than the index's - 23.95%.

The Sharpe ratio for the tangency portfolio was 0.80, indicating a favorable risk- adjusted return compared to the Vanguard index's 0.61. Portfolio 1 also achieved a higher Sortino ratio (a variation of the Sharpe Ratio that uses the standard deviation of negative portfolio returns instead of the total standard deviation) of 1.35 against the index's 0.94, suggesting better performance during downside volatility.

The analysis of annual returns highlighted our portfolio's robust performance, consistently outperforming the Vanguard 500 Index Investor across the majority of the years in the backtest period. The graphical representation of portfolio growth further underscores the superior progression of the tangency portfolio balance over time in comparison to the benchmark index.

In conclusion, the portfolio's performance metrics such as higher alpha, lower beta, and significant upside capture ratio (of 129.52 against 100.00) emphasize its effective management and strategic asset allocation that have contributed to its out- performance relative to the Vanguard 500 Index Investor.

### 3.2.2 Risk-parity Portfolio

In order to conduct a thorough portfolio optimization analysis, we included the risk parity weighted portfolio, which allocates capital with a focus on equalizing the risk contribution from each asset, rather than basing allocations on market size or expected returns. This method calibrates the investment mix to ensure that each asset proportionally influences the portfolio's risk profile. These portfolios are typically constructed using an optimization process that involves minimizing a specific expression, subject to the full investment constraint:

$$\min_{w} \frac{1}{2} w^T \cdot C \cdot w - log(w^T \cdot d)$$

$$s.t. \qquad 1^T \cdot w = 1$$

In this equation:

- $\min_{w}$ indicates the minimization over the portfolio weights $w$.

- $w$ is the vector of asset weights in the portfolio.

- $C$ is the covariance matrix of asset returns.

- $\frac{1}{2} w^T \cdot C \cdot w$ is the portfolio variance, a common risk measure.

- $d$ is a vector of the diagonal elements of $C$, representing the individual variances (risks) of the assets.

- $- \log(w^T \cdot d)$ is a term used to encourage diversification; it penalizes the logarithm of the weighted sum of individual asset risks.

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- $1^T \cdot w = 1$ is the constraint that the sum of the weights must be equal to 1, ensuring a fully invested portfolio

The risk parity optimization for the portfolio comprising the stocks GS, NVDA, AAPL, NKE, CVX, GOOGL, AMZN, GE, MSFT, and CAT, based on their daily historical data from December 3rd, 2018, to December 3rd, 2023, yields the following optimized weights.

| Stock | Weight (%) |
|-------|-----------|
| MSFT | 6.75 |
| CAT | 39.15 |
| CVX | 8.12 |
| NVDA | 4.52 |
| AAPL | 6.59 |
| GE | 6.85 |
| GS | 7.12 |
| NKE | 7.32 |
| AMZN | 6.81 |
| GOOGL | 6.77 |

Similarly to the mean-variance portfolio, we observe a significant allocation to the CAT stock in this portfolio, reflective of its consistently low standard deviation over the years. To accurately assess the reliability and performance of this portfolio, it is essential to conduct a thorough backtest. This process should include evaluating portfolio returns, risk characteristics, style exposures, and drawdowns. Following the backtest, the comparison with a benchmark index will provide an understanding of the portfolio's performance in relation to the broader market.

Also in this case, the risk parity weighted portfolio was benchmarked against the Vanguard 500 Index, and the timeframe to evaluate its performance remains the same, from December 3rd, 2018, to December 3rd, 2023.

| Portfolio | CAGR (%) | Stdev (%) | Max. Drawdown (%) | Sharpe Ratio | Sortino Ratio | Market Correlation |
|-----------|----------|-----------|-------------------|--------------|---------------|--------------------|
| Risk parity portfolio | 22.92 | 24.49 | −25.55 | 0.89 | 1.51 | 0.90 |
| Vanguard 500 Index Investor | 12.36 | 19.04 | −23.95 | 0.61 | 0.94 | 1.00 |

As reported in the table, the risk parity portfolio achieved a superior compound annual growth rate (CAGR) of 22.92% , more than double the Vanguard index's CAGR of 12.36%, over the relevant time frame.

Volatility metrics indicate that the risk parity portfolio had a slightly higher standard deviation at 24.49%, in comparison to the Vanguard index's 19.04%, which may suggest higher risk. Nonetheless, the risk parity portfolio's best year gain was robust at 34.93%, outpacing the Vanguard index's 31.33%. The worst year loss for the risk parity portfolio was less severe at -7.40%, versus the index's more significant loss of -18.23%.

In terms of risk-adjusted performance, the risk parity portfolio posted a Sharpe ratio of 0.89 against the Vanguard index's 0.61, indicating that the excess return per unit of risk was more favorable. Additionally, a higher Sortino ratio of 1.51 for the risk parity portfolio, relative to the Vanguard index's 0.94, demonstrates better performance in downward market movements.

The annual return data shows that the risk parity portfolio consistently outpaced the Vanguard 500 Index Investor. The portfolio growth chart further highlights the risk parity portfolio's robust accumulation of value over time, in contrast to the benchmark index.

From a risk and return perspective, the risk parity portfolio's alpha value of 8.09% underscores its ability to generate returns above the benchmark, with a beta of 1.16 indicating its movements are somewhat more volatile than the market.

On the whole, the backtest results reveal that the risk parity portfolio not only surpassed the Vanguard 500 Index Investor in terms of total return but also achieved this with favorable risk-adjusted return measures, indicating a well-managed and strategically balanced investment approach.





To conclude, our analyses indicate a consistently higher Sharpe ratio achieved in both cases, suggesting that our stock selection strategy and portfolio optimization techniques have been robust and effective with historical data. However, it is crucial to remember that past performance of returns and volatility metrics is not indicative of future results.

In summary, our selected stocks are strategically chosen to align with the ongoing macroeconomic environment. This portfolio is designed to capitalize on technological advancements, financial sector shifts, consumer behavior changes, energy sector developments, and industrial growth. Our approach is not static; it is responsive to economic changes, ensuring our portfolio remains robust and effective in a dynamic market landscape.

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