

Formulating an equally weighted stock portfolio based on downside risk (Sortino Ratio)

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Abstract:

Investors commonly use historical risk-adjusted performance measures to guide stock choice, yet it remains unclear whether limiting risk analysis to downside volatility only can reliably identify stocks that will deliver increased future returns. This study examined whether the Sortino ratio, a measure of downside risk, can be used to construct a diversified, profit-oriented portfolio that outperforms lower-ranked stocks and market benchmarks. We hypothesized that portfolios comprising the five stocks with the highest Sortino ratios out of a particular sectoral stock pool would generate higher returns from 2015 to 2025 than portfolios comprising of the five stocks with the lowest Sortino ratios of the same. From an initial sample of 179 large, publicly traded U.S. companies across six sectors, 141 stocks meeting market capitalization and historical-data requirements were picked and analyzed. Sortino ratios were calculated using monthly returns from the 2011-2014 formation period and the resulting high and low Sortino portfolios were evaluated over ten years. The high-sortino portfolio outperformed low-sortino portfolio by 78.65% at the 10 year mark and both surpassed the S&P 500 and our 141-stock pool. The findings suggest that the Sortino ratio can support long-term stock selection and portfolio construction to an extent. The effectiveness varies by sector and should be utilized in combination with broader company and market specific analysis.

Introduction:

The stock market has been an extremely popular form of money-making for years now across the globe and at incredibly high levels in the USA with 58% of all households holding stock in 2022 — a time of economic uncertainty (1). The stock market is viewed as a great way to generate relatively passive income. However the stock market comes with risks. The risk varies from stock-to-stock based off of a variety of factors such as market capitalization, price to earnings ratios, and more. Stocks refer to parts of public companies that can be bought as investment by the average consumer. Companies offer these publicly in an effort to raise money for business growth. The stock price is dependent on a variety of factors and is controlled by the “market”, a collection of buyers and sellers. The aforementioned factors include earnings, buyer-sentiment, debt, product launches, laws and more.

A common practice among investing is diversification. This is the act of incorporating a variety of stocks across different sectors and industries to

protect their portfolio from dramatic price changes (2) – in particular from dramatic price decreases. We conducted this study using data collected from 6 sectors – healthcare, technology, consumer discretionary, industrials, energy, financials – to visualize the relationship between the Sortino ratio (a measure of downside risk) and market returns, and to conclude whether using the Sortino ratio to build a complete stock portfolio would be optimal for profit-seeking investors. (3)

In short, the Sortino ratio is a measure of downside risk (4). It is defined as a risk-adjusted measure of portfolio performance that only considers the standard deviation of the downside risk. It is a variation of the Sharpe ratio, a popular ratio used to measure total risk (5). A greater Sortino ratio indicates that a certain investment provides greater returns for each unit of bad risk (downside risk) taken.

To test the hypothesis for each of the 6 sectors, two portfolios will be constructed that will be modeled alongside the S&P 500 sectoral ETF and the stock pool that we used for the particular sector. One portfolio with the 5 stocks with the highest Sortino ratios of the pool and the second with the 5 stocks with the lowest Sortino ratios of the pool. All the sectors were equally weighted for total portfolio comparisons, and the portfolio was held passively (no buying or selling after buying it at a particular price point).

The independent variables in this study include the historical price data of the selected stocks and the downside risk (Sortino ratio) calculated for each stock based on data from 2011-2014. For the market as a whole we took the S&P 500 as a representative point of comparison. The S&P 500 consists of the top 500 largest publicly traded stocks on the US market. The S&P 500 has had a 12.89% 10-year compound annualized growth rate and an average annual return since its inception in 1957 of 10.56% which drops to around 6.69% when taking inflation into account (6).

The Sortino ratio produces an investments risk-adjusted return while focusing only on downside risk instead of total volatility like other ratios/formulas such as the popular Sharpe ratio (7). The ratio focuses on the downside volatility that is caused from both systematic and unsystematic risks. Briefly, systematic risks are risks that affect/exist in the entire stock market. Unsystematic risks are unique to a specific industry or even just a company. They arise due to a variety of internal and external factors. A historic example of systematic risk would be the 2008 Financial Crisis where the housing market

as a whole collapsed in the US and destroyed valuations of all asset classes both locally and globally. Meanwhile one of unsystematic risk would be the 2001 Enron accounting scandal, a company-specific danger. Unsystematic risks are generally perceived to be reduceable / avoidable through diversification, while systematic risks are often known as “non-diversifiable risks” (8).

The formula to calculate the Sortino ratio of a stock is as follows:

$$S = \frac{R_r - R_f}{\sigma_d}$$

The Sortino ratio is calculated by measuring the excess return of an investment (R_r) above the risk-free rate (R_f) relative to how much additional return an investor earns for each unit of downside risk taken. This makes it a target way of evaluating investments compared to measure that measure broader volatility. As shown in Equation 1, the Sortino ratio is equal to the difference between the expected return of the portfolio and the risk-free rate divided by the downside deviation of the portfolio’s returns (σ_d). (9)

Downside deviation differs from standard deviation as it only measures the volatility of returns that fall below a minimum acceptable return threshold which is typically zero or the risk-free rate. Positive returns above the threshold are ignored entirely in this calculation. This makes downside deviation a more precise measure of the risk of losing money rather than treating both upward and downward movements equally desirable (9).

We hypothesized that a portfolio consisting of purely the highest Sortino ratio (relative to the sector pool) stocks within a specific sector will provide higher returns over a 10 year time frame (2015-2025) when compared to stocks with the lowest Sortino ratios in the same sector. Additionally we also hypothesized that the portfolios would outperform their respective S&P 500 sectoral index and the sector pool we picked.

Results:

To test the hypothesis, stocks across six sectors – health care, information technology, financials, energy, utilities and industrials – were used. Although the investigation was a retrospective study, we chose a stock pool that had a minimum of 10 billion market capitalization value at the end of 2014 and

beginning of 2015. Additionally, availability of stock information from end of 2011 through to 2014 to calculate the Sortino ratio values.

Firstly, the health care sector was studied. The top 5 Sortino ratio stocks included: Regeneron Pharmaceuticals (REGN), McKesson Corporation (REGN), CVS Health Corporation (CVS), Eli Lilly and Company (LLY), Amgen Inc (AMGN). While the bottom 5 Sortino ratio stocks were: Agilent Technologies (A), Edwards Lifesciences Corporation (EW), Intuitive Surgical (ISRG), Boston Scientific Corporation (BSX) and Stryker Corporation (SYK). From the results we observed that the bottom 5 Sortino ratio stocks expressed higher returns compared to the top 5 counterpart by around 264.65%. The bottom 5 Sortino ratio healthcare stocks outperformed the top 5 at every time marker with the exception of the 6-month mark. This completely opposes our initial hypothesis that the top 5 Sortino ratio stocks would demonstrate higher returns in comparison to the bottom 5 counterparts. Over the selected term the bottom 5 Sortino ratio stocks have also largely beat the S&P 500 healthcare index returns and our healthcare pool returns which further opposes the hypothesis.

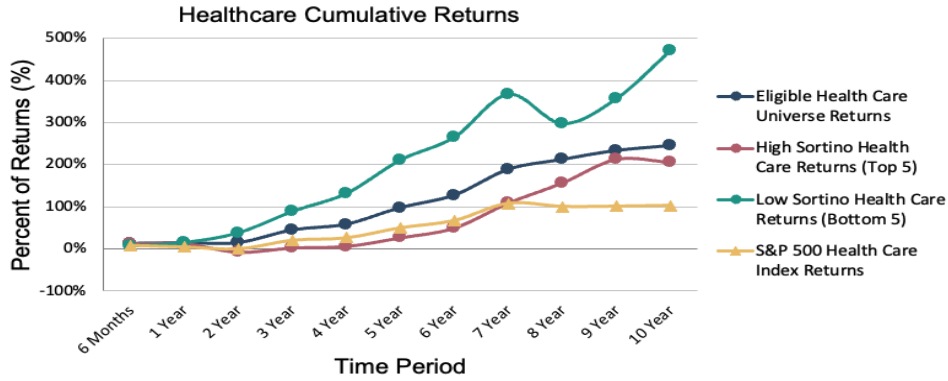


Figure 1: Healthcare sector data. Displays the relationship between the cumulative percentage of returns from 2015 to 2025 and stocks in the total Healthcare universe, top 5 Sortino portfolio, bottom 5 Sortino portfolio, and the S&P 500 healthcare index. We chose 5 stocks to represent the top Sortino portfolio (REGN, MCK, CVS, LLY, AMGN) and 5 stocks to represent the bottom Sortino portfolio (A, EW, ISRG, BSX, SYK).

Our second study was the technology sector. The top 5 Sortino ratio stocks included: Broadcom Inc. (AVGO), KLA Corporation (KLAC), Intuit Inc. (INTU), Adobe Inc. (ADBE), Micron Technology, Inc. (MU). While the

bottom 5 Sortino ratio stocks were: Automatic Data Processing, Inc. (ADP), HP Inc. (HPQ), International Business Machines Corporation (IBM), Corning Incorporated (GLW) and NVIDIA Corporation (NVDA). The results clearly show that the top 5 Sortino ratio picks demonstrated higher returns over the bottom 5 Sortino ratio picks by the end of the time period. At the 10-year mark the top 5 beat the bottom 5 picks by 124.60% and outperforms both the S&P 500 technology sectoral index and the technology stock pool used for the investigation as well. This supports the hypothesis that higher Sortino ratios translate into higher returns. There was a particularly large gap between the above top 5 and bottom 5 Sortino ratio portfolios in the 9th year of investigation with the top 5 beating the bottom 5 by 335.91%. The top 5 Sortino ratio technology stocks consistently beat out the bottom 5 counterparts apart from the 2-year mark. Additionally both portfolios beat out their respective S&P 500 sectoral index and stock pool at the end of the investigation period.

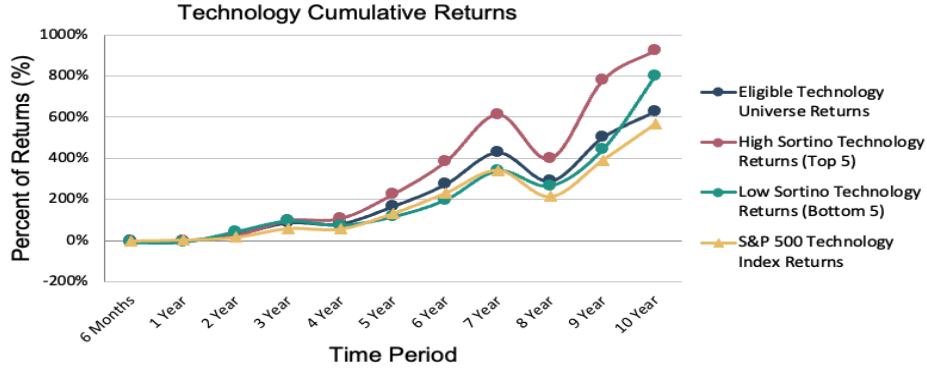


Figure 2: Technology sector data. Displays the relationship between the cumulative percentage of returns from 2015 to 2025 and stocks in the total Technology universe, top 5 Sortino portfolio, bottom 5 Sortino portfolio, and the S&P 500 technology index. We chose 5 stocks to represent the top Sortino portfolio (AVGO, KLAC, INTU, ADBE, MU) and 5 stocks to represent the bottom Sortino portfolio (ADP, HPQ, IBM, GLW, NVDA).

Our third empirical study was the consumer discretionary sector. The top 5 Sortino ratio stocks included: The Home Depot Inc. (HD), The TJX Companies Inc. (TJX), Genuine Parts Company (GPC), Ross Stores Inc. (ROST), Tesla Inc. (TSLA). While the bottom 5 Sortino ratio stocks were: Ford Motor Company (F), General Motors Company (GM), Carnival Corporation & plc

(CCL), Best Buy Co. Inc. (BBY) and Royal Caribbean Cruises Ltd. (RCL). The consumer discretionary sector much like the technology shows the top 5 Sortino ratio stocks beating out the bottom 5 but by a huge 436.38% in the 10th year, the largest gap we have recorded this investigation. The top 5 also beat the S&P 500 sectoral index and our consumer discretionary stock pool. The results here support our primary hypothesis. The top 5's returns were consistently higher than the bottom 5 apart from the 3-year mark.

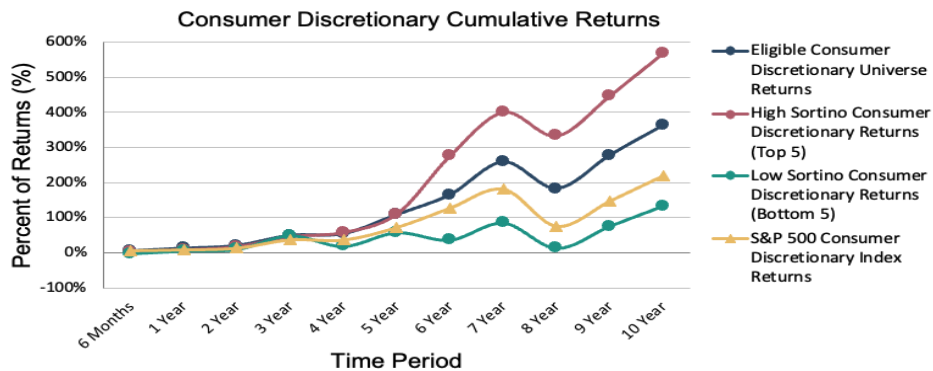


Figure 3: Consumer Discretionary sector data. Displays the relationship between the cumulative percentage of returns from 2015 to 2025 and stocks in the total Consumer Discretionary universe, top 5 Sortino portfolio, bottom 5 Sortino portfolio, and the S&P 500 consumer discretionary index. We chose 5 stocks to represent the top Sortino portfolio (HD, TJX, GPC, ROST, TSLA) and 5 stocks to represent the bottom Sortino portfolio (F, GM, CCL, BBY, RCL).

For our fourth study we investigated the industrials sector. The top 5 Sortino ratio stocks included: Lockheed Martin Corporation (LMT), Automatic Data Processing, Inc. (ADP), Union Pacific Corporation (UNP), Northrop Grumman Corporation (NOC), Johnson Controls International plc (JCI). While the bottom 5 Sortino ratio stocks were: Caterpillar Inc. (CAT), Deere & Company (DE), Emerson Electric Co. (EMR), PACCAR Inc (PCAR) and Cummins Inc. (CMI). The industrials sector study stood out amongst the other studies. By the 10-year mark the bottom 5 Sortino ratio industrial stocks outperform the top 5 by 64.62%, the smallest difference in cumulative returns we have observed this investigation. Additionally, throughout the entire period the bottom 5 portfolio outperforms the top 5 portfolio at 4 out of the 11 time markers, the 6-month, 6-year, 9-year and 10-year marks.

Both portfolios outperform the S&P 500 industrials sectoral index and the industrial stock pool we used. This opposes our main hypothesis that a higher Sortino ratio is consistent with higher returns.

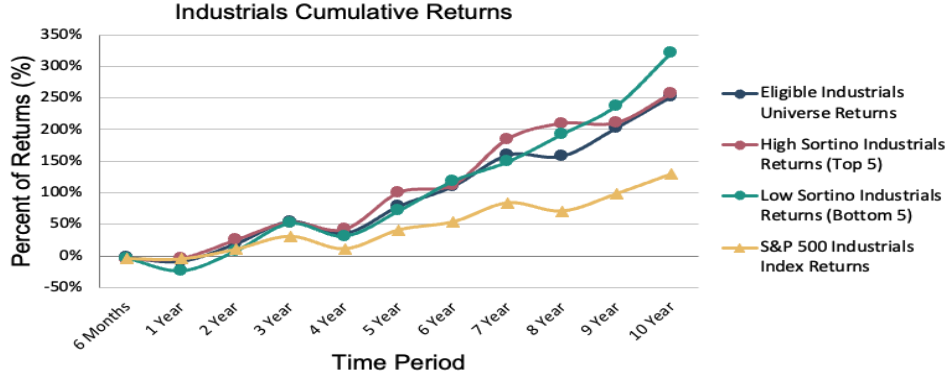


Figure 4: Industrials sector data. Displays the relationship between the cumulative percentage of returns from 2015 to 2025 and stocks in the total Industrials universe, top 5 Sortino portfolio, bottom 5 Sortino portfolio, and the S&P 500 industrials index. We chose 5 stocks to represent the top Sortino portfolio (LMT, ADP, UNP, NOC, JCI) and 5 stocks to represent the bottom Sortino portfolio (CAT, DE, EMR, PCAR, CMI).

The fifth study was on the energy sector. The top 5 Sortino ratio stocks included: Phillips 66 (PSX), ONEOK, Inc. (OKE), The Williams Companies, Inc. (WMB), Coterra Energy Inc. (CTRA), Kinder Morgan, Inc. (KMI). While the bottom 5 Sortino ratio stocks were: APA Corporation (APA), Devon Energy Corporation (DVN), Occidental Petroleum Corporation (OXY), Halliburton Company (HAL) and Baker Hughes Company (BKR). Our results revealed that the top 5 highest Sortino ratio energy stocks significantly outperformed the bottom 5 Sortino ratio energy stocks. There was a 191.85% difference in cumulative returns which directly supports our initial hypothesis. The top 5's returns were consistently higher than the bottom 5 apart from in year 1 and in the long run beat both the respective S&P 500 sectoral index and our energy stock pool. This study supports our hypothesis that the top 5 Sortino ratio stocks would outperform the bottom 5.

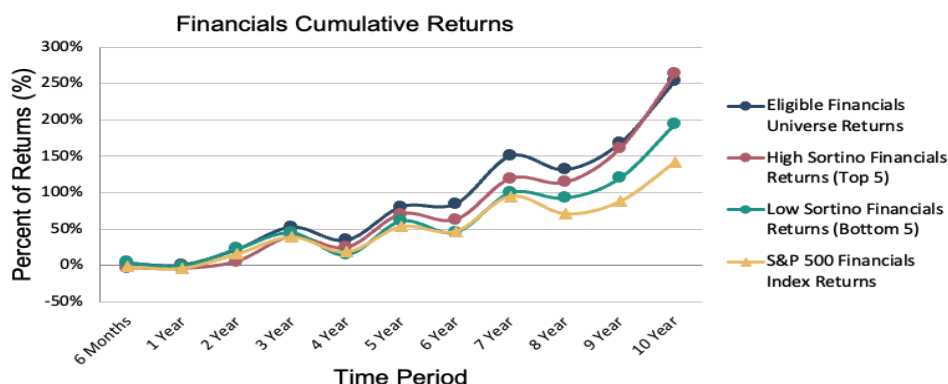


Figure 5: Financials sector data. Displays the relationship between the cumulative percentage of returns from 2015 to 2025 and stocks in the total Financials universe, top 5 Sortino portfolio, bottom 5 Sortino portfolio, and the S&P 500 financials index. We chose 5 stocks to represent the top Sortino portfolio (MCO, CB, ALL, AXP, WFC) and 5 stocks to represent the bottom Sortino portfolio (C, AIG, GS, AFL, BAC).

Our final empirical study was about the financials sector. The top 5 Sortino ratio stocks included: Moody's Corporation (MCO), Chubb Limited (CB), The Allstate Corporation (ALL), American Express Company (AXP), Wells Fargo & Company (WFC). While the bottom 5 Sortino ratio stocks were: Citigroup Inc. (C), American International Group, Inc. (AIG), The Goldman Sachs Group, Inc. (GS), Aflac Incorporated (AFL) and Bank of America Corporation (BAC). From our results we determined that the differences in cumulative results between the top 5 Sortino ratio financials stocks and bottom 5 Sortino ratio financials stocks were much lower in comparison to the other empirical studies. The bottom 5 beat out the top 5 in time periods 6 months through to 3 years and ultimately the top 5 beat the bottom 5 by 69.91% which is one of the lowest gaps in cumulative results. In the long run the top 5 portfolio beats the S&P 500 financials index and the financials stock pool used for the investigation but by a small margin. This ultimately does directly support our primary hypothesis that higher Sortino ratios are indicative of higher returns.

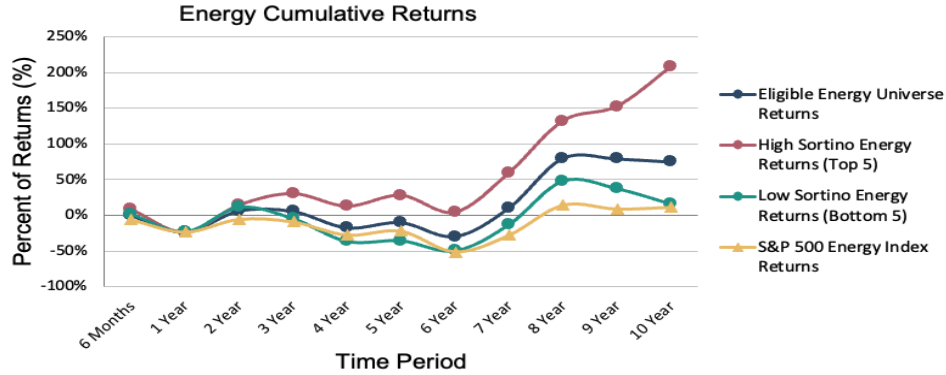


Figure 6: Energy sector data. Displays the relationship between the cumulative percentage of returns from 2015 to 2025 and stocks in the total Energy universe, top 5 Sortino portfolio, bottom 5 Sortino portfolio, and the S&P 500 energy index. We chose 5 stocks to represent the top Sortino portfolio (PSX, OKE, WMB, CTRA, KMI) and 5 stocks to represent the bottom Sortino portfolio (APA, DVN, OXY, HAL, BKR).

For the total portfolio all the sectors were equally weighted which means each of the 6 portfolios would have an equal amount of money originally invested. The high Sortino ratio portfolio consisting of the 25 high Sortino ratio stocks used for the previous 6 empirical studies did outperform the portfolio consisting of all the 25 low Sortino ratio stocks. Both portfolios beat the S&P 500 as a whole and the total stock pool used for the investigation. The top 5 portfolio beats out the bottom portfolio by 78.65% at the 10-year mark however the bottom 5 portfolio did beat the top 5 portfolio in year 2 and year 3 by 9.58% and 9.44% respectively. The overall portfolio consisting of the 6 sectors does support our initial hypothesis that higher Sortino ratio stocks outperform lower Sortino ratio stocks.

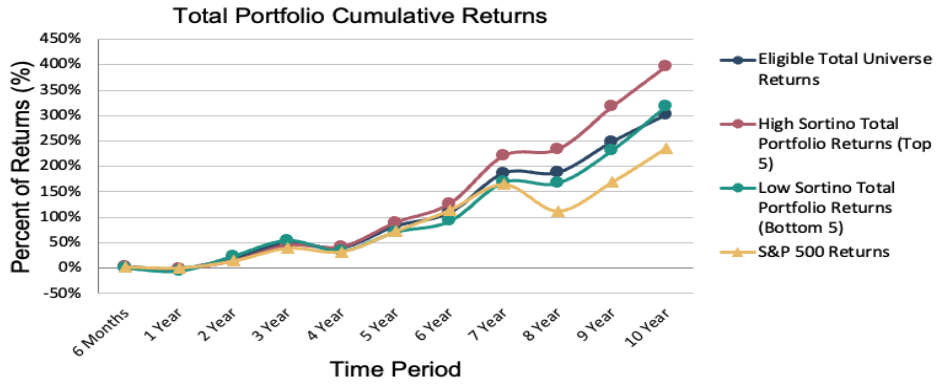


Figure 7: Total portfolio data. Displays the relationship between the cumulative percentage of returns from 2015 to 2025 and stocks in the total universe, top 5 Sortino portfolio, bottom 5 Sortino portfolio, and the S&P 500. We combined the sector portfolios to represent the total portfolio, where the top Sortino portfolio includes the selected high-Sortino stocks from all six sectors and the bottom Sortino portfolio includes the selected low-Sortino stocks from all six sectors.

Discussion:

In the process of constructing the portfolio for our empirical study we primarily considered the 5 securities with the highest Sortino ratio values within a certain sector. The reason for this consideration was mainly because of the initial hypothesis; higher Sortino ratio securities would yield more returns. Ultimately, we compared the performance of the top 5 securities with the average return of our entire stock pool for a given sector, the respective S&P 500 sectoral index and the 5 securities with the lowest Sortino ratio values. In terms of the total portfolio the high Sortino ratio stock outperformed the low Sortino ratio stocks, the total stock pool used and the S&P 500 in the long run. However, the low Sortino ratio stocks did outperform the high Sortino ratio stocks on the 2-year and 3-year mark, this shows that the hypothesis was not fully accurate as the resulting performances are not in complete accordance with the expectation.

When looking more deeply into the results, the consumer discretionary, energy, financials and technology sectors showed similarities across the period of 10 years. In all 4 of these industries the respective top 5 Sortino ratio stocks outperformed the bottom 5 Sortino ratio stocks by the end of the end of the

10 year period. Consumer discretionary, energy and the technology sectors all faced one time period where the bottom 5 outperformed the top 5 within the first 3 years. However, in the financial sector the bottom 5 outperformed the top 5 for the first 4 time periods, 6-month through till the 3-year mark. Out of the 4, the financials sector showed the smallest difference in cumulative returns at the end of the time period of 69.91% while consumer discretionary the highest with 436.38%.

The healthcare and industrials sector showed the opposite results. At the end of the 10 year time period the bottom 5 portfolios of these sectors outperformed the top 5 portfolios of the same. There likely are a multitude of reasons that led to these results which could be basis for further investigation. Much like the first 4 sectors discussed in none of these sectors did one portfolio outperform the other consistently throughout the time-period. For the healthcare sector at the 6-month mark the top 5 portfolio outperformed the bottom 5 portfolio while in the industrials sector although the bottom 5 portfolio outperformed the top 5 portfolio at the end of the 10 year time period, in 7 out of the 11 time periods investigated the top 5 portfolio was outperforming the bottom 5.

A possible explanation for this discrepancy in the healthcare sector is that healthcare companies are highly affected by firm-specific developments including drug trials, regulatory approvals such as FDA approvals, product launches and more. Companies that had experienced greater downside volatility during the formation period may have as a result received lower Sortino ratios, even though the volatility did not necessarily indicate permanently weak business performance. Subsequently if some of the companies achieved favorable outcomes clinically or commercially, their share prices may have risen considerably. Conversely companies with high Sortino ratios historically may have already reflected stable performance and optimistic valuations leaving smaller scope for exceptional gains.

In the case of the industrials sector a possible explanation is the prolonged recovery in industrial activity following the 2008 financial crisis. Industrial production declined sharply during the crisis but subsequently recovered as construction, manufacturing and capital investment improved. This may have particularly benefited the bottom 5 stocks that may be cyclical in nature whose revenues are sensitive to economic and industrial demand. As a result, their lower historical Sortino ratios may have reflected greater cyclical

vulnerability while their later returns captured the upside of the continuing economic recovery.

Both the top 5 and bottom 5 portfolios across five sectors and the total portfolio outperformed the respective S&P 500 sectoral index with the exception of the consumer discretionary sector. In this sector only the top 5 beat the S&P 500 Consumer Discretionary Index with the bottom 5 falling short. The consumer discretionary sector overall was quite unique. From year 0 to 5 the growth rate was relatively small compared to what happened from year 5 to year 7. It can be speculated that this was due to covid. Year 5 to Year 7 or 2020 to 2022 was the peak of the covid pandemic where spending on in-person events such as traveling, dining and etc. slowed down and spending surged on things like home improvement, recreational hobbies and electronics.

The Sortino Ratio is calculated based on historical price data, it does not take into account any factors that may influence an investor to purchase or sell a stock such as unexpected technological developments, new discoveries and more. These factors may have led to an increase in productive capacity or efficiency which would lead to greater profitability.

Ultimately it has to be emphasized that the research was undertaken for a limited number of companies for only the time period from 2011 to 2025. In forthcoming studies, the research can only be generalized given the pool of companies for each sector is monitored further and that a larger number of stocks should be considered across different time periods and possibly more sectors. Additionally, as discussed before, the healthcare sector and industrial sector did not support our hypothesis. Although we have discussed possible causes for this unexpected outcome, it should be investigated further to determine the validity of the trend.

Materials and Methods:

To start off on building the portfolio and evaluate the effect of downside risk on a portfolio's returns, we searched for multiple sectors and chose securities for this study. We first selected about 30 stocks from each of the 6 sectors. This totaled to 179 stocks that were large, commonly traded US public companies in each sector at the time. After this the stocks were further processed by the criteria that they had a minimum market capitalization of 10B USD and had sufficient monthly adjusted price data for 2011-2014, the formation period. This filter reduced the eligible stocks from 179 to 141 which was the final

stock pool.

Monthly closing-price data for each security, the S&P 500 Index and the corresponding S&P 500 sector indices were obtained from Yahoo Finance from 2011-2025 (10). The monthly risk-free rates were sourced from the Kenneth R. French Data Libray (11). The data were organized by sector and used to calculate monthly stock returns.

The period from 2011 to 2014 was treated as the portfolio-formation period. The Sortino ratio for each eligible security was calculated as:

$$S = \frac{R_r - R_f}{\sigma_d}$$

Where R_r represents the security's average monthly return and R_f represents the monthly risk-free rate. Unlike a conventional volatility measure, the σ_d (downside deviation) considers only returns falling below the specified target return. (9)

The Sortino ratio was the portfolio-ranking variable. Within each sector, the five securities with the highest formation-period Sortino ratios were assigned to the high-Sortino portfolio frequently referred to as the top 5 portfolio while the lowest 5 to the low-Sortino portfolio frequently referred to as the bottom 5 portfolio.

The performance was evaluated out of sample from 2015 to 2025. Monthly returns were compounded to obtain cumulative returns after six months and then at annual intervals. For each sector, the eligible universe, high-Sortino portfolio, low-Sortino portfolio and corresponding S&P 500 sector index were compared. A combined analysis was also conducted across all six sectors, using the overall S&P 500 index as the benchmark.

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