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ARTIFICIAL INTELLIGENCE AND THE TRADER'S
TOUCH: A COMPARATIVE STUDY



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ABSTRACT

This report presents a comparative study exploring the efficacy of human-driven trading methodologies against AI-powered approaches in portfolio management within the stock market. Beginning with a meticulous selection process, we curate 4 diversified portfolios of 5 stocks each (one by human, one by GPT 3.5, one by GPT 4 and one by AI performance metric analysis) across key sectors, employing a range of financial metrics to identify optimal candidates. Subsequently, we conduct a comprehensive evaluation of both human and AI trading portfolios, leveraging analytical techniques including adjusted closing price trends, sentiment analysis, and technical indicators such as Simple Moving Averages (SMA). Additionally, we delve into the development and performance analysis of AI-driven trading strategies, utilizing machine learning algorithms for autonomous decision-making. Through rigorous analysis and comparison against traditional benchmarks such as the SPY Index, we aim to elucidate the strengths and limitations of each approach. Employing a variety of programming languages and tools including R, Python, and Excel, our study provides valuable insights into the evolving landscape of financial analytics, shedding light on the symbiotic relationship between human expertise and machine intelligence in navigating the complexities of the financial markets.

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INTRODUCTION

In today's dynamic financial landscape, the intersection of artificial intelligence (AI) and traditional trading strategies has become increasingly prominent. This report delves into the realm of financial analytics, exploring the effectiveness of AI-driven trading strategies compared to human-centric approaches.

Artificial Intelligence (AI) has been making significant strides in various domains, and the financial sector is no exception. The application of AI in trading, commonly known as AI trading, has garnered considerable attention due to its potential to revolutionize investment decision-making processes. Simultaneously, human trading and technical analysis remain crucial components of the financial landscape, each offering unique advantages and insights.

AI trading leverages advanced algorithms and machine learning techniques to analyze vast amounts of data, identify patterns, and make informed trading decisions (Nti et al., 2020). By processing real-time market data, news, and sentiment analysis, AI systems can potentially identify lucrative trading opportunities more efficiently than human traders (Hiransha et al., 2018). Additionally, AI systems can execute trades with high speed and precision, minimizing the impact of human emotions and biases (Kou et al., 2021).

However, human traders bring invaluable expertise, intuition, and experience to the trading process. They can interpret market dynamics, geopolitical events, and qualitative factors that may be challenging for AI systems to comprehend (Nti et al., 2020). Human traders can also adapt to changing market conditions and incorporate subjective judgments, which can be essential in navigating complex financial environments (Kou et al., 2021).

Technical analysis, a widely used approach in financial markets, involves studying historical price and volume data to identify patterns and trends (Pring, 2014). It relies on the premise that market behavior is not entirely random and that past price movements can provide insights into future price movements (Murphy, 1999). Technical analysts use a variety of tools, such as chart patterns, indicators, and oscillators, to make trading decisions (Pring, 2014).

The integration of AI trading, human trading, and technical analysis can potentially lead to synergistic benefits. AI systems can augment human decision-making by providing data-driven insights, while human traders can incorporate qualitative factors and intuition to refine trading strategies (Nti et al., 2020). Technical analysis can complement both AI and human trading by identifying potential entry and exit points and validating trading signals (Kou et al., 2021).

Scope: This project aims to analyze and compare the performance of human traders versus AI algorithms across a diversified portfolio of stocks from five key sectors: Healthcare, Energy, Technology, Consumer Discretionary, and Financials.

Essential Parameters: Our analysis encompasses a comprehensive array of financial metrics and methodologies, including sector allocation, market capitalization, beta, P/E ratio, profit margin, revenue growth, dividend yield, and debt-to-equity ratio. Furthermore, we employ technical indicators such as adjusted closing price trends, daily percentage change, rolling mean and standard deviation, Bollinger bands, moving average convergence/divergence (MACD), and statistical analysis metrics.

Objectives:

1. To identify two high-performing portfolios of stocks across diverse sectors through rigorous selection criteria for AI and human trading.
2. To conduct risk analysis and performance evaluation of both human and AI-driven trading portfolios.
3. To compare the effectiveness of AI trading strategies against traditional human trading methodologies and technical analysis.
4. To analyze the impact of sentiment analysis and technical indicators on trading decisions.

Time Period for trading: The project encompasses the period from January 1, 2020, to December 31, 2023.

Key milestones include data collection, portfolio construction, risk analysis, AI model development, trading strategy implementation, performance evaluation, and final comparison of results.

Through this comparative study, we aim to provide valuable insights into the evolving landscape of financial markets and the role of AI in shaping trading strategies.

LITERATURE REVIEW

Artificial Intelligence (AI) has significantly impacted financial trading strategies, presenting novel approaches through algorithms that can outperform traditional human strategies in some contexts. Research on AI trading strategies, particularly through deep reinforcement learning, demonstrates that these methods can adapt dynamically to market changes and yield high profits ([Li, Liu, & Wang, 2022](#)). However, the comparative efficiency between AI and human trading remains a contentious topic, with various studies attempting to delineate the strengths and weaknesses of each approach.

One significant advantage of AI trading is its ability to process vast amounts of data rapidly, a capability well beyond human traders. For example, the use of Blockchain and Smart Contracts in energy trading illustrates how AI can optimize transactions in complex networks, reducing costs and enhancing efficiency ([Alskaf et al., 2022](#)). Additionally, AI models, such as those incorporating Generative Adversarial Networks, are becoming sophisticated in fine-tuning trading strategies, pushing the boundaries of market analytics and prediction ([Koshiyama, Firoozye, & Treleaven, 2019](#)).

On the other hand, human traders still hold advantages, particularly in their ability to understand subtle nuances and socio-economic factors affecting markets, which are often challenging for AI to decode. Studies highlight that human traders are better at interpreting misleading signals and managing uncertain market conditions ([Bao, Nekrasova, Neugebauer, & Riyanto, 2021](#)). Furthermore, human-centric trading strategies continue to evolve, integrating insights from behavioral economics to refine trading decisions ([Bamber, Barron, & Stevens, 2010](#)).

Recent studies also explore the intersection of AI and human decision-making, proposing hybrid trading systems that capitalize on both computational speed and human insight. For instance, Emami (2021) discusses a human-inspired optimization algorithm that mimics stock exchange trading strategies, enhancing the performance of AI systems ([Emami, 2021](#)).

LITERATURE GAPS AND FUTURE RESEARCH

While the advancements in AI trading are promising, significant gaps remain in understanding the long-term implications of automated trading systems on market stability and integrity. There is a need for more empirical studies that compare AI and human trading over extended periods to assess impacts on market efficiency and participant behavior ([Wen, Wang, Yue, Zhu, & Zhu, 2023](#)). Additionally, the ethical considerations of AI trading, including privacy concerns and potential market manipulation, require deeper investigation.

Future research should focus on hybrid models that combine AI's analytical capabilities with human traders' strategic insights. Developing such integrated approaches could leverage the strengths of both AI and human trading, potentially leading to more robust and resilient financial markets. Studies should also explore regulatory frameworks tailored to the nuances of AI in trading to safeguard against systemic risks and enhance transparency ([Azzutti, Ringe, & Stiehl, 2022](#)).

METHODOLOGY

STEP 1: STOCK SELECTION AND PORTFOLIO CONSTRUCTION

SELECTION OF STOCKS FROM FIVE DIFFERENT SECTORS

Selecting the five sectors—Healthcare, Energy, Technology, Consumer Discretionary, and Financials—involved a systematic approach aimed at diversification and representation of key segments within the economy. Each sector represents a distinct area of economic activity with its own set of dynamics, drivers, and risk profiles. Here's an elaboration on how these sectors were chosen:

1. **Healthcare:** The healthcare sector encompasses a wide range of industries involved in providing medical goods, services, and technologies. It includes pharmaceutical companies, biotechnology firms, medical device manufacturers, healthcare providers, and related entities. Healthcare is a vital sector with steady demand, innovation potential, and often defensive characteristics.
2. **Energy:** The energy sector encompasses companies involved in the exploration, production, refining, and distribution of energy resources such as oil, natural gas, coal, renewable energy, and utilities. It plays a crucial role in global economic activity and is subject to geopolitical factors, supply-demand dynamics, and regulatory policies.
3. **Technology:** The technology sector comprises companies engaged in developing and providing technology products, software, hardware, telecommunications, semiconductor devices, and IT

services. It is known for its innovation-driven growth, disruption potential, and high volatility, making it an attractive area for investment and analysis.

4. **Consumer Discretionary:** The consumer discretionary sector includes companies that produce non-essential goods and services, such as automobiles, apparel, retail, leisure, entertainment, and luxury goods. Consumer spending patterns, economic cycles, and consumer sentiment heavily influence this sector's performance.
5. **Financials:** The financial sector encompasses banks, insurance companies, investment firms, real estate companies, and other financial services providers. It plays a critical role in facilitating economic activities, managing risks, and allocating capital. Financial stocks are sensitive to interest rates, regulatory changes, and macroeconomic trends.

These sectors were chosen based on their representation of different segments of the economy, their significance in investment portfolios, and their potential for providing diversification benefits. By selecting stocks from these diverse sectors, our portfolios aim to capture a broad spectrum of market trends and mitigate sector-specific risks.

TOP 50 STOCKS SELECTION

FOR THE TECHNICAL ANALYSIS PORTFOLIO

S. NO.	Sector Allocation	Human	Chat GPT-3.5	GPT-4
1	Healthcare	Johnson & Johnson	Johnson & Johnson	Pfizer
2	Healthcare	Pfizer Inc.	Pfizer Inc.	Merck & Co.
3	Healthcare	Merck & Co., Inc.	Merck & Co., Inc.	AbbVie
4	Healthcare	Novartis AG	AbbVie Inc.	Johnson & Johnson
5	Healthcare	Roche Holding AG	Amgen Inc.	Novartis
6	Healthcare	Abbott Laboratories	Regeneron Pharmaceuticals, Inc.	Roche
7	Healthcare	Amgen Inc.	Gilead Sciences, Inc.	Bristol Myers Squibb
8	Healthcare	Bristol Myers Squibb	Bristol Myers Squibb	Sanofi
9	Healthcare	Thermo Fisher Scientific Inc.	Vertex Pharmaceuticals Incorporated	AstraZeneca
10	Healthcare	UnitedHealth Group Inc.	UnitedHealth Group Inc.	GSK
11	Energy	NextEra Energy, Inc.	Exxon Mobil Corporation	Chevron
12	Energy	Tesla, Inc.	Chevron Corporation	Shell
13	Energy	Enphase Energy, Inc.	Royal Dutch Shell plc	PetroChina
14	Energy	Brookfield Renewable Partners L.P.	TotalEnergies SE	TotalEnergies
15	Energy	BP plc	BP plc	ConocoPhillips
16	Energy	First Solar, Inc.	NextEra Energy, Inc.	Petrobras
17	Energy	SunPower Corporation	Enbridge Inc.	BP
18	Energy	Ørsted A/S	TC Energy Corporation	Equinor
19	Energy	Canadian Solar Inc.	Canadian Solar Inc.	Vestas
20	Energy	Renewable Energy Group, Inc.	First Solar, Inc.	Orsted
21	Technology	Apple Inc.	Apple Inc.	Apple
22	Technology	Microsoft Corporation	Microsoft Corporation	Microsoft
23	Technology	Alphabet Inc.	Amazon.com, Inc.	Alphabet Inc.
24	Technology	Amazon.com, Inc.	Alphabet Inc.	Amazon.com, Inc.
25	Technology	Meta Platforms, Inc.	NVIDIA Corporation	NVIDIA Corporation
26	Technology	NVIDIA Corporation	Intel Corporation	Meta Platforms, Inc.
27	Technology	Adobe Inc.	Salesforce.com, Inc.	Broadcom
28	Technology	Salesforce.com, Inc.	Adobe Inc.	Tencent Holdings
29	Technology	Taiwan Semiconductor Manufacturing Company Limited	Cisco Systems, Inc.	Cisco Systems
30	Technology	Advanced Micro Devices, Inc.	Qualcomm Incorporated	Oracle Corporation
31	Consumer Discretionary	Chipotle Mexican Grill Inc	Walmart Inc.	Amazon.com Inc.
32	Consumer Discretionary	Best Buy Co. Inc.	Tesla, Inc.	LVMH Moët Hennessy
33	Consumer Discretionary	Nike, Inc.	Nike, Inc.	Tesla Inc.
34	Consumer Discretionary	Hormel Foods Corp.	The Walt Disney Company	The Home Depot Inc.
35	Consumer Discretionary	Starbucks Corporation	Home Depot, Inc.	Nike Inc.
36	Consumer Discretionary	McDonald's Corporation	Booking Holdings Inc.	Netflix Inc.
37	Consumer Discretionary	The Walt Disney Company	Lululemon Athletica Inc.	The Walt Disney Company
38	Consumer Discretionary	Booking Holdings Inc.	Netflix, Inc.	Lululemon Athletica Inc.
39	Consumer Discretionary	LVMH Moët Hennessy Louis Vuitton SE	General Motors Company	Activision Blizzard Inc.
40	Consumer Discretionary	Etsy, Inc.	Target Corporation	PulteGroup Inc.
41	Financials	JPMorgan Chase & Co.	JPMorgan Chase & Co.	JPMorgan Chase & Co.
42	Financials	Bank of America Corporation	Bank of America Corporation	Intuit Inc.
43	Financials	Visa Inc.	Visa Inc.	Equifax Inc.
44	Financials	Mastercard Incorporated	Mastercard Incorporated	Visa Inc.
45	Financials	PayPal Holdings, Inc.	American Express Company	American Express Company
46	Financials	Goldman Sachs Group, Inc.	Berkshire Hathaway Inc.	Broadridge Financial Solutions, Inc.
47	Financials	Morgan Stanley	PayPal Holdings, Inc.	PayPal Holdings, Inc.
48	Financials	Berkshire Hathaway Inc.	Square, Inc.	AssetMark Financial Holdings, Inc.
49	Financials	American Express Company	Capital One Financial Corporation	EZCORP, Inc.
50	Financials	Wells Fargo & Company	Allstate Corporation	Navient Corporation

S. NO.	Company Name	Ticker	Sector Allocation	Market Capitalization (USD)	Beta	P/E Ratio	Profit Margin	Revenue Growth (quarterly yoy)	Dividend Yield	Debt-to-Equity Ratio
1	Johnson & Johnson	JNJ	Healthcare	387.31 billion	0.54	30.92	41.28%	7.30%	2.94%	44.25%
2	Pfizer Inc.	PFE	Healthcare	153.47 billion	0.57	73.46	3.62%	-41.30%	6.05%	84.37%
3	Merck & Co., Inc.	MRK	Healthcare	326.48 billion	0.39	920.29	0.61%	5.80%	2.38%	84.42%
4	Novartis AG	NVS	Healthcare	235.36 billion	0.47	25.18	31.83%	7.40%	3.64%	56.55%
5	Roche Holding AG	RHHBY	Healthcare	212.68 billion	0.16	16.02	19.02%	-6.50%	4.22%	92.75%
6	Abbott Laboratories	ABT	Healthcare	205.95 billion	0.75	36.41	14.27%	1.50%	1.85%	40.88%
7	Amgen Inc.	AMGN	Healthcare	153.47 billion	0.62	22.93	23.83%	19.80%	3.14%	1049.79%
8	Bristol Myers Squibb	BMY	Healthcare	102.16 billion	0.37	13.09	17.83%	0.60%	4.75%	140.82%
9	Thermo Fisher Scientific Inc.	TMO	Healthcare	214.86 billion	0.8	36.49	13.99%	-4.90%	0.28%	78.37%
10	UnitedHealth Group Inc.	UNH	Healthcare	485.88 billion	0.55	22.03	6.02%	14.10%	1.43%	63.22%
11	NextEra Energy, Inc.	NEE	Energy	113.19 billion	0.52	15.32	26.00%	11.60%	3.74%	125.49%
12	Tesla, Inc.	TSLA	Energy	624.81 billion	2.43	46.26	15.50%	3.50%	0%	15.05%
13	Enphase Energy, Inc.	ENPH	Energy	16.27 billion	1.47	38.91	19.16%	-58.20%	0%	133.97%
14	Brookfield Renewable Partners L.P.	BEP	Energy	15.079 billion	0.8	N/A	-1.99%	8.40%	6.13%	99.27%
15	Plug Power Inc.	PILUG	Energy	1.84 billion	1.67	N/A	-106.74%	5.30%	0%	27.72%
16	First Solar, Inc.	FSLR	Energy	15.45 billion	1.41	32.71	14.99%	27.40%	0%	8.62%
17	SunPower Corporation	SPWR	Energy	552.39 million	1.58	N/A	-14.66%	-28.20%	0%	123.71%
18	Orsted A/S	ORSTED.CO	Energy	158.53 billion	0.68	N/A	-25.87%	-19.30%	3.57%	113.18%
19	Canadian Solar Inc.	CSIQ	Energy	1.37 billion	1.29	4.23	4.48%	-4.50%	0%	90.18%
20	Renewable Energy Group, Inc.	REGI	Energy	3.106 billion	0.59	16.51	0%	12.13%	0%	31%
21	Apple Inc.	AAPL	Technology	2.80 trillion	1.31	28.17	26.16%	2.10%	0.55%	145.80%
22	Microsoft Corporation	MSFT	Technology	3.03 trillion	0.9	36.91	36.27%	17.60%	0.74%	46.74%
23	Alphabet Inc.	GOOGL	Technology	1.72 trillion	1.06	23.92	24.01%	13.50%	0%	10.54%
24	Amazon.com, Inc.	AMZN	Technology	1.81 trillion	1.14	60.25	5.29%	13.90%	0%	80.04%
25	Meta Platforms, Inc.	META	Technology	1.23 trillion	1.15	32.35	28.98%	24.70%	0.42%	24.76%
26	NVIDIA Corporation	NVDA	Technology	1.98 trillion	1.68	66.24	48.85%	265.30%	0.02%	25.73%
27	Adobe Inc.	ADBE	Technology	253.34 billion	1.34	47.38	27.97%	11.60%	0%	24.70%
28	Salesforce.com Inc.	CRM	Technology	290.78 billion	1.28	113.78	7.63%	11.30%	0%	23.69%
29	Taiwan Semiconductor Manufacturing Company Limited	TSM	Technology	578.13 billion	1.23	25.57	38.79%	18.70%	1.57%	26.50%
30	Advanced Micro Devices, Inc.	AMD	Technology	284.39 billion	1.63	332.09	3.77%	10.20%	0%	5.56%
31	Chipotle Mexican Grill Inc	CMG	Consumer Discretionary	72.95 billion	1.29	59.88	15.40%	15.40%	0%	132.31%
32	Best Buy Co. Inc.	BBY	Consumer Discretionary	16.47 billion	1.51	13.2	2.93%	-7.80%	4.81%	143.28%
33	Nike, Inc.	NKE	Consumer Discretionary	158.39 billion	1.11	30.48	10.28%	0.50%	1.42%	86.08%
34	Home Depot, Inc.	HD	Consumer Discretionary	369.84 billion	0.98	24.58	9.92%	-2.90%	2.42%	5004.12%
35	Starbucks Corporation	SBUX	Consumer Discretionary	106.74 billion	0.99	25.15	11.70%	8.20%	2.39%	-174.80%
36	McDonald's Corporation	MCD	Consumer Discretionary	215.51 billion	0.73	25.48	13.73%	8.10%	2.25%	822.90%
37	The Walt Disney Company	DIS	Consumer Discretionary	197.52 billion	1.38	66.3	3.36%	0.20%	0.84%	45.50%
38	Booking Holdings Inc.	BKNG	Consumer Discretionary	119.59 billion	1.41	29.74	20.08%	18.20%	1.00%	-516.90%
39	LVMH Moët Hennessy Louis Vuitton SE	MC.PA	Consumer Discretionary	458.96 billion	1	27.99	17.61%	3.40%	1.54%	62.19%
40	Etsy, Inc.	ETSY	Consumer Discretionary	8.53 billion	2.09	32.1	11.19%	4.30%	0%	-420.00%
41	JPMorgan Chase & Co.	JPM	Financials	528.14 billion	1.12	11.24	33.94%	11.10%	2.29%	133.10%
42	Bank of America Corporation	BAC	Financials	264.60 billion	1.4	11.16	28.15%	-11.00%	2.86%	114.60%
43	Visa Inc.	V	Financials	570.85 billion	0.97	32.52	53.92%	8.80%	0.73%	52.10%
44	Mastercard Incorporated	MA	Financials	442.67 billion	1.08	39.78	44.60%	12.60%	0.56%	235.19%
45	PayPal Holdings, Inc.	PYPL	Financials	63.59 billion	1.47	15.51	14.26%	8.70%	0.00%	56.26%
46	Goldman Sachs Group, Inc.	GS	Financials	127.26 billion	1.42	17.1	18.83%	11.60%	2.82%	597.24%
47	Morgan Stanley	MS	Financials	140.61 billion	1.43	16.52	16.95%	1.80%	3.93%	378.60%
48	Berkshire Hathaway Inc.	BRK-B	Financials	885.93 billion	0.88	9.1	26.40%	19.60%	0.00%	23.40%
49	American Express Company	AXP	Financials	157.05 billion	1.23	19.4	15.06%	9.20%	1.11%	216.69%
50	Wells Fargo & Company	WFC	Financials	393.65 billion	1.18	11.34	24.80%	0.60%	2.59%	118.20%

Selecting the top 50 stocks, with 10 stocks from each of the five sectors—Healthcare, Energy, Technology, Consumer Discretionary, and Financials—involved a combination of quantitative and qualitative analysis. The process aimed to identify industry leaders, companies with strong fundamentals, and those likely to outperform based on market trends and news sentiment. Here's how the selection process might have been conducted:

- Market Research:** Extensive market research was conducted to identify top-performing companies within each sector. This involved analyzing industry reports, market trends, analyst recommendations, and performance relative to benchmark indices such as the S&P 500.
- News Sentiment Analysis:** News sentiment analysis was used to gauge market sentiment towards specific stocks and sectors. Positive news coverage, favorable analyst ratings, and corporate announcements indicating growth prospects were considered as favorable signals.
- S&P 500 Inclusion:** Stocks included in the S&P 500 index were given preference due to their status as industry leaders and their influence on market trends. Inclusion in the S&P 500 reflects a company's size, liquidity, and overall market significance.
- Diversification:** Efforts were made to ensure diversification within each sector by selecting companies from different sub-industries or with exposure to different market segments. This helped to spread risk and capture a broader range of opportunities within each sector.

TOP 25 STOCKS SELECTION

S. NO.	Company Name	Ticker	Sector Allocation	Market Capitalization (USD)	Beta	P/E Ratio	Profit Margin	Revenue Growth (quarterly yoy)	Dividend Yield	Debt-to-Equity Ratio
1	Johnson & Johnson	JNJ	Healthcare	387.31 billion	0.54	30.92	41.28%	7.30%	2.94%	44.25%
2	Abbott Laboratories	ABT	Healthcare	205.95 billion	0.75	36.41	14.27%	1.50%	1.85%	40.88%
3	Amgen Inc.	AMGN	Healthcare	153.47 billion	0.62	22.93	23.83%	19.80%	3.14%	1049.79%
4	Novartis AG	NVS	Healthcare	235.36 billion	0.47	25.18	31.83%	7.40%	3.64%	56.55%
5	Merck & Co., Inc.	MRK	Healthcare	326.48 billion	0.39	920.29	0.61%	5.80%	2.38%	84.42%
6	NextEra Energy, Inc.	NEE	Energy	113.19 billion	0.52	15.32	26.00%	11.60%	3.74%	125.49%
7	Enphase Energy, Inc.	ENPH	Energy	16.27 billion	1.47	38.91	19.16%	-58.20%	0%	133.97%
8	First Solar, Inc.	FSLR	Energy	15.45 billion	1.41	32.71	14.99%	27.40%	0%	8.62%
9	Brookfield Renewable Partners L.P.	BEP	Energy	15.079 billion	0.8	N/A	-1.99%	8.40%	6.13%	99.27%
10	Tesla, Inc.	TSLA	Energy	624.81 billion	2.43	46.26	15.50%	3.50%	0%	15.05%
11	Alphabet Inc.	GOOGL	Technology	130.4 billion	0.51	34.41	20.41%	17.60%	0.74%	46.45%
12	Aspile Inc.	AAPL	Technology	2.85 trillion	1.31	28.17	26.16%	2.10%	0.53%	145.80%
13	NVIDIA Corporation	NVDA	Technology	1.91 trillion	1.68	66.24	48.85%	265.30%	0.22%	35.73%
14	Taiwan Semiconductor Manufacturing Company Limited	TSM	Technology	518.13 billion	1.23	25.57	38.79%	18.70%	1.57%	26.50%
15	Alphabet Inc.	GOOGL	Technology	1.72 trillion	1.06	23.92	24.01%	13.50%	0%	10.54%
16	Chipotle Mexican Grill Inc	CMG	Consumer Discretionary	72.95 billion	1.29	59.88	15.40%	15.40%	0%	132.31%
17	Booking Holdings Inc.	BKNG	Consumer Discretionary	119.59 billion	1.41	29.74	20.08%	18.20%	1.00%	-516.90%
18	McDonald's Corporation	MCD	Consumer Discretionary	215.51 billion	0.73	25.48	13.73%	8.10%	2.25%	-822.90%
19	LVMH Moët Hennessy Louis Vuitton SE	MC.PA	Consumer Discretionary	458.96 billion	1	27.99	17.61%	3.40%	1.54%	62.19%
20	Nike, Inc.	NKE	Consumer Discretionary	158.39 billion	1.11	30.48	10.28%	0.50%	1.42%	86.08%
21	Visa Inc.	V	Financials	570.85 billion	0.97	32.52	53.92%	8.80%	0.73%	52.10%
22	Mastercard Incorporated	MA	Financials	442.67 billion	1.08	39.78	44.60%	12.60%	0.56%	235.19%
23	JPMorgan Chase & Co.	JPM	Financials	528.14 billion	1.12	11.24	33.94%	11.10%	2.29%	133.10%
24	Berkshire Hathaway Inc.	BRK-B	Financials	885.93 billion	0.88	9.1	26.40%	19.60%	0.00%	23.40%
25	Bank of America Corporation	BAC	Financials	264.60 billion	1.4	11.16	28.15%	-11.00%	2.86%	114.60%

Here's how each criterion contributed to the top 25 stocks selection process:

- Sector Allocation:** Ensures a diversified portfolio that minimizes risk by spreading investments across different sectors. Each sector reacts differently to economic cycles, and diversification helps in balancing the portfolio against sector-specific downturns.
- Market Capitalization:** Refers to the total market value of a company's outstanding shares and is calculated by multiplying the stock's price by its total number of outstanding shares. Larger companies (higher market capitalization) are often considered safer investments as they are more established, but smaller cap stocks might offer higher growth potential.
- Beta:** A measure of a stock's volatility relative to the overall market. A beta less than 1 means the stock is less volatile than the market, while a beta greater than 1 indicates higher volatility. Low beta stocks were favored to reduce portfolio volatility and provide more stable returns.
- Price-to-Earnings (P/E) Ratio:** Helps assess if a stock is over or undervalued compared to its earnings. A lower P/E ratio might suggest that the stock is undervalued, hence a potentially lucrative investment if other indicators are favorable.
- Profit Margin:** Indicates how much profit a company makes for every dollar of sales; higher profit margins suggest a more efficiently managed company that retains more per dollar of sales.
- Revenue Growth (Quarterly Year-Over-Year):** Measures the percentage increase in a company's sales compared to the same quarter in the previous year. High revenue growth can indicate a company that is expanding and potentially increasing its market share.
- Dividend Yield:** A financial ratio that shows how much a company pays out in dividends each year relative to its stock price. While not necessarily a make-or-break factor, a reasonable dividend yield can be attractive, especially for income-focused investors.
- Debt-to-Equity Ratio:** Compares a company's total liabilities to its shareholder equity. A lower ratio suggests that a company is not overly reliant on debt to finance its operations, which could make it more resilient during economic downturns.

These metrics were analyzed using financial data available through Yahoo Finance.

This stage focused on specific criteria to balance both risk and return:

- Low Debt-to-Equity Ratio:** Chosen to ensure that the companies are not excessively indebted, which can be crucial in times of economic stress.

- **High Profit Margin and Revenue Growth:** Stocks that demonstrate both high profit margins and strong revenue growth are generally seen as well managed and positioned for future success.
- **Low Beta:** Selected to maintain a lower risk profile for the portfolio, making it less sensitive to large market movements.
- **Reasonable P/E Ratio:** Ensures that the stocks are reasonably valued in terms of their earnings, not overpriced, which could limit future gains.

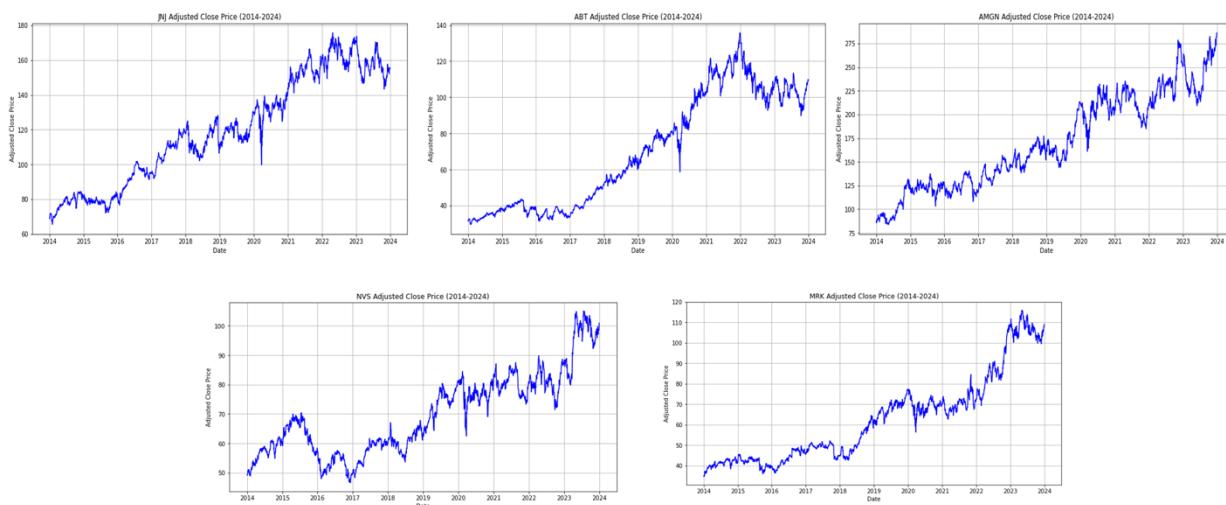
TOP 5 STOCKS SELECTION

S. NO.	Company Name	Ticker	Sector Allocation
1	Amgen Inc.	AMGN	Healthcare
2	NextEra Energy, Inc.	NEE	Energy
3	NVIDIA Corporation	NVDA	Technology
4	McDonald's Corporation	MCD	Consumer Discretionary
5	Visa Inc.	V	Financials

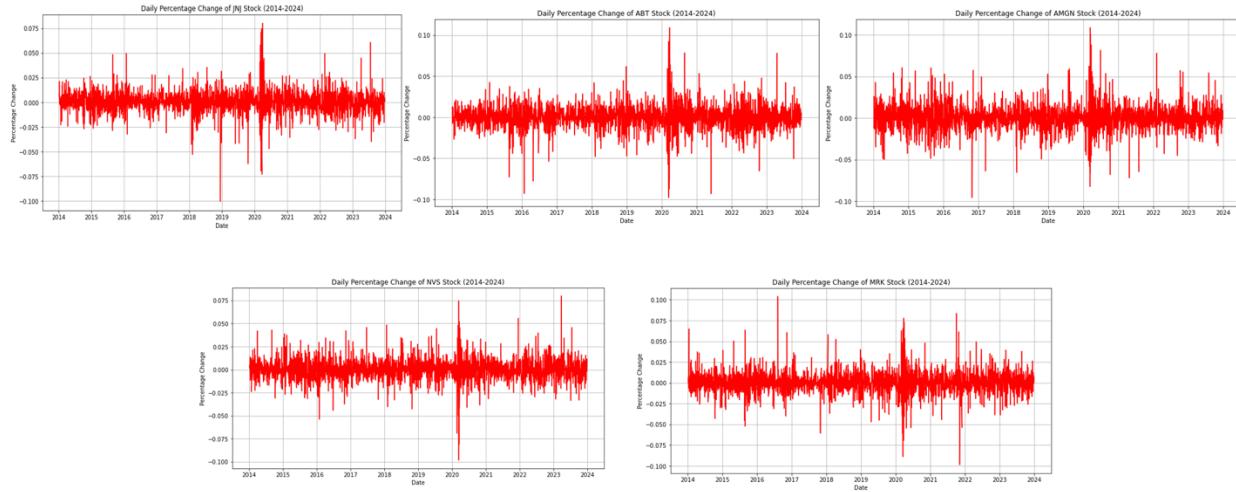
The final selection of the top 5 stocks, one from each sector, involved a meticulous process supported by detailed visualizations and statistical analyses. Here's a breakdown of how we shortlisted one stock from each sector and narrowed it down to our 5-stock portfolio.

This focused analysis and example of the Healthcare sector exemplifies our thorough approach to stock selection and portfolio construction:

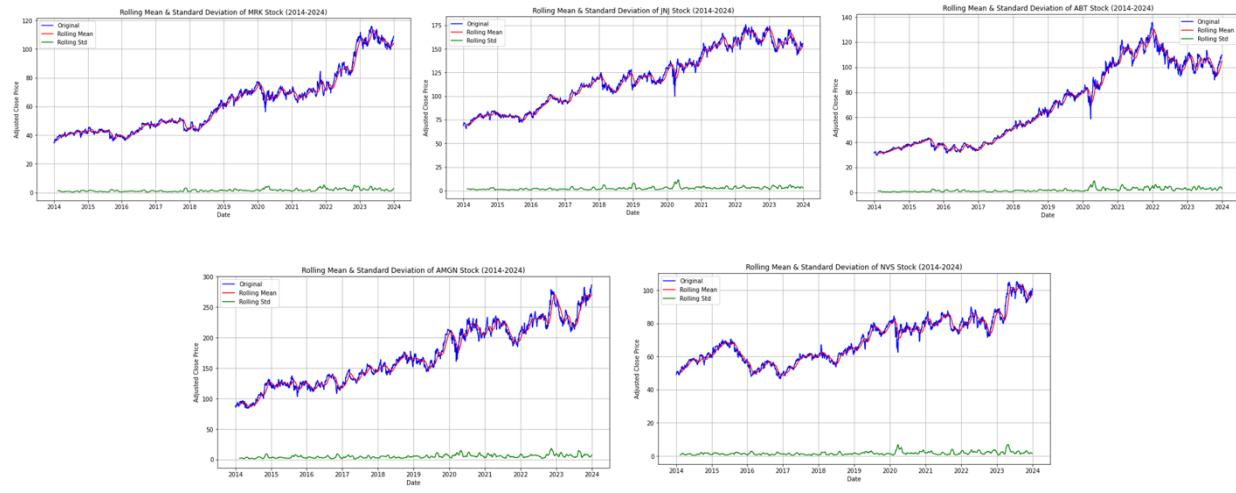
1. **Adjusted Closing Price Trends:** We analyzed the historical adjusted closing prices of stocks within each sector to identify long-term trends and potential price movements. Visualizing these trends helped us gauge the overall trajectory of each stock and assess its performance relative to its sector peers.



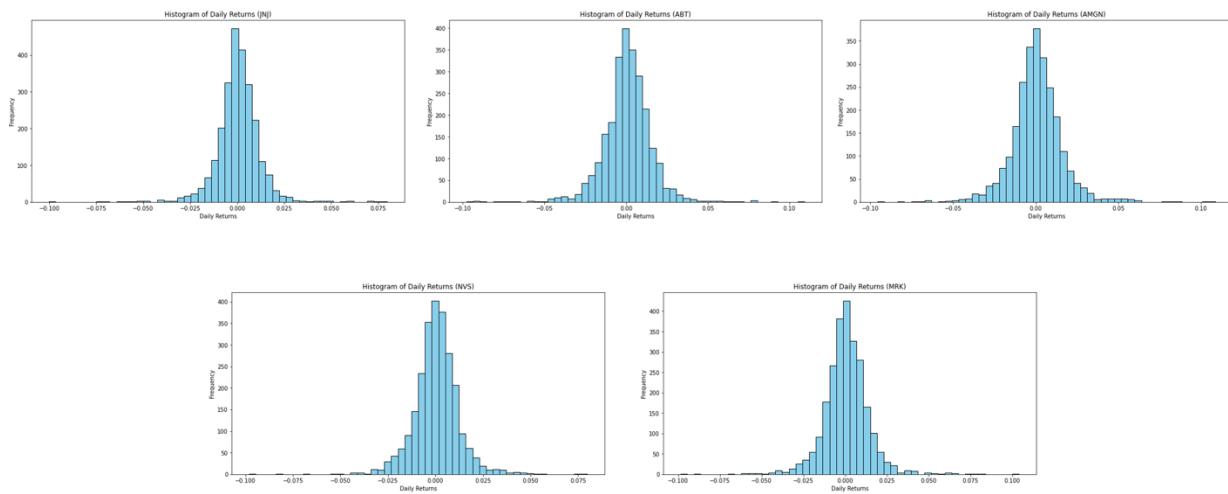
2. **Daily Percentage Change:** By calculating the daily percentage change in stock prices, we assessed short-term volatility and momentum. Stocks with consistent and favorable daily price movements were given preference, indicating strength and resilience in the face of market fluctuations.



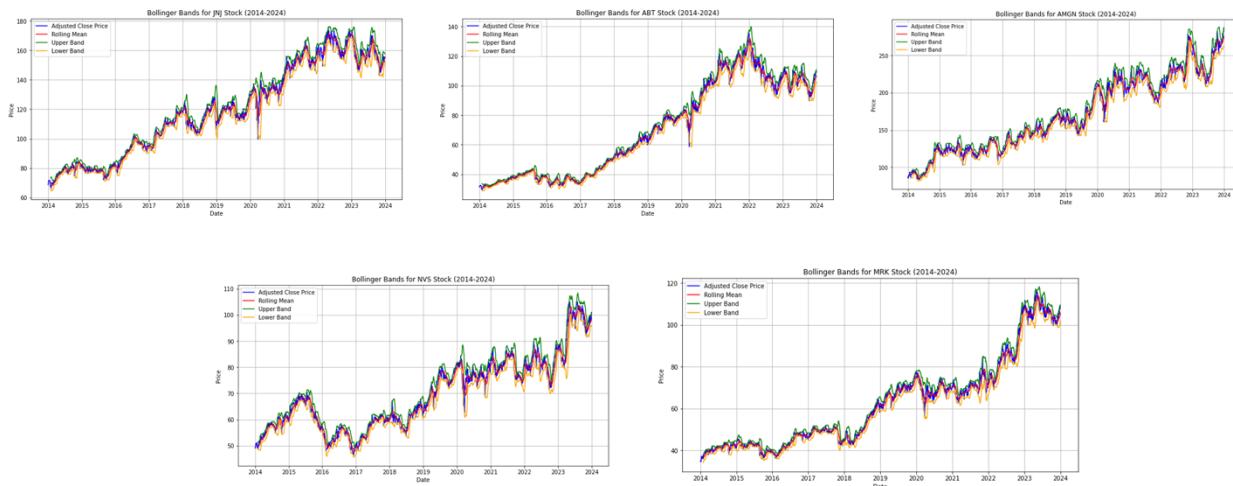
3. **Rolling Mean and Standard Deviation:** We computed rolling averages and standard deviations of stock prices to smooth out short-term fluctuations and identify underlying trends. This analysis helped us discern patterns and deviations from the mean, aiding in decision-making regarding stock selection.



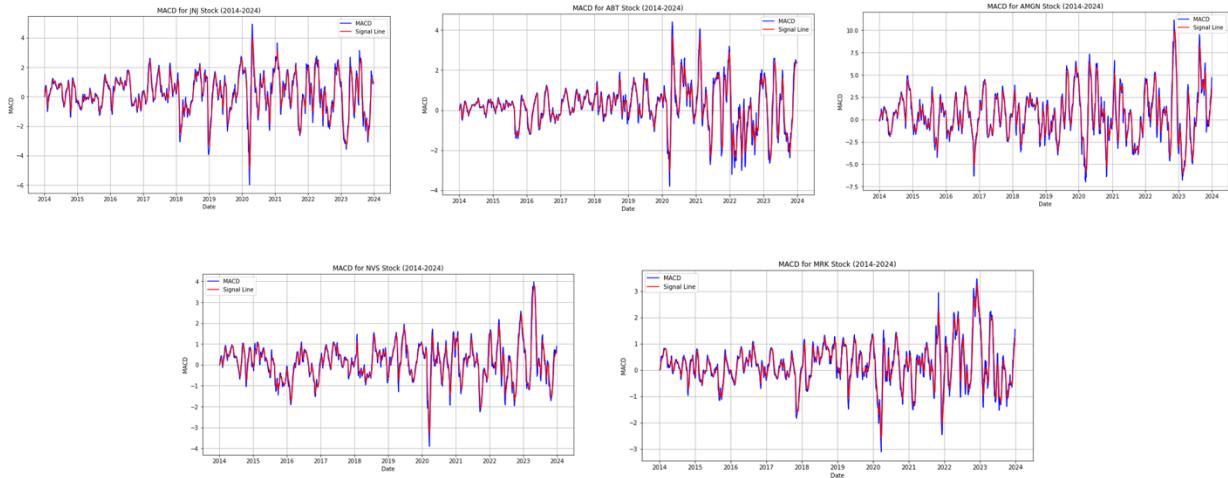
4. **Histogram of Daily Returns:** Histograms of daily returns provided insights into the distribution of stock returns and their frequency. We examined skewness, kurtosis, and other statistical measures to understand the shape and characteristics of return distributions, helping us assess risk and potential reward.



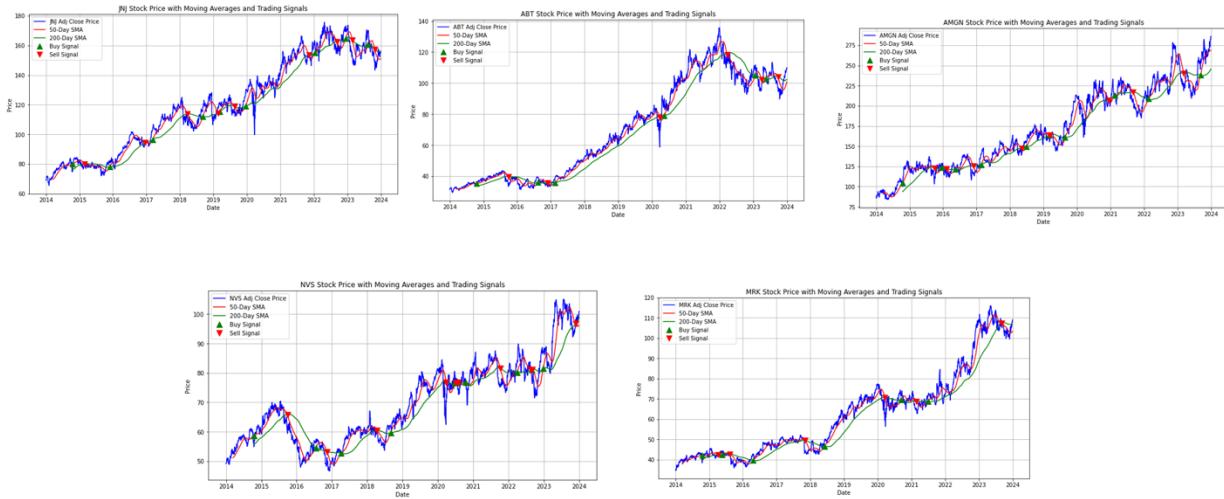
5. **Bollinger Bands:** Bollinger Bands were used to visualize the volatility and trading range of each stock. Stocks trading near the upper or lower bands were evaluated for potential breakouts or reversals, signaling entry or exit points.



6. **Moving Average Convergence/Divergence (MACD):** MACD analysis helped us identify shifts in momentum and potential trend reversals. Crossovers between the MACD line and the signal line provided signals for buying or selling opportunities.



- 7. Stock Prices with Moving Averages and Trading Signals:** Overlaying stock prices with various moving averages helped us identify key support and resistance levels. Additionally, trading signals derived from moving average crossovers or other technical indicators guided our decision-making process.



- 8. Statistical Analysis:** We conducted comprehensive statistical analyses, including calculations of average daily return, daily standard deviation of returns, annualized average return, annualized volatility, skewness, kurtosis, and Value at Risk (VaR) at a 5% confidence level. These metrics provided quantitative insights into risk-adjusted performance and portfolio characteristics.

a. Healthcare Sector:

- i. **JNJ (Johnson & Johnson):** With an average daily return of 0.0004 and an annualized average return of 0.0980, JNJ demonstrates relatively stable performance with

moderate returns. Its annualized volatility of 0.1800 indicates lower risk compared to some other stocks in the sector.

- ii. ABT (Abbott Laboratories), AMGN (Amgen Inc.), NVS (Novartis AG), MRK (Merck & Co., Inc.): These stocks also exhibit stable returns with varying levels of volatility and risk.

HEALTHCARE	JNJ	ABT	AMGN	NVS	MRK
Average Daily Return	0.0004	0.0006	0.0006	0.0004	0.0005
Daily Standard Deviation of Returns	0.0113	0.0147	0.0155	0.0118	0.0135
Annualized Average Return	0.0980	0.1528	0.1492	0.0897	0.1376
Annualized Volatility	0.1800	0.2341	0.2466	0.1874	0.2141
Skewness	-0.2017	-0.2053	0.2733	-0.0822	0.1413
Kurtosis	9.4023	6.8449	5.1432	6.1635	6.9605
VaR at 5% confidence level	-0.0163	-0.0219	-0.0233	-0.0184	-0.0199

b. Energy Sector:

- i. ENPH (Enphase Energy, Inc.): ENPH stands out with an exceptionally high annualized average return of 0.6247, indicating strong performance and potential for high returns. However, its high volatility, as indicated by an annualized volatility of 0.8127, suggests increased risk associated with this stock.
- ii. NEE (NextEra Energy, Inc.), FSLR (First Solar, Inc.), BEP (Brookfield Renewable Partners LP), TSLA (Tesla, Inc.): These stocks demonstrate a mix of performance and risk profiles, with varying levels of volatility and return potential.

ENERGY	NEE	ENPH	FSLR	BEP	TSLA
Average Daily Return	0.0006	0.0025	0.0009	0.0006	0.0019
Daily Standard Deviation of Returns	0.0148	0.0512	0.0301	0.0179	0.0351
Annualized Average Return	0.1596	0.6247	0.2228	0.1549	0.4765
Annualized Volatility	0.2352	0.8127	0.4774	0.2846	0.5566
Skewness	-0.1767	0.6228	0.6744	0.2392	0.2141
Kurtosis	11.7873	8.7781	6.5790	10.6229	4.3891
VaR at 5% confidence level	-0.0202	-0.0719	-0.0436	-0.0262	-0.0509

c. Energy Sector:

- i. ENPH (Enphase Energy, Inc.): ENPH stands out with an exceptionally high annualized average return of 0.6247, indicating strong performance and potential for high returns. However, its high volatility, as indicated by an annualized volatility of 0.8127, suggests increased risk associated with this stock.
- ii. NEE (NextEra Energy, Inc.), FSLR (First Solar, Inc.), BEP (Brookfield Renewable Partners LP), TSLA (Tesla, Inc.): These stocks demonstrate a mix of performance and risk profiles, with varying levels of volatility and return potential.

TECHNOLOGY	MSFT	AAPL	NVDA	TSM	GOOGL
Average Daily Return	0.0011	0.0011	0.0024	0.0010	0.0008
Daily Standard Deviation of Returns	0.0171	0.0179	0.0292	0.0190	0.0176
Annualized Average Return	0.2858	0.2817	0.5963	0.2547	0.2004
Annualized Volatility	0.2707	0.2838	0.4637	0.3013	0.2788
Skewness	0.1097	-0.0340	0.6807	0.2559	0.2298
Kurtosis	7.8477	5.5364	9.8029	4.5051	6.7961
VaR at 5% confidence level	-0.0263	-0.0267	-0.0426	-0.0288	-0.0264

d. Consumer Discretionary Sector:

- iii. **CMG (Chipotle Mexican Grill, Inc.):** CMG exhibits high average daily returns and annualized average returns, indicating strong performance within the sector. However, its high volatility, as indicated by an annualized volatility of 0.3422, suggests increased risk associated with this stock.
- iii. **BKNG (Booking Holdings Inc.), MCD (McDonald's Corporation), NKE (Nike, Inc.):** These stocks demonstrate a mix of performance and risk profiles, with varying levels of volatility and return potential.

CONSUMER	CMG	BKNG	MCD	MC.PA	NKE
Average Daily Return	0.0008	0.0006	0.0006	0.0009	0.0006
Daily Standard Deviation of Returns	0.0216	0.0200	0.0125	0.0169	0.0179
Annualized Average Return	0.2019	0.1608	0.1550	0.2225	0.1504
Annualized Volatility	0.3422	0.3175	0.1977	0.2685	0.2835
Skewness	0.9442	0.0417	0.5336	0.0890	0.5067
Kurtosis	14.6911	8.6776	34.7309	3.3181	11.4796
VaR at 5% confidence level	-0.0299	-0.0287	-0.0163	-0.0257	-0.0257

e. Financials Sector:

- a. **MA (Mastercard Incorporated):** MA stands out with a relatively high average daily return and annualized average return, indicating strong performance within the sector. Its annualized volatility of 0.2732 suggests moderate risk associated with this stock.
- b. **V (Visa Inc.), JPM (JPMorgan Chase & Co.), BRK-B (Berkshire Hathaway Inc.), BAC (Bank of America Corporation):** These stocks also demonstrate strong performance metrics with moderate levels of volatility, indicating stability and growth potential.

FINANCIALS	V	MA	JPM	BRK-B	BAC
Average Daily Return	0.0008	0.0008	0.0007	0.0005	0.0006
Daily Standard Deviation of Returns	0.0156	0.0172	0.0170	0.0121	0.0195
Annualized Average Return	0.1930	0.2069	0.1710	0.1298	0.1411
Annualized Volatility	0.2477	0.2732	0.2694	0.1925	0.3103
Skewness	0.2911	0.3033	0.3296	0.0002	0.2764
Kurtosis	9.9044	9.4292	14.0230	11.2161	9.9450
VaR at 5% confidence level	-0.0239	-0.0272	-0.0251	-0.0174	-0.0287

FOR THE AI PORTFOLIO

We initially attempted to create AI portfolios using both ChatGPT-4 and ChatGPT-3.5, but the returns didn't align with our trading strategy. Consequently, we developed a separate AI portfolio using stocks from the S&P 500 index.

The code fetches historical data for S&P 500 constituent stocks, calculates metrics such as volume, volatility, and price movement, assigns weights to these metrics, computes scores for each stock, and finally selects the top 5 stocks based on their scores.

```
Top 5 Stocks to Trade from S&P 500 INDEX:  
AMD Score: 24638938.011705797  
AAPL Score: 23686811.633057006  
AMZN Score: 23532636.972601373  
F Score: 23230108.434835967  
BAC Score: 19306624.082099903
```

STEP 2: PORTFOLIO RISK ANALYSIS

PART 1: DATA PREPARATION

- Downloaded historical daily or weekly adjusted closing prices for 5 selected stocks over a suitable time period.
- Computed log returns for each stock using the adjusted closing prices by taking the natural logarithm of the ratio of the current day's adjusted closing price to the previous day's.
- Calculated annual returns for each stock from the log returns by summing the log returns for each year.
- Utilized the PerformanceAnalytics Package in R for further analysis.

PART 2: MEAN, VOLATILITY AND SHARPE RATIO

- Calculated Mean and Volatility using two approaches:
 - Approach 1: Scaled the weekly average log returns and standard deviation of log returns to obtain annualized mean return and volatility.
 - Approach 2: Computed the mean and volatility directly from the annual returns.

```

##      Annual_Mean Weekly_Scaled_Mean
## AMGN      0.09          0.12
## NEE       0.11          0.13
## NVDA      0.51          0.49
## MCD       0.15          0.14
## V         0.16          0.16

```

```

##      Mean Volatility SR
## AMGN 0.12        0.24 0.49
## NEE   0.13        0.24 0.56
## NVDA 0.49        0.43 1.15
## MCD   0.14        0.19 0.74
## V     0.16        0.22 0.73

```

```

##      Annual_Volatility Weekly_Scaled_Volatility
## AMGN           0.12            0.24
## NEE            0.21            0.24
## NVDA           0.65            0.43
## MCD            0.12            0.19
## V              0.15            0.22

```

STEP 3: COMPUTE THE COVARIANCE MATRIX

- Used Matrix Multiplication Approach leveraging the computed annual volatility for each asset and the correlation matrix.

```

[1] "Covariance Matrix:"
      AMGN      NEE      NVDA      MCD      V
AMGN 0.05837098 0.01391665 0.02768524 0.01444122 0.02340415
NEE  0.01391665 0.05529033 0.02418778 0.01963138 0.01812735
NVDA 0.02768524 0.02418778 0.18110195 0.02425693 0.04181776
MCD  0.01444122 0.01963138 0.02425693 0.03480189 0.02306919
V    0.02340415 0.01812735 0.04181776 0.02306919 0.04876263

```

```

##      Symbol Correlation
## 1    AMGN -0.07412686
## 2    NEE  -0.02745505
## 3    NVDA  0.07274767
## 4    MCD  -0.06856374
## 5    V    -0.14040157

```

STEP 4: ASSIGN PORTFOLIO WEIGHTS

- Defined a function in R to calculate the portfolio mean and volatility.

- Generated a sequence of portfolio weights.
- Applied the function on each weight, resulting in approximately 140,000 points for visualization.

mu_p	sig_p
Min. :0.0937	Min. :0.1601
1st Qu.:0.1130	1st Qu.:0.1781
Median :0.1258	Median :0.1927
Mean :0.1319	Mean :0.2054
3rd Qu.:0.1467	3rd Qu.:0.2187
Max. :0.2301	Max. :0.4256

Risk	Return
0.242	0.119
0.224	0.121
0.210	0.122
0.199	0.123
0.191	0.124
0.188	0.125
0.190	0.127
0.195	0.128
0.205	0.129
0.219	0.130

Rationale:

Since we found the mean vector and covariance matrix, we can utilize the fact the portfolio mean return is:

$$\mu_p = \mathbf{w}^\top \boldsymbol{\mu}$$

and the portfolio volatility is

$$\sigma_p = \sqrt{\mathbf{w}^\top \boldsymbol{\Sigma} \mathbf{w}}$$

whereas the vector of portfolio weights is given by

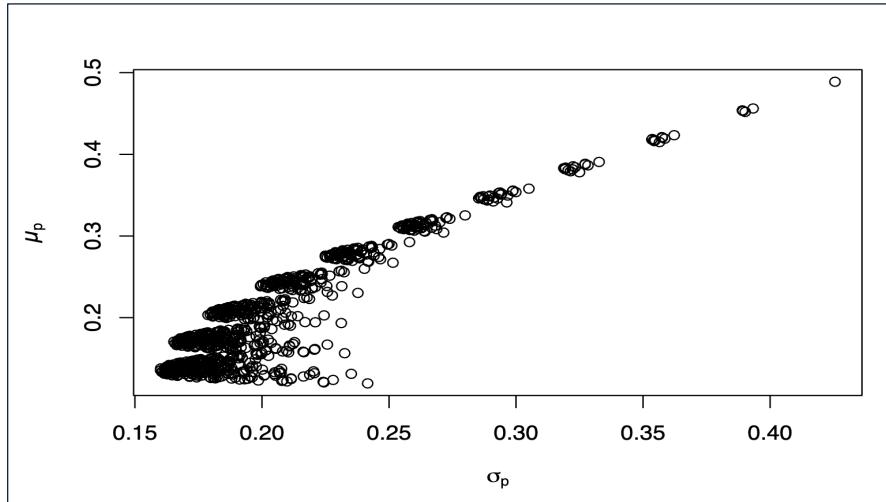
$$\mathbf{w} = \begin{bmatrix} w \\ 1-w \end{bmatrix}$$

The key to the problem is to determine both the portfolio mean and volatility returns as a function of w

STEP 5: CREATED EFFICIENT FRONTIER

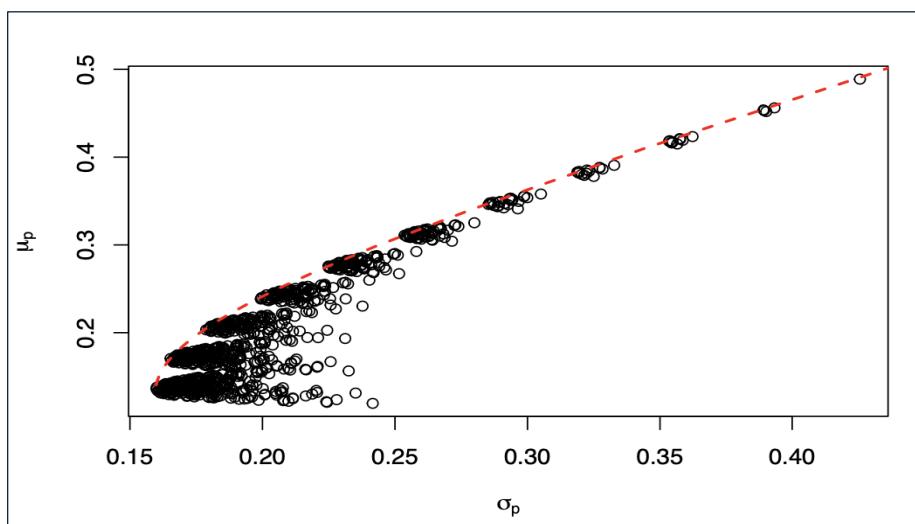
- Plotted the Efficient Frontier with:
 - X-axis: Portfolio volatility (σ_p)
 - Y-axis: Portfolio expected return (μ_p)

- Showed an upward sloping curve indicating the risk-return tradeoff.
- Observed dense points at lower risk-return and scattered points at higher risk-return.



STEP 6: MEAN-VARIANCE OPTIMIZATION

- Implemented mean-variance optimization approach.
- Represented the efficient frontier with a red line.
- Highlighted that optimal portfolios lie on the efficient frontier, offering either higher expected return for the same risk or lower risk for the same expected return, depending on the investor's risk-return preferences.

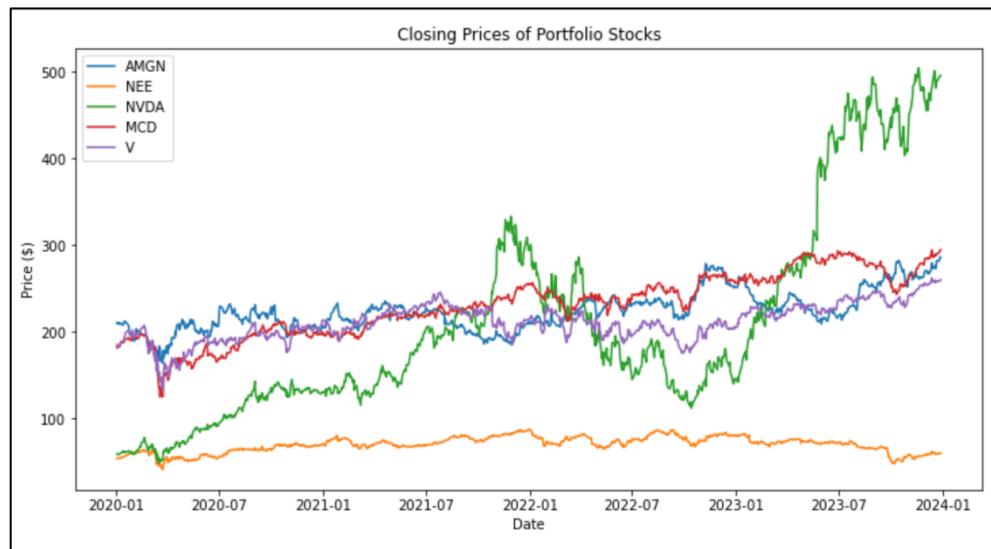


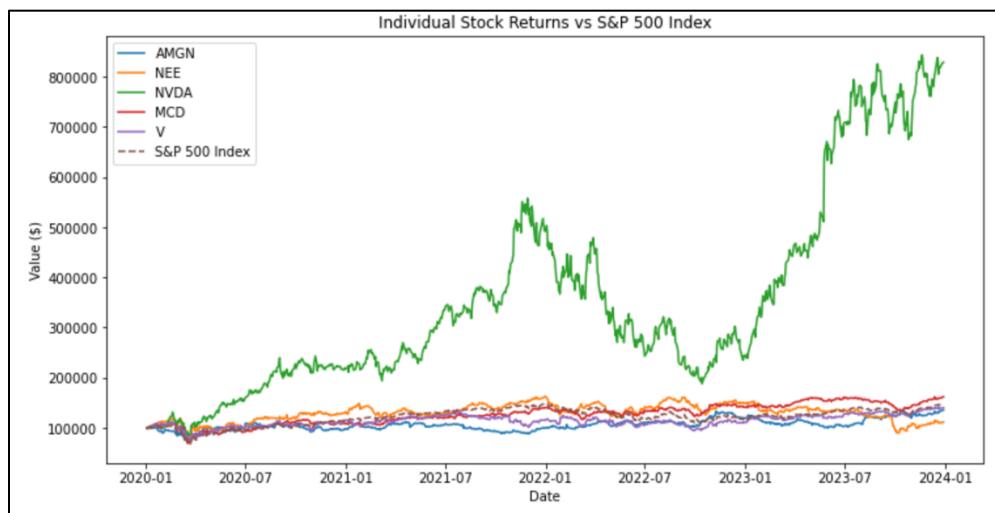
STEP 3: TECHNICAL ANALYSIS HUMAN TRADING

OUR PORTFOLIO AND CODE

Company Name
Amgen Inc.
NextEra Energy, Inc.
NVIDIA Corporation
McDonald's Corporation
Visa Inc.

- Our code conducts comprehensive technical analysis of a stock portfolio relative to S&P 500.
- Fetches historical stock price data, visualizes portfolio performance, calculates returns, and computes various financial metrics.
- Ultimately, it aims to provide us with insights into how well their portfolio is performing and how it compares to the broader market.



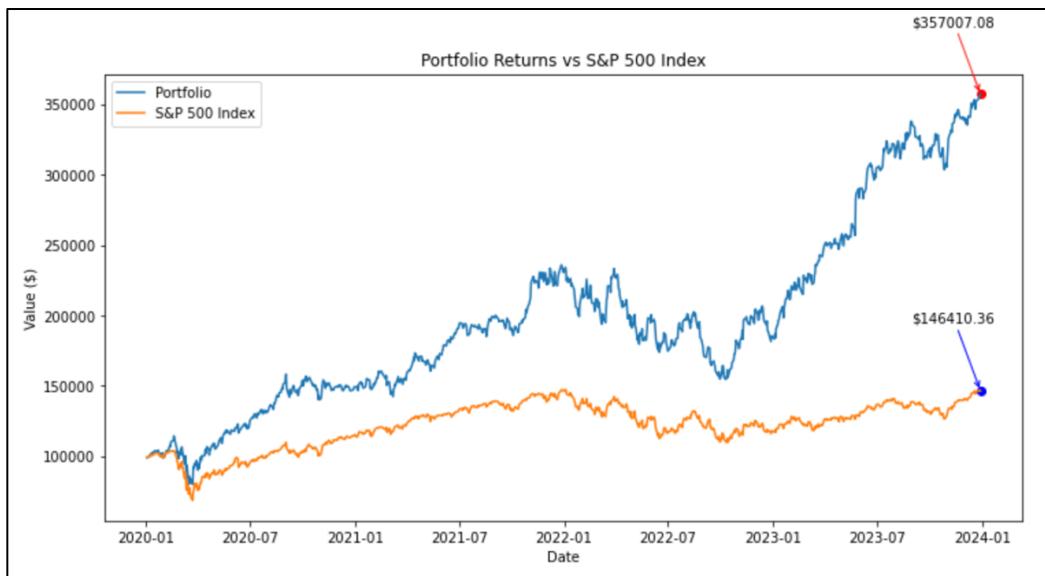


PORTRFOLIO WEIGHTS AND WEIGHTED RETURNS

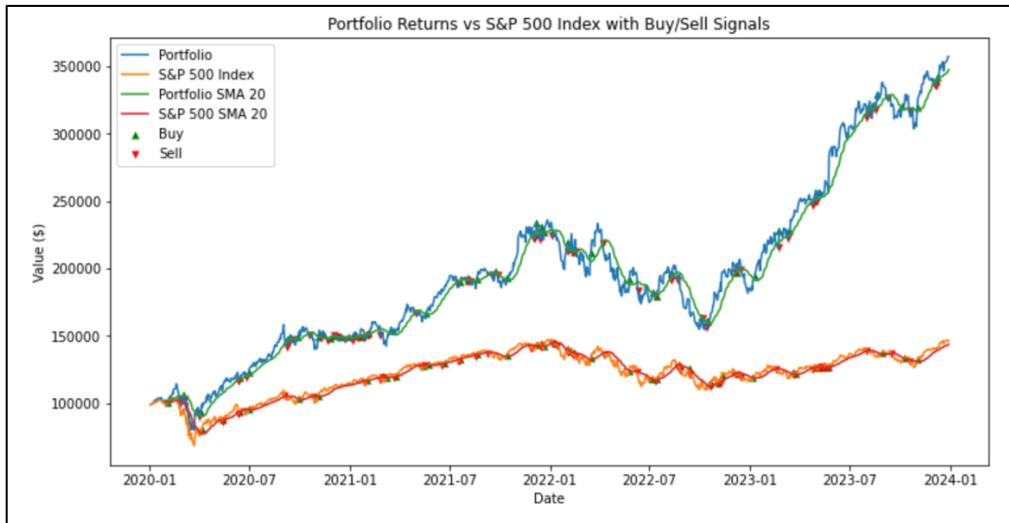
Portfolio weights:

AMGN	: 0.23
NEE	: 0.21
NVDA	: -0.01
MCD	: 0.44
V	: 0.14

2020-01-03	98953.065740
2020-01-06	99503.019092
2020-01-07	99808.609437
2020-01-08	100483.552371
2020-01-09	101368.199998
	...
2023-12-22	352231.815199
2023-12-26	353965.301135
2023-12-27	355501.154984
2023-12-28	356952.076500
2023-12-29	357007.077293



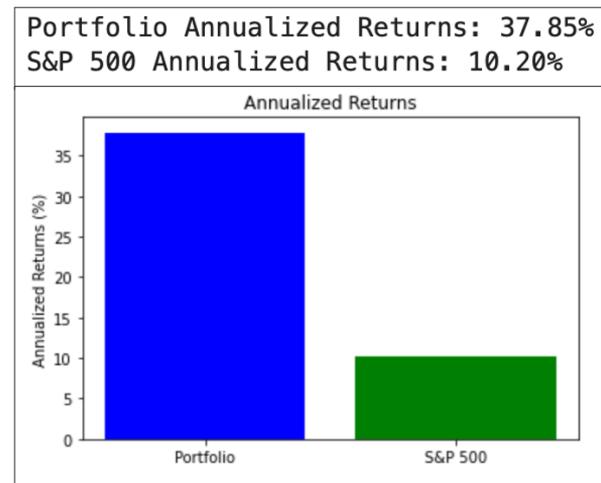
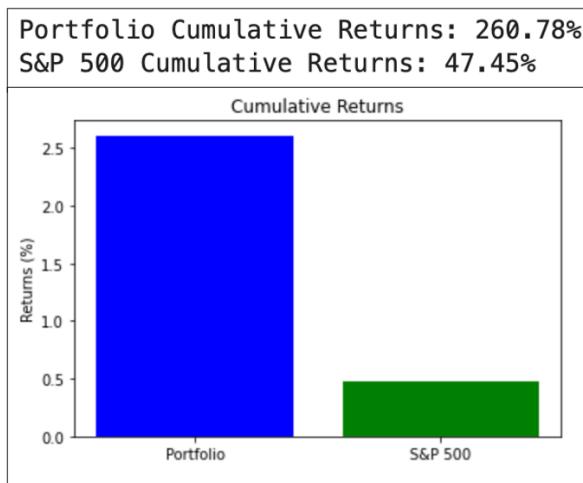
SIMPLE MOVING AVERAGE (SMA) AND TRADING SIGNALS



So for our strategy, Simple Moving Average is calculated for portfolio as well as SPY for a 20 day rolling period. When the value goes below average a buy signal is generated and when the value goes above average a sell signal is generated. The graph shows the portfolio's value with marked buy and sell points, based on the SMA strategy. This visual aid helps illustrate how strategic trades are timed to optimize entry and exit points in the market.

GRAPH: Towards the latter part of the timeline (post-2023), the portfolio exhibits a notable divergence, consistently maintaining values above the S&P 500, indicating superior performance during this period.

CUMULATIVE AND ANNUALIZED RETURNS

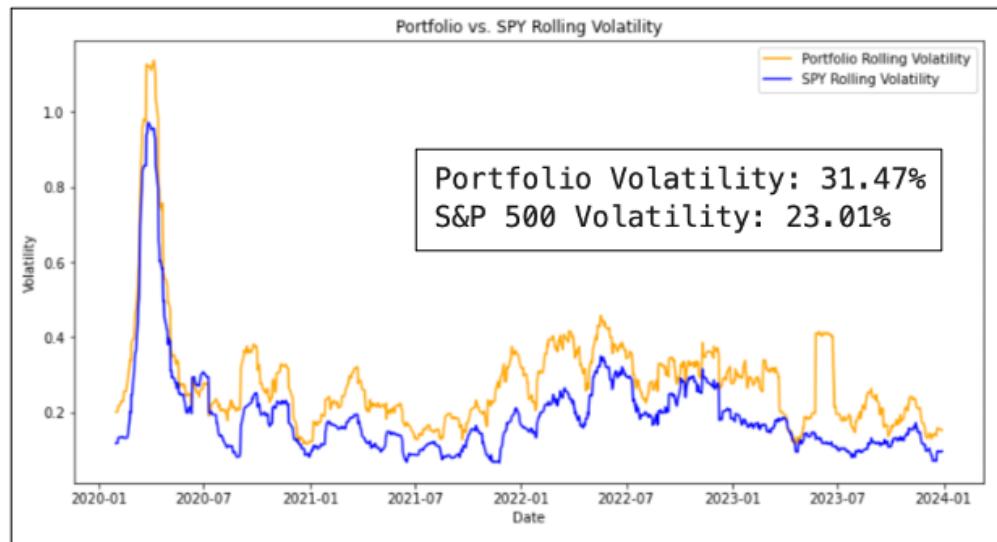


The cumulative returns represent the total growth of the portfolio over the investment period. Annualized returns provide a standardized measure of the portfolio's annual performance, allowing for easier comparison across different time periods.

VOLATILITY, SHARPE RATIO, SORTINO RATIO, AND TREYNOR RATIO

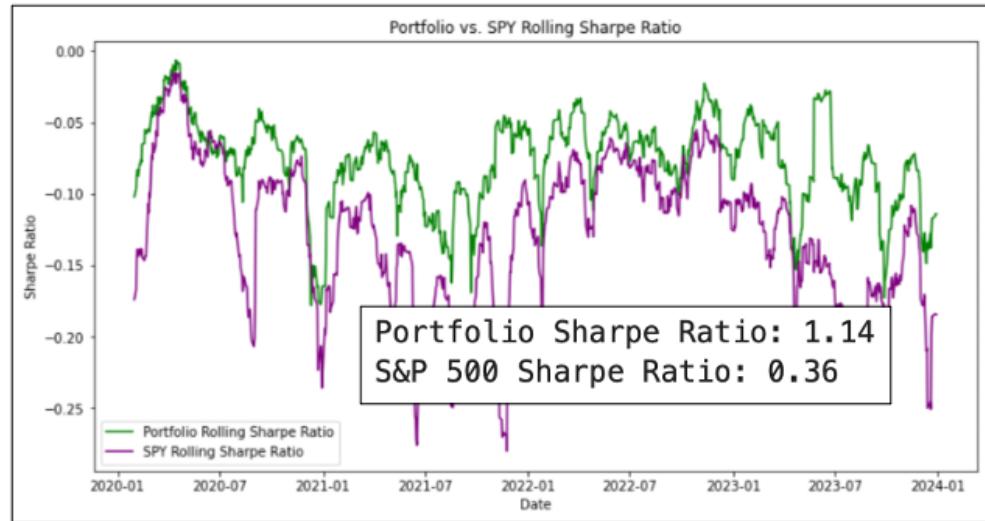
Rolling Volatility Comparison

- Graph: Shows the volatility of the portfolio and the S&P 500 over time. Volatility is measured as the standard deviation of returns, indicating how widely returns can vary.
- Values: The portfolio has a volatility of 31.47%, which is higher than the S&P 500's volatility of 23.01%. This suggests that the portfolio carries a higher level of risk or variation in returns compared to the broader market.



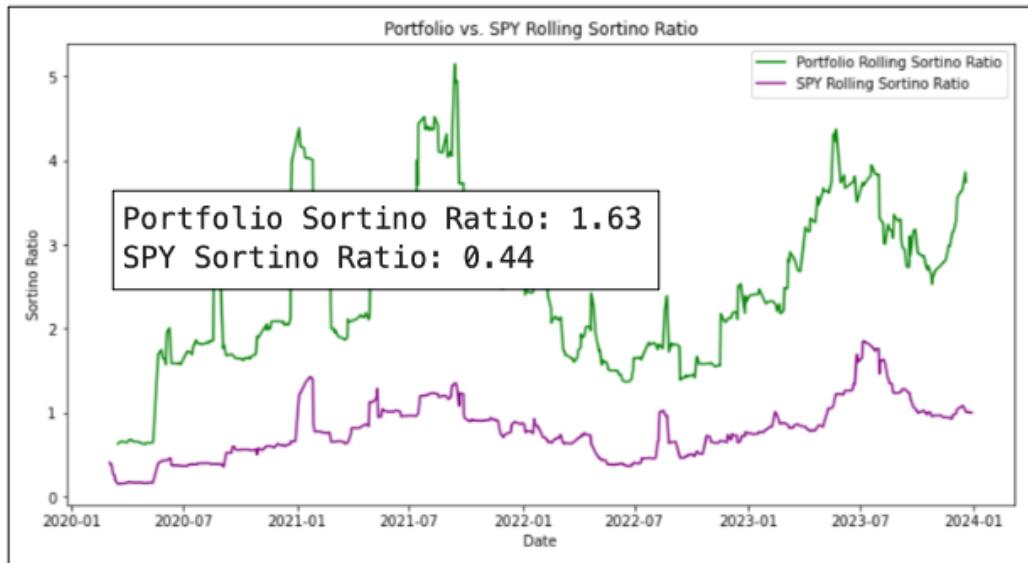
Rolling Sharpe Ratio Comparison

- Graph: Depicts the rolling Sharpe Ratios for both the portfolio and the S&P 500. The Sharpe Ratio measures risk-adjusted performance by dividing excess return by volatility.
- Values: The portfolio's overall Sharpe Ratio of 1.14 significantly exceeds the S&P 500's 0.36. This indicates that the portfolio provides a better return per unit of risk than the benchmark, showcasing efficient management and/or strategy.



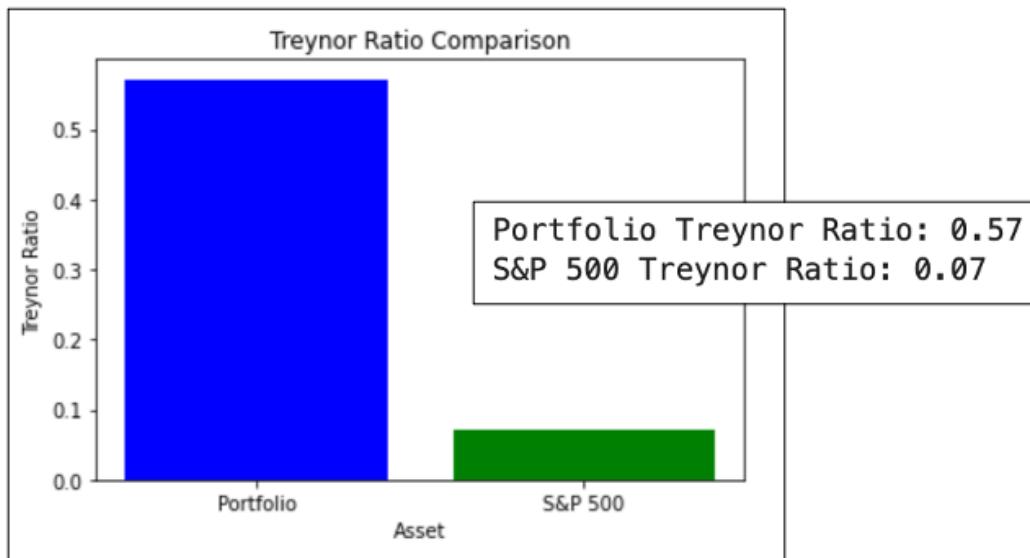
Rolling Sortino Ratio Comparison

- Graph: Illustrates the rolling Sortino Ratios, which adjust for the size of a portfolio's downside volatility rather than total volatility, providing a better measure when underperformance is viewed as more critical than overall volatility.
- Values: The portfolio's Sortino Ratio of 1.63 far outstrips the S&P 500's 0.44. This highlights that the portfolio has achieved superior returns on a risk-adjusted basis when considering only downside risk, which is particularly appealing to risk-averse investors.



Treynor Ratio Comparison

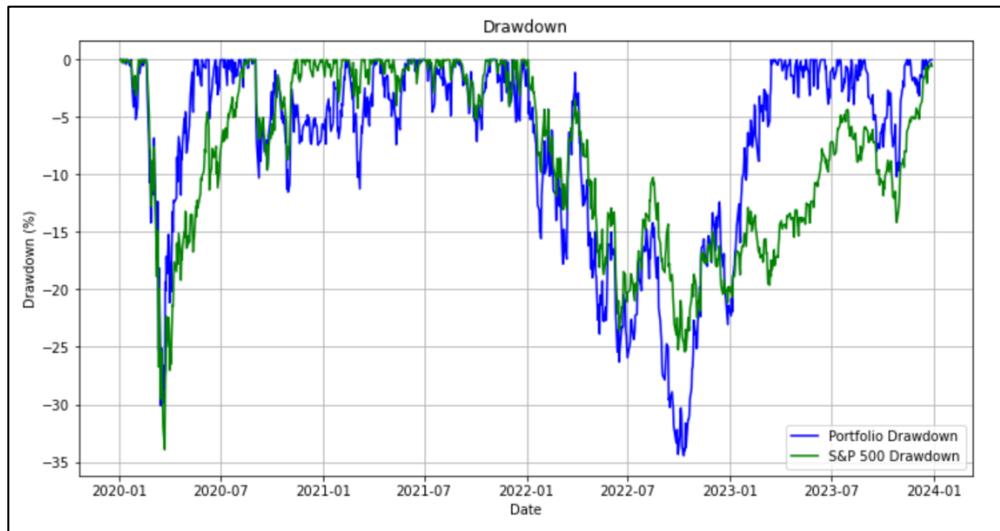
- Graph: This is actually a comparative bar chart showing the Treynor Ratios of the portfolio and the S&P 500. The Treynor Ratio measures returns earned in excess of that which could have been earned on a riskless investment per each unit of market risk.
- Values: The portfolio's Treynor Ratio of 0.57 compares favorably to the S&P 500's 0.07, suggesting that the portfolio is generating much more return per unit of market risk than the broader market.



DRAWDOWN AND OTHER METRICS

Drawdown Graph

- Graphical Representation: Shows the drawdowns for both your portfolio and the S&P 500 over a specific time period. Drawdown is the peak-to-trough decline during a specific recorded period of an investment, an indicator of downside risk.
- Comparison of Drawdowns: The portfolio drawdown line (green) and the S&P 500 drawdown line (blue) indicate the maximum observed losses from a peak to a trough before a new peak is achieved. It appears that your portfolio experienced a maximum drawdown slightly less severe than that of the S&P 500, indicating robustness in face of market downturns.



Portfolio Maximum Drawdown: -34.47%
S&P 500 Maximum Drawdown: -33.92%

Covariance Matrix: Displays the covariance between the returns of your portfolio and the S&P 500. The matrix shows small values, indicating relatively low simultaneous variations between the two returns. Covariance is crucial in assessing how two investments move in relation to each other, impacting portfolio diversification.

	Portfolio Returns	S&P 500 Returns
Portfolio Returns	0.000393	0.000247
S&P 500 Returns	0.000247	0.000210

Alpha (26.22%): Indicates your portfolio's performance relative to the benchmark, adjusted for risk. A positive alpha of 26.22% suggests that the portfolio significantly outperformed the S&P 500, after adjusting for risk.

Beta (1.17): Measures the volatility of your portfolio relative to the S&P 500. A beta of 1.17 suggests that your portfolio is slightly more volatile than the market.

Alpha: 26.22%
Beta: 1.17

Capture Ratios

- Upside Capture Ratio (1.54): Shows how well your portfolio performs relative to the S&P 500 in periods when the market is up. A ratio above 1 indicates better performance compared to the benchmark during the upside market movements.
- Downside Capture Ratio (1.38): Reflects how your portfolio performs relative to the S&P 500 in periods when the market is down. A ratio above 1 suggests that the portfolio captures more of the downside than the benchmark.

Upside Capture Ratio: 1.54
Downside Capture Ratio: 1.38

Recovery Factor

- Portfolio Recovery Factor (7.56): Indicates how well the portfolio recovers from its peak drawdown compared to its cumulative returns. A higher recovery factor is indicative of strong resilience and effective risk management.
- S&P 500 Recovery Factor (1.40): Compared to the portfolio's higher recovery factor, this suggests your management strategies effectively mitigated risks and capitalized on recovery opportunities better than the market.

Portfolio Recovery Factor: 7.56
S&P 500 Recovery Factor: 1.40

Correlation

- **Correlation (0.86):** Shows a high degree of correlation between your portfolio returns and the S&P 500 returns. A correlation close to 1 implies that the portfolio's returns are highly synchronized with the market movements, which could impact diversification benefits.

Correlation: 0.86

RESULTS FOR TECHNICAL ANALYSIS

Metric	Portfolio	SPY
Initial Investment	\$100,000	\$100,000
Final value	\$357,007	\$146,410
Total Return	260.78%	47.45%
Volatility	31.47%	23.01%
Beta	1.17	-
Alpha	0.26	-
Correlation	0.86	-
Treynor Ratio	57%	7%
Sharpe Ratio	1.139129	0.356418
Sortino Ratio	1.634436	0.441878
Recovery Factor	7.56	1.4
Max Drawdown	-34.47%	-33.92%

- Performance: Achieved a remarkable 260.78% return, outperforming the benchmark by a significant margin.
- Risk Management: Despite higher volatility, demonstrated superior risk-adjusted returns with strong Sharpe and Sortino Ratios.
- Alpha and Treynor Ratio: Showed positive alpha and a Treynor Ratio of 57%, indicating efficient risk-adjusted performance.
- Correlation and Recovery: Strong correlation with market movements and robust recovery capability with a factor of 7.56.
- Drawdown: Experienced a maximum drawdown of -34.47%, showcasing resilience during market fluctuations.

STEP 4: AI TRADING STRATEGY

STOCKS IN OUR PORTFOLIO

- AMD (Advanced Micro Devices, Inc.)
- AAPL (Apple Inc.)

- AMZN (Amazon.com Inc.)
- F (Ford Motor Company)
- BAC (Bank of America Corporation)

PARAMETERS USED

- symbols: A list of stock symbols to trade, including "AMD", "AAPL", "AMZN", "F", and "BAC".
- cash_at_risk: The percentage of cash to risk per trade, set to 0.5.
- sleeptime: The duration to sleep between trading iterations, set to 24 hours.
- start_date: Start date for backtesting, set to January 1, 2020.
- end_date: End date for backtesting, set to December 31, 2023.

OUR CODE

```

API_KEY = "PK4EVSKKARSY8RBMX0CU"
API_SECRET = "26UVpcuQeumwfGF1vkLSbaMkfaIU8vHjQEhwxs6a"
BASE_URL = "https://paper-api.alpaca.markets/v2"

ALPACA_CREDS = {
    "API_KEY": API_KEY,
    "API_SECRET": API_SECRET,
    "PAPER": True
}

class MLTrader(Strategy):
    def initialize(self, symbols:list=["AMD", "AAPL", "AMZN", "F", "BAC"], cash_at_risk:float=.5):
        self.symbols = symbols
        self.sleeptime = "24H"
        self.last_trade = {symbol: None for symbol in symbols}
        self.cash_at_risk = cash_at_risk
        self.api = REST(base_url=BASE_URL, key_id=API_KEY, secret_key=API_SECRET)

    def position_sizing(self, symbol):
        cash = self.get_cash()
        last_price = self.get_last_price(symbol)
        quantity = round(cash * self.cash_at_risk / last_price, 0)
        return cash, last_price, quantity

    def get_dates(self):
        today = self.get_datetime()
        three_days_prior = today - Timedelta(days=3)
        return today.strftime('%Y-%m-%d'), three_days_prior.strftime('%Y-%m-%d')

    def get_sentiment(self, symbol):
        today, three_days_prior = self.get_dates()
        news = self.api.get_news(symbol=symbol, start=three_days_prior, end=today)
        news = [ev._dict__["_raw"]["headline"] for ev in news]
        probability, sentiment = estimate_sentiment(news)
        return probability, sentiment

```

- Establish a connection to the Alpaca API for trading.
- The initialize method sets up the initial parameters for the strategy, such as the list of symbols to trade, sleeptime, last trade symbol, and the percentage of cash to risk per trade.
- The get_sentiment method fetches news headlines for a symbol within the specified time frame and applies sentiment analysis using the estimate_sentiment function. It returns the sentiment ("positive" or "negative") and the probability associated with that sentiment.

OUR STRATEGY

```

def on_trading_iteration(self):
    for symbol in self.symbols:
        cash, last_price, quantity = self.position_sizing(symbol)
        probability, sentiment = self.get_sentiment(symbol)

        if cash > last_price:
            if sentiment == "positive" and probability > .999:
                if self.last_trade[symbol] == "sell":
                    self.sell_all(symbol)
                    order = self.create_order(
                        symbol,
                        quantity,
                        "buy",
                        type="bracket",
                        take_profit_price=last_price * 1.20,
                        stop_loss_price=last_price * .95
                    )
                    self.submit_order(order)
                    self.last_trade[symbol] = "buy"
            elif sentiment == "negative" and probability > .999:
                if self.last_trade[symbol] == "buy":
                    self.sell_all(symbol)
                    order = self.create_order(
                        symbol,
                        quantity,
                        "sell",
                        type="bracket",
                        take_profit_price=last_price * .8,
                        stop_loss_price=last_price * 1.05
                    )
                    self.submit_order(order)
                    self.last_trade[symbol] = "sell"

```

1. Position Sizing:

- Calculate the quantity of shares to trade for each symbol based on the available cash and the percentage of cash to risk per trade.

2. Sentiment Analysis:

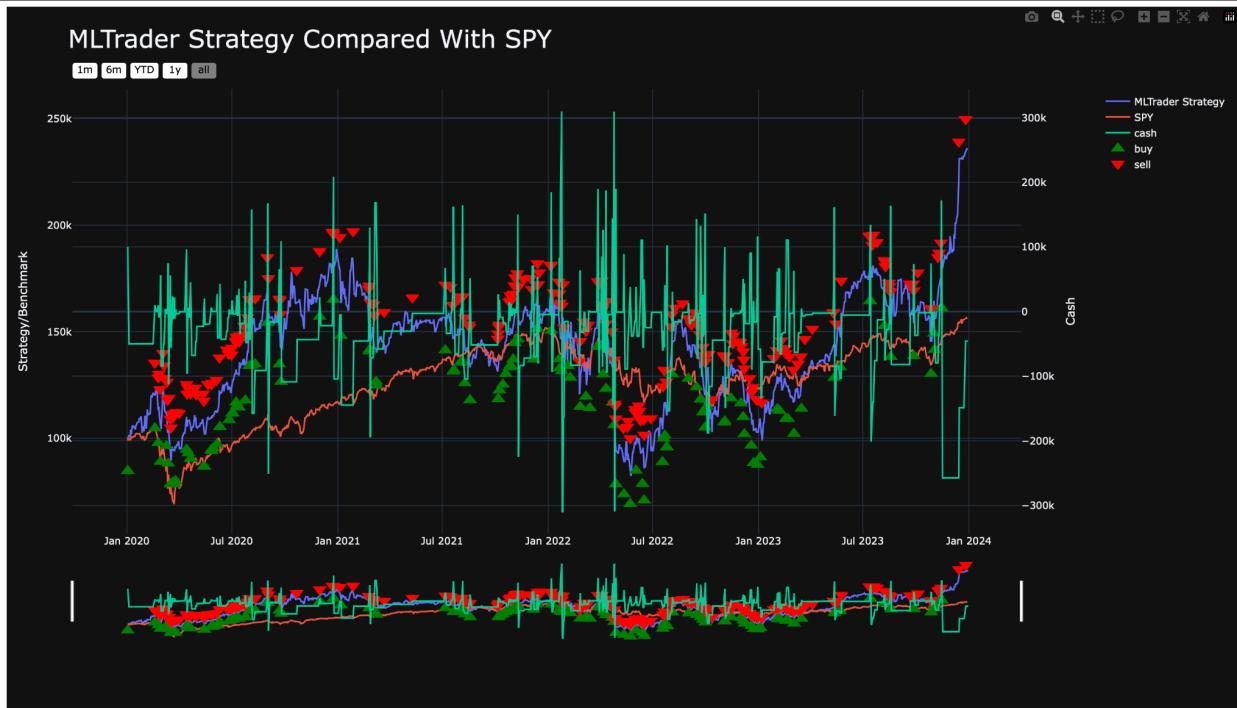
- Fetch recent news headlines for each symbol within a specified time frame.
- Apply sentiment analysis to the news headlines using the **estimate_sentiment** function.
- Determine the sentiment ("positive" or "negative") and the associated probability for each symbol.

3. Trading Decisions:

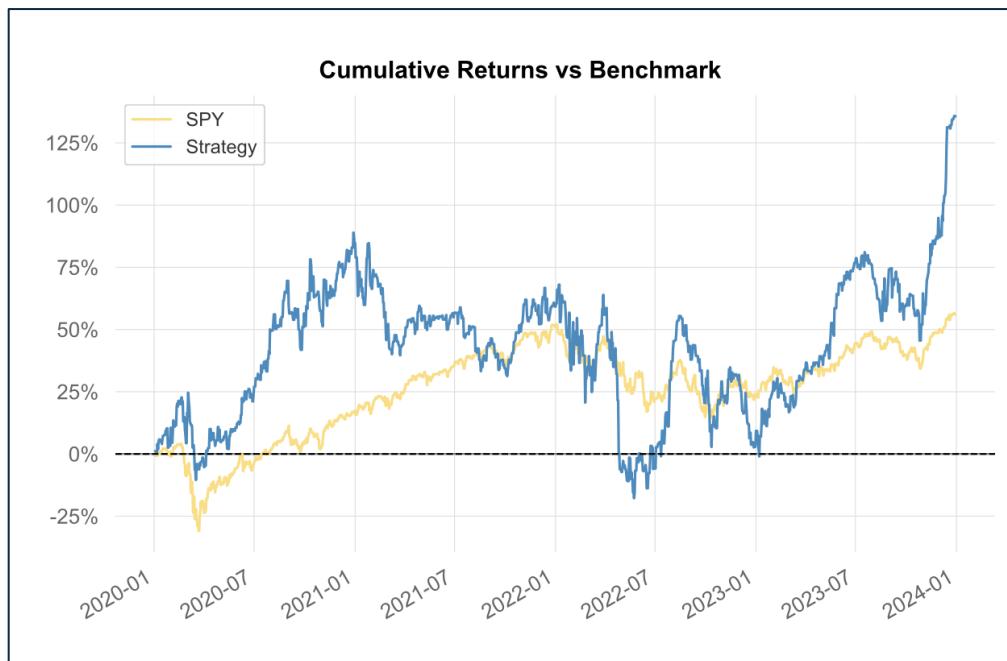
- For each symbol:
 - If there is sufficient cash available and the sentiment is "positive" with a probability above a certain threshold:
 - If the last trade for the symbol was a "sell", liquidate the position by selling all shares.
 - Place a buy order with a bracket order type, specifying a take profit price (20% above the last price) and a stop loss price (5% below the last price).
 - Update the last trade for the symbol to "buy".
 - If the sentiment is "negative" with a probability above a certain threshold:
 - If the last trade for the symbol was a "buy", liquidate the position by selling all shares.
 - Place a sell order with a bracket order type, specifying a take profit price (20% below the last price) and a stop loss price (5% above the last price).
 - Update the last trade for the symbol to "sell".

In summary, the strategy buys stocks when sentiment analysis indicates a high probability of positive sentiment and sells stocks when sentiment analysis indicates a high probability of negative sentiment. It uses bracket orders to set profit targets and stop loss levels for risk management.

SPY VS. OUR STRATEGY WITH THE TRADING SIGNALS



PORTFOLIO RETURNS VS. SPY RETURNS



Total Return:

- Our strategy achieved a much higher total return of 135.69% over the period.
- The benchmark SPY had a total return of 56.05%, which is significantly lower.

Annualized Return (CAGR):

- Our strategy's annualized return, or Compound Annual Growth Rate (CAGR), was 23.96%.
- The benchmark SPY had a lower annualized return of 11.79%.

Key Performance Metrics		
Metric	SPY	Strategy
Risk-Free Rate	5.24%	5.24%
Time in Market	69.0%	63.0%
Total Return	56.05%	135.69%
CAGR% (Annual Return)	11.79%	23.96%

These metrics indicate that our portfolio strategy outperformed the S&P 500 index in terms of overall returns over the period analyzed. It generated more than double the total return and more than twice the annualized return compared to the benchmark.

RETURN METRICS

Metric	SPY	Strategy
Expected Daily	0.03%	0.06%
Expected Monthly	0.93%	1.8%
Expected Yearly	11.77%	23.9%
Kelly Criterion	-0.46%	2.28%
Risk of Ruin	0.0%	0.0%
Daily Value-at-Risk	-1.91%	-3.85%
Expected Shortfall (cVaR)	-1.91%	-3.85%

Metric	SPY	Strategy
Max Consecutive Wins	4	6
Max Consecutive Losses	4	5
Gain/Pain Ratio	0.12	0.14
Gain/Pain (1M)	0.64	0.75
Payoff Ratio	0.85	0.95
Profit Factor	1.12	1.14
Common Sense Ratio	1.11	1.26
CPC Index	0.51	0.57
Tail Ratio	0.99	1.1
Outlier Win Ratio	10.45	5.29
Outlier Loss Ratio	5.37	2.52

Expected Returns:

- Our strategy is expected to generate higher daily (0.06% vs. 0.03%), monthly (1.8% vs. 0.93%), and yearly (23.9% vs. 11.77%) returns compared to SPY.

Kelly Criterion:

- The Kelly Criterion measures the optimal position size to maximize long-term growth.
- Our strategy has a higher Kelly Criterion of 2.28%, indicating a more favorable position sizing compared to -0.46% for SPY.

Risk of Ruin:

- Both our strategy and SPY have a 0% risk of ruin, suggesting a low probability of complete capital depletion.

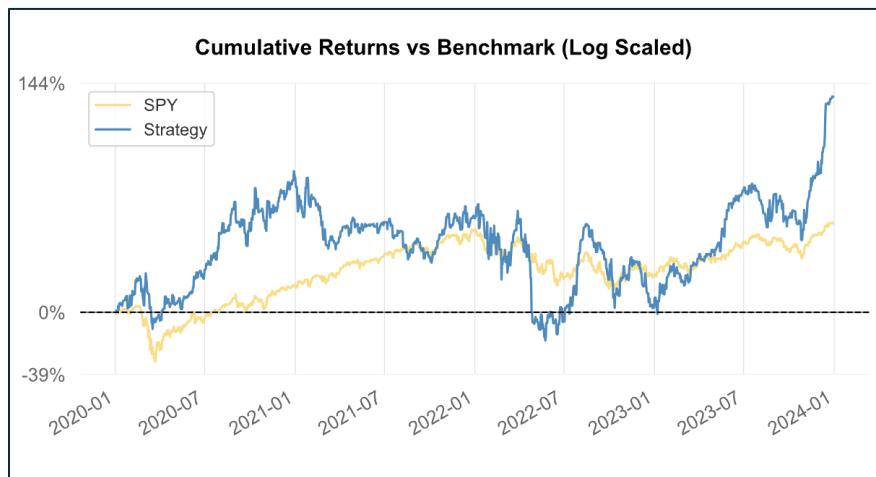
Downside Risk:

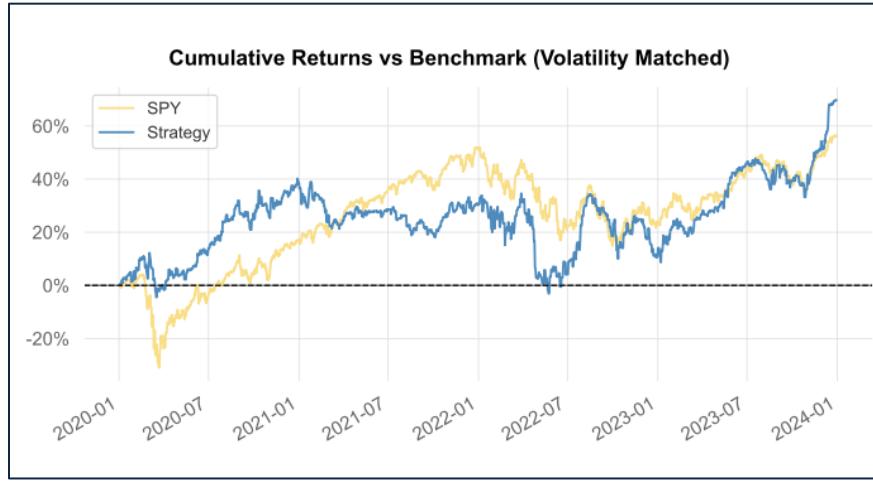
- Our strategy has a higher daily Value-at-Risk (-3.85% vs. -1.91% for SPY), indicating a higher potential for daily losses.
- Similarly, our strategy has a higher Expected Shortfall or Conditional Value-at-Risk (-3.85% vs. -1.91% for SPY), suggesting larger expected losses in the tail of the return distribution.

In summary, our strategy demonstrates higher expected returns across different time frames and a more favorable position sizing based on the Kelly Criterion.

However, it also carries higher downside risk, with higher potential daily losses and larger expected losses in extreme scenarios compared to the benchmark.

CUMULATIVE RETURNS V.S. SPY RETURNS

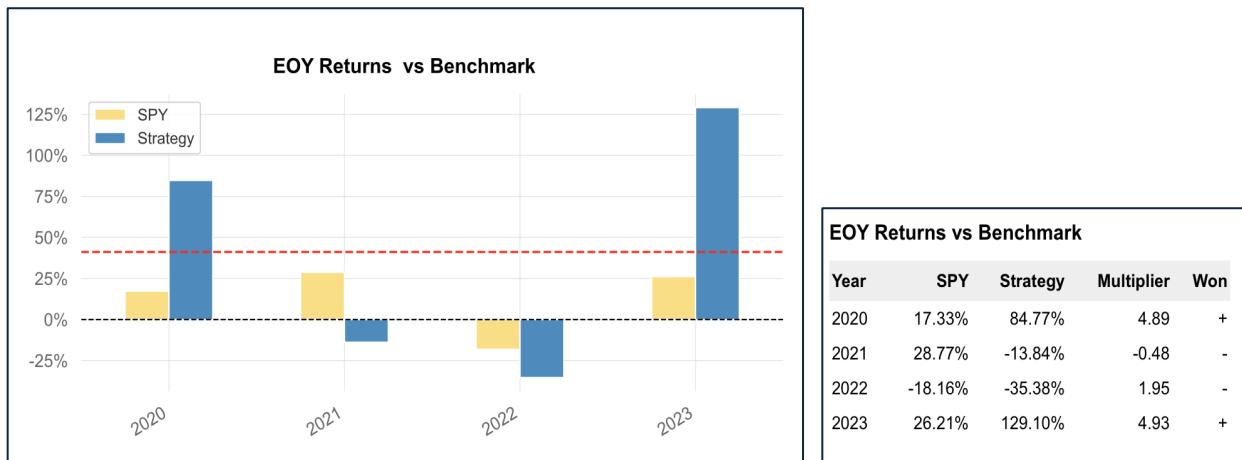




The top graph plots the cumulative returns on a log-scaled y-axis - our strategy significantly outperformed the benchmark, achieving substantially higher cumulative returns over the analyzed period.

The bottom graph compares the cumulative returns while adjusting for volatility differences between our strategy and the benchmark. After accounting for volatility, our strategy (blue line) consistently outperformed the SPY benchmark (yellow line) over the entirety of the period.

END-OF-YEAR (EOY) RETURNS



The bar chart on the left visually compares the EOY returns. It shows that our strategy (blue bars) significantly outperformed SPY (yellow bars) in 2020 and 2023, but underperformed in 2021 and 2022.

The table on the right provides numerical details of the EOY returns and includes additional metrics:

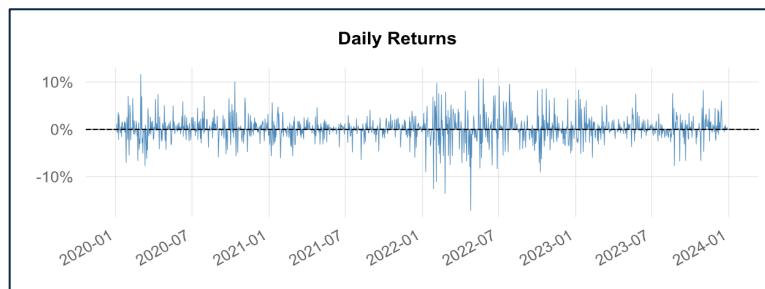
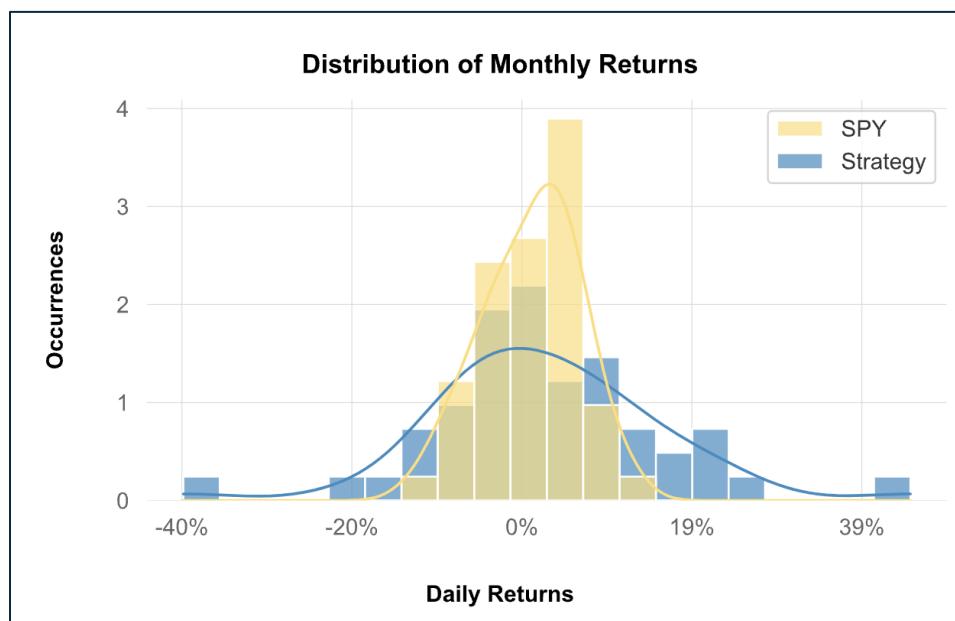
1. In 2020, our strategy returned 84.77%, outperforming SPY's 17.33%

2. In 2021, our strategy had a negative return of -13.84%, underperforming SPY's positive return of 28.77%
3. In 2022, both our strategy (-35.38%) and SPY (-18.16%) had negative returns, but our strategy underperformed
4. In 2023, our strategy had an exceptional return of 129.10%, outperforming SPY's 26.21%

The "Multiplier" column shows how many times our strategy's return was higher (or lower if negative) than SPY's return for that year.

A "+" in the "Won" column indicates that our strategy outperformed SPY for that year.

DAILY AND MONTHLY RETURNS



Distribution of Monthly Returns:

- Our strategy's distribution has a higher peak and fatter tails, indicating more extreme positive and negative monthly returns compared to SPY.

Daily Returns:

- Our strategy shows higher volatility in daily returns, with more frequent and larger positive and negative daily moves compared to SPY.

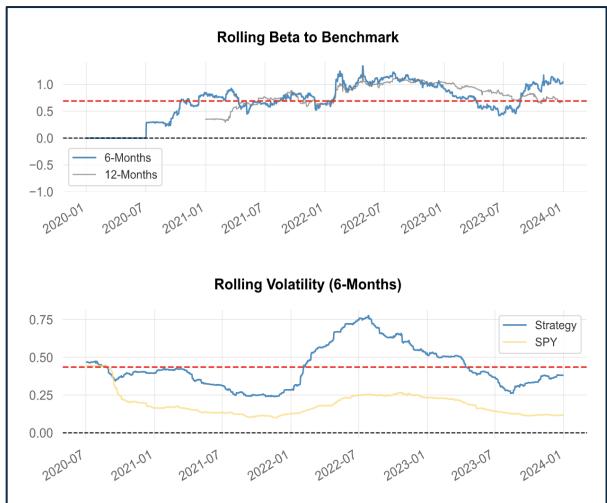
Performance Metrics:

- The table provides additional metrics related to daily and monthly performance.
- Our strategy had a higher average up month but also a higher average down month, reflecting higher volatility.

Metric	SPY	Strategy
Avg. Up Month	5.43%	12.53%
Avg. Down Month	-5.72%	-10.14%
Win Days	53.84%	52.31%
Win Month	62.5%	56.25%
Win Quarter	68.75%	56.25%
Win Year	75.0%	50.0%

Overall, the visuals and metrics suggest that while our strategy generated higher average positive returns, it also experienced more extreme positive and negative daily and monthly returns, leading to higher volatility compared to SPY.

ROLLING BETA AND VOLATILITY



Metric	SPY	Strategy
Volatility (ann.)	22.61%	45.71%
R^2	0.09	0.09
Information Ratio	0.02	0.02
Calmar	0.35	0.42
Skew	-0.57	-0.16
Kurtosis	16.3	6.49
Beta	-	0.6
Alpha	-	0.24
Correlation	-	29.71%
Treynor Ratio	-	217.12%

Rolling Beta to Benchmark:

- The rolling 6-month and 12-month beta lines show how our strategy's beta (sensitivity to benchmark movements) has varied over time.
- Our strategy's beta has fluctuated above and below 1, indicating periods where it was sensitive to the benchmark's movements.

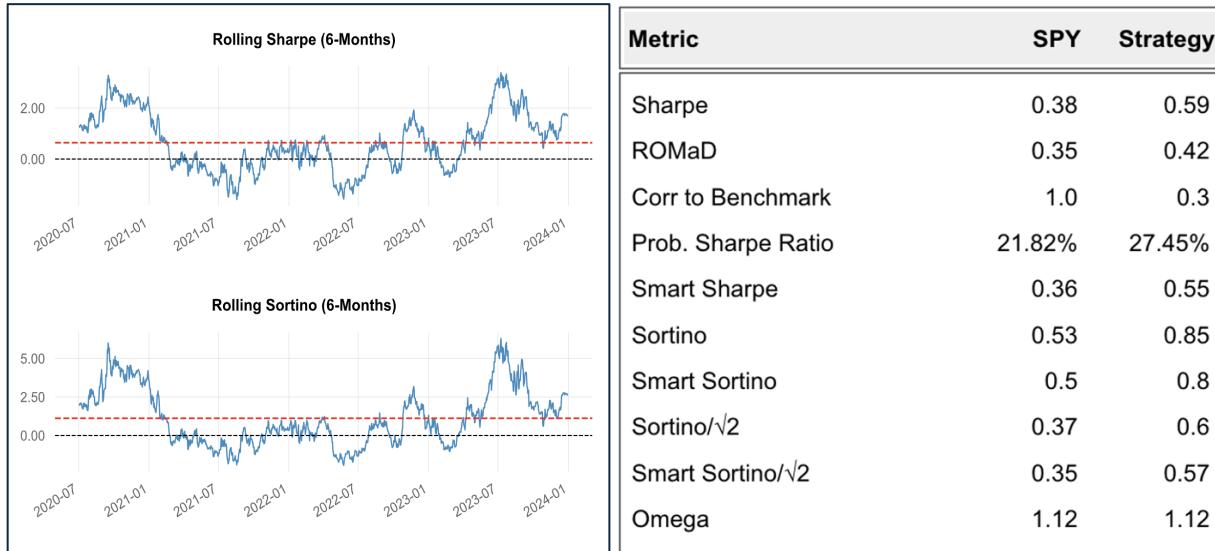
Rolling Volatility (6-Months):

- The rolling 6-month volatility chart shows that our strategy consistently exhibited higher volatility compared to the SPY benchmark.
- This aligns with the annualized volatility figures in the table, where our strategy's volatility (45.71%) is significantly higher than SPY's (22.61%).

Other Metrics:

- The table also confirms our strategy's higher volatility and provides additional risk metrics like Skewness and Kurtosis, indicating a more favorable return distribution.
- The Treynor Ratio of 217.12% suggests our strategy generated higher returns per unit of market risk taken.

ROLLING SHARPE AND SORTINO RATIO



Rolling Sharpe (6-Months):

- The rolling 6-month Sharpe Ratio chart shows that our strategy consistently exhibited higher risk-adjusted returns.

- This is further supported by the overall Sharpe Ratio of 0.59 for our strategy versus 0.38 for SPY in the table.

Rolling Sortino (6-Months):

- The rolling 6-month Sortino Ratio, which focuses only on downside risk, also indicates our strategy's superior risk-adjusted performance compared to the benchmark.
- The table shows our strategy's Sortino Ratio of 0.85 is significantly higher than SPY's 0.53.

Other Metrics:

- The table includes additional risk-adjusted metrics like Smart Sharpe, Smart Sortino, and Omega Ratio, where our strategy outperforms the benchmark.

DRAWDOWN



Metric	SPY	Strategy
Max Drawdown	-33.68%	-56.46%
Longest DD Days	708	1064
Avg. Drawdown	-2.09%	-5.87%
Avg. Drawdown Days	21	44
Recovery Factor	1.63	2.26
Ulcer Index	0.1	0.24
Serenity Index	0.29	0.3

Worst 10 Drawdowns

Started	Recovered	Drawdown	Days
2020-12-30	2023-11-28	-56.46%	1064
2020-03-04	2020-06-13	-28.10%	102
2020-09-01	2020-10-10	-16.33%	40
2020-10-13	2020-12-15	-15.07%	64
2020-02-21	2020-03-02	-14.99%	11
2020-01-26	2020-01-30	-6.99%	5
2020-02-02	2020-02-04	-5.46%	3
2023-11-30	2023-12-05	-3.96%	6
2020-06-23	2020-06-30	-3.95%	8
2020-08-09	2020-08-22	-3.78%	14

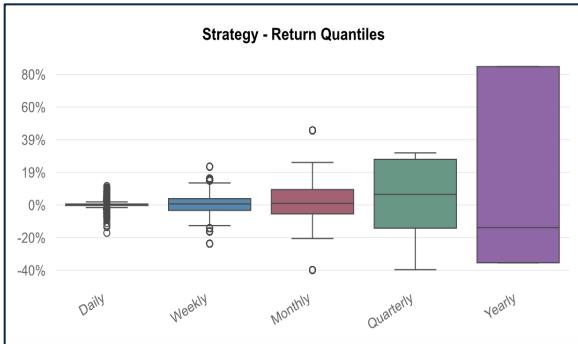
Drawdown is the peak-to-trough decline during a specific period. The largest drawdown experienced by the strategy was -56.46%, which began on December 30, 2020, and ended on November 28, 2023. This drawdown lasted 1064 days.

Overall, the sheet suggests that the strategy has experienced larger drawdowns and higher volatility than the SPY benchmark. However, our strategy has also recovered from drawdowns more quickly and has a higher recovery factor.

MONTHLY RETURNS FROM OUR STRATEGY

	Strategy - Monthly Returns (%)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2020	10.51	-5.56	-7.62	9.02	6.78	10.30	20.60	13.54	-7.72	0.68	9.45	7.17
2021	-9.96	-10.91	-0.73	7.79	-2.17	1.01	-4.34	-3.98	-6.57	13.30	2.15	2.28
2022	-11.13	-5.43	16.54	-39.82	4.75	-4.21	45.72	2.77	-14.56	7.18	0.27	-20.53
2023	21.24	-4.60	12.55	3.08	18.72	7.80	-0.40	-1.05	-8.55	-4.57	26.06	23.03

- Performance:** The strategy has had a mix of positive and negative returns, with some months experiencing significant gains and others significant losses. There is no clear upward or downward trend in the returns over time.
- Volatility:** The strategy appears to be quite volatile, with returns ranging from -39.82% to 45.72%. This suggests that the strategy may be risky, and investors should be prepared for the possibility of large losses.
- Best and worst months:** The best month for the strategy was July 2022, with a return of 45.72%. The worst month was December 2022, with a return of -20.53%.



Metric	SPY	Strategy
Avg. Up Month	5.43%	12.53%
Avg. Down Month	-5.72%	-10.14%
Win Days	53.84%	52.31%
Win Month	62.5%	56.25%
Win Quarter	68.75%	56.25%
Win Year	75.0%	50.0%

RESULTS FOR AI TRADING STRATEGY

Metric	Portfolio	SPY
Initial Investment	\$100,000	\$100,000
Final value	\$235,689	\$156,499
Total Return	135.69%	56.05%
Volatility	45.71%	22.61%
Beta	0.60	-
Alpha	0.24	-
Correlation	0.30	-
Treynor Ratio	217.12%	-
Sharpe Ratio	0.59	0.38
Sotino Ratio	0.85	0.53
Recovery Factor	2.26	1.63
Max Drawdown	-56.46%	-33.68%

- Performance: Achieved a total return of 135.69%, surpassing the benchmark's return of 56.05%.
- Risk Management: Despite higher volatility (45.71%), maintained a respectable Sharpe Ratio of 0.59 and Sortino Ratio of 0.85.
- Alpha and Treynor Ratio: Showed positive alpha and an exceptional Treynor Ratio of 217.12%, indicating efficient risk-adjusted performance.
- Correlation and Recovery: Lower correlation with market movements (0.30) but demonstrated a solid recovery factor of 2.26.
- Drawdown: Experienced a significant maximum drawdown of -56.46%, indicating higher risk tolerance.

STEP 5: COMPARISON

Approach	AI Trading bot		Technical Analysis	
Metric	Portfolio	SPY	Portfolio	SPY
Initial Investment	\$100,000	\$100,000	\$100,000	\$100,000
Final value	\$235,689	\$156,499	\$357,007	\$146,410
Total Return	135.69%	56.05%	260.78%	47.45%
Volatility	45.71%	22.61%	31.47%	23.01%
Beta	0.60	-	1.17	-
Alpha	0.24	-	0.26	-
Correlation	0.30	-	0.86	-
Treynor Ratio	217.12%	-	57%	7%
Sharpe Ratio	0.59	0.38	1.139129	0.356418
Sotino Ratio	0.85	0.53	1.634436	0.441878
Recovery Factor	2.26	1.63	7.56	1.4
Max Drawdown	-56.46%	-33.68%	-34.47%	-33.92%

- Technical analysis outperformed the AI trading bot approach across several key metrics.
- Technical analysis demonstrated higher returns, lower volatility, stronger correlation with the market, better risk-adjusted returns, stronger recovery capability from drawdowns, and less severe drawdowns compared to the AI trading bot approach.
- Therefore, technical analysis appears to be the more effective strategy.

OUR THOUGHTS

- While AI excels in processing vast amounts of data, executing trades swiftly, and maintaining discipline, human traders bring invaluable qualities such as:
 - Intuition
 - Adaptability

- Judgment
 - Ethical consideration
- Integrating AI algorithms with human oversight maximizes benefits.
 - Hybrid approach combines AI speed and precision with human judgment.
 - Enables investors to navigate markets, capitalize on opportunities, and mitigate risks effectively.
 - Results in more robust and successful investment outcomes.

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