



Portfolio Optimization and Sharpe Ratio Analysis

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Introduction & Objective



Objective:

- The goal of this project is to construct a diversified portfolio with a Sharpe ratio greater than 1.0 by using technical trading strategies such as Moving Average Crossover and Bollinger Bands.
- The portfolio consists of 8 financial instruments across different asset classes, including equities, fixed income, commodities, and currencies.
- The objective is to achieve a high Sharpe ratio by applying these strategies and leveraging diversification to reduce risk while optimizing returns.

Selected Instruments:

Equities	Fixed Income	Commodity	Currency Pair
<ul style="list-style-type: none">• Apple (AAPL)• Amazon (AMZN)• General Electric (GE)• Intel (INTC)• S&P 500 ETF (SPY)	<ul style="list-style-type: none">• Fidelity Investment Grade Bond Index (FBNDX)	<ul style="list-style-type: none">• Gold (GOLD)	<ul style="list-style-type: none">• Euro (EUR)





Strategy Implementation

Technical Trading Strategies:

Moving Average Crossover:

- Uses two moving averages: a **fast (short-term)** and a **slow (long-term)**.
- **Buy Signal:** Fast MA crosses above Slow MA.
- **Sell Signal:** Fast MA crosses below Slow MA.
- Variations:
 - **Go Flat (MAFlat):** No position when no crossover.
 - **Go Short (MAShort):** Short position when market downturn is expected.

Bollinger Bands:

- Uses a moving average with bands based on price **volatility**.
- **Buy Signal:** Price touches/falls below the lower band.
- **Sell Signal:** Price touches/rises above the upper band.
- Identifies overbought/oversold conditions and **volatility**.





Strategy Implementation

After running scatter plots for each strategy on the selected instruments (AAPL, AMZN, GE, INTC, SPY, FBNDX, GOLD, EUR), we selected the following parameters for the best trade-offs between risk and reward:

Moving Average Parameters:

- **Fast Window = 11, Slow Window = 220**

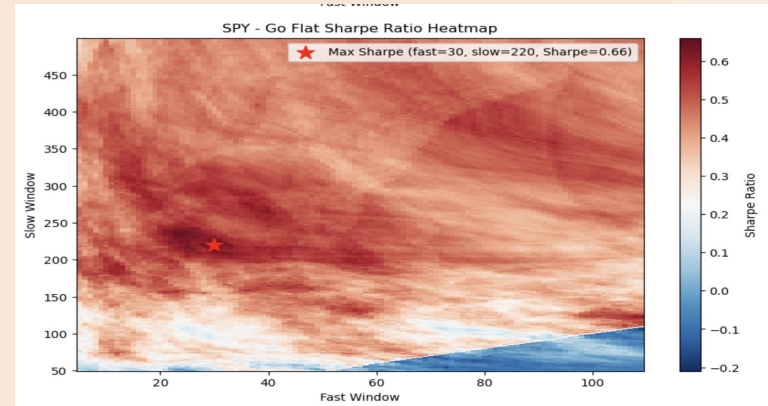
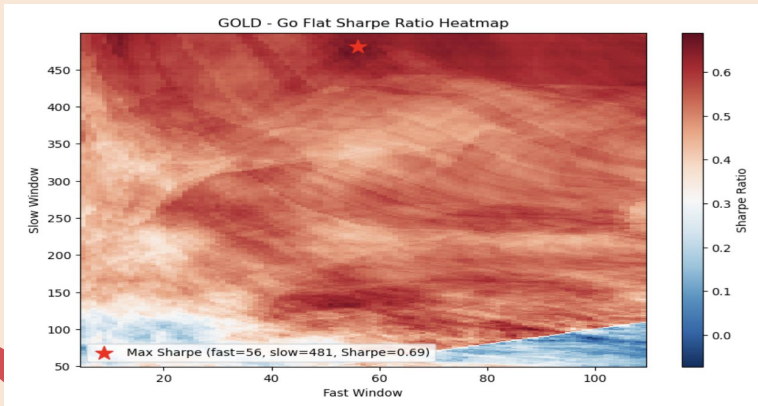
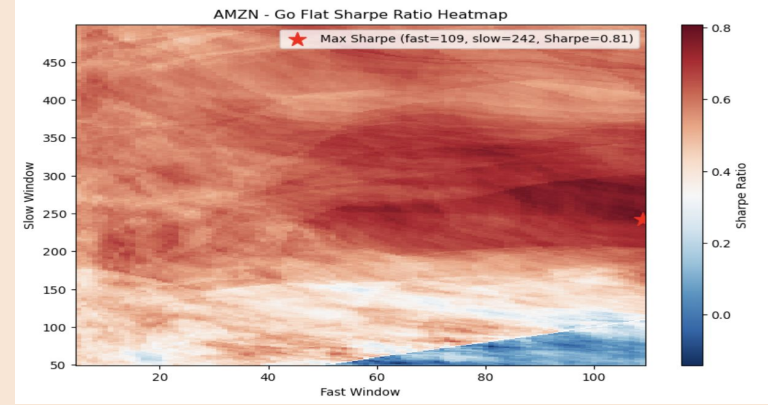
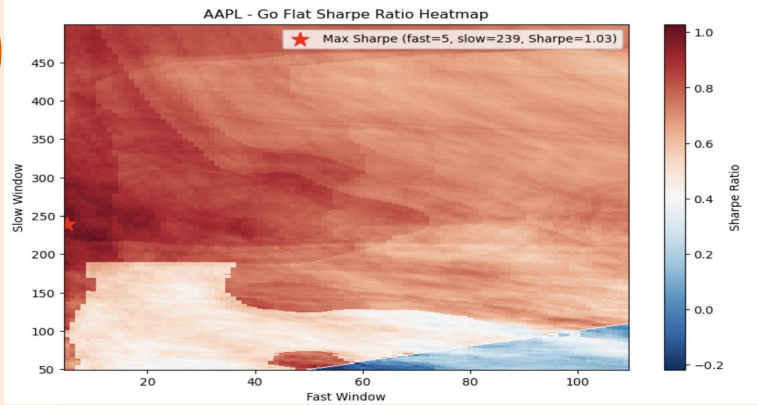
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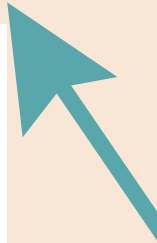
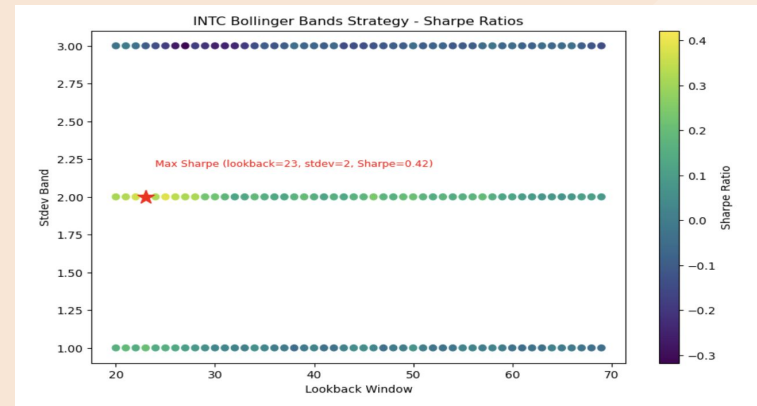
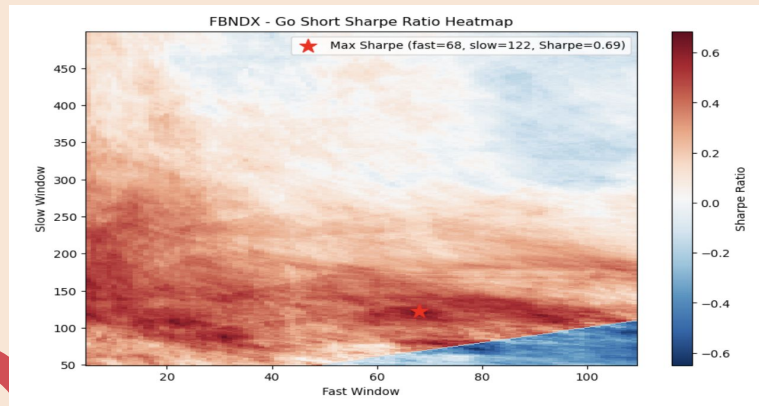
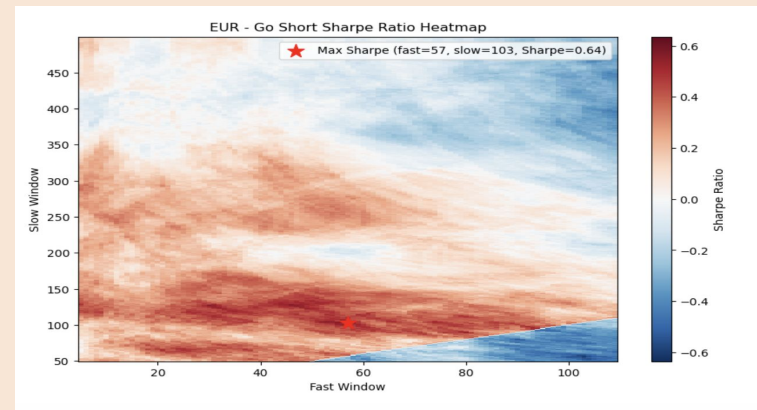
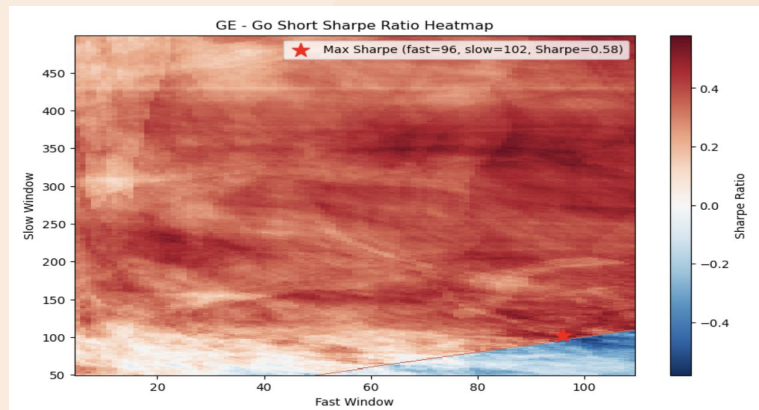
- **Lookback Window = 23, Standard Deviation Band = 2**

Why These Parameters?

- **Go Flat Strategy:** AAPL, AMZN, SPYS and Gold were chosen because they provided the highest Sharpe ratios in their analyses (AAPL: **1.029**, AMZN: **0.808**, GOLD: **0.689**, SPY: **0.660**).
- **Go Short Strategy:** EUR, GE and FBNDX performed well under shorting conditions (EUR: **0.635**, GE: **0.580**, FBNDX: **0.685**).
- **Bollinger Bands Strategy:** INTC was selected for Bollinger Bands due to reasonably high Sharpe ratios (INTC: **0.422**).
- We chose a **Fast Window of 11** and **Slow Window of 220** after analyzing Sharpe ratios across all instruments, ensuring consistent improvements across the portfolio.









Portfolio Construction

Selected Instruments and Strategies:

Go Flat Strategy:

- **AAPL**: Sharpe ratio = 1.029
- **AMZN**: Sharpe ratio = 0.808
- **GOLD**: Sharpe ratio = 0.689
- **SPY**: Sharpe ratio = 0.660

Go Short Strategy:

- **GE**: Sharpe ratio = 0.580
- **EUR**: Sharpe ratio = 0.635
- **FBNDX**: Sharpe ratio = 0.685

Bollinger Bands Strategy:

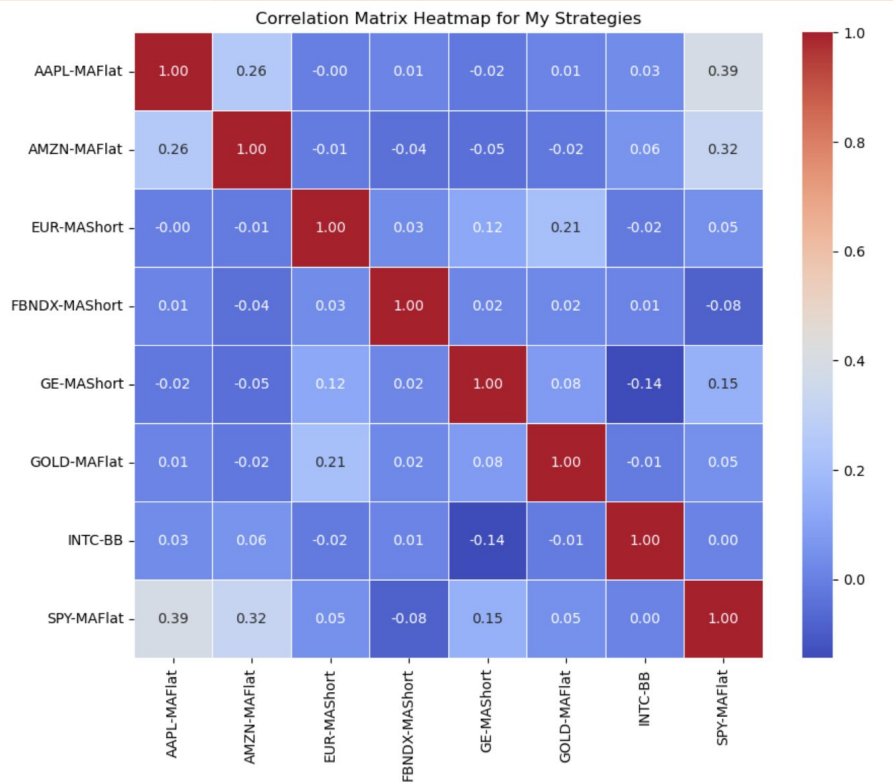
- **INTC**: Sharpe ratio = 0.422

Portfolio Constraints:

- The portfolio must have a **Sharpe ratio > 1.0**.
- Each strategy (Go Flat, Go Short, Bollinger Bands) must be used **at least once**.
- The parameters chosen (fastWindow = 11, slowWindow = 220, bbWindow = 23, bbStdevBand = 2) aim to optimize Sharpe ratios across all instruments.



Correlation Structure



Positive Correlations:

- AAPL-MAFlat and SPY-MAFlat (0.39)
- SPY-MAFlat and AMZN-MAFlat (0.32)

Negative Correlations:

- INTC-BB and GE-MAShort (-0.14)

Low Correlations:

- SPY-MAFlat and INTC-BB (0.00)
- GOLD-MAFlat and INTC-BB (-0.01)
- GOLD-MAFlat and AAPL-MAFlat (0.01)



Equal Weight Portfolio Performance

Sharpe Ratio & Performance:

Equal-Weighted Portfolio Sharpe Ratio: 1.285
The Sharpe ratio of the equal-weighted portfolio is greater than all individual strategies, providing better risk-adjusted returns.

Key Observations:

- The **Equal-Weighted Portfolio outperforms** all individual strategies in terms of the Sharpe ratio.
- This reflects the **diversification benefit**, where combining strategies lowers risk and improves overall performance.

Individual Strategy Sharpe Ratios:

AAPL-MAFlat:	1.018386
AMZN-MAFlat:	0.663359
EUR-MAShort:	0.243639
FBNDX-MAShort:	0.404243
GE-MAShort:	0.404015
GOLD-MAFlat:	0.439929
INTC-BB:	0.442973
SPY-MAFlat:	0.543493





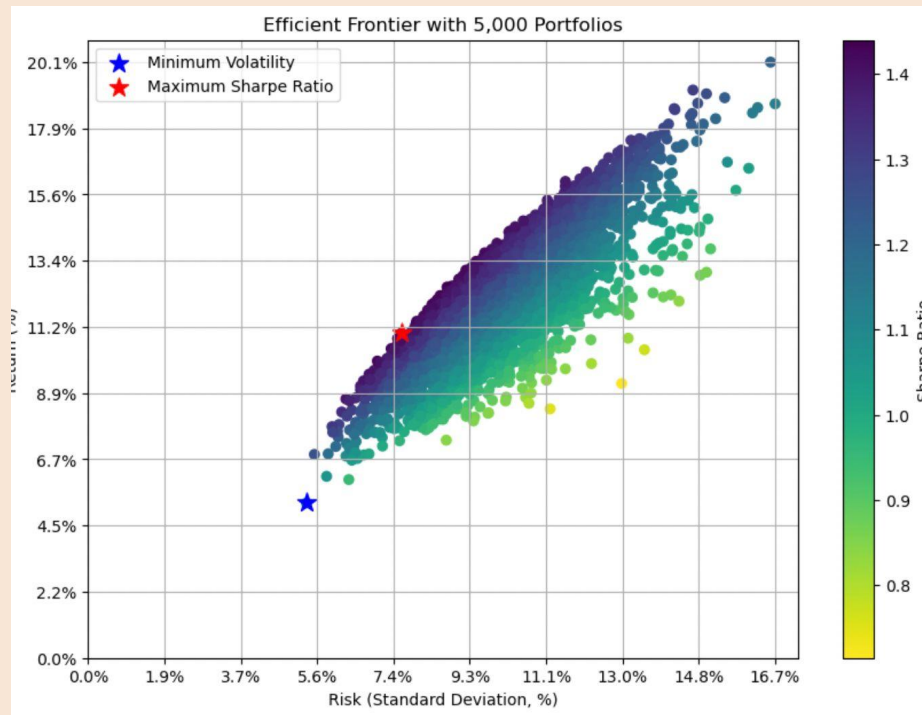
Mean-Variance Optimization (MVO)

Monte Carlo Simulation:

We ran a 5,000-step Monte Carlo simulation with a seed of 64 to generate random portfolio weightings. Each portfolio's risk (standard deviation) and return were calculated to plot the efficient frontier.

Min. Volatility Portfolio Sharpe: 0.96

Max. Sharpe Portfolio Sharpe: 1.35





Mean-Variance Optimization (MVO)

Optimal weights:

• Minimum Volatility Portfolio:

- AAPL-MAFlat: 0.86%
- AMZN-MAFlat: 5.12%
- EUR-MAShort: 17.06%
- FBNDX-MAShort: 35.90%
- GE-MAShort: 0.83%
- GOLD-MAFlat: 13.50%
- INTC-BB: 0.16%
- SPY-MAFlat: 26.57%

• Maximum Sharpe Portfolio:

- AAPL-MAFlat: 19.40%
- AMZN-MAFlat: 7.87%
- EUR-MAShort: 15.72%
- FBNDX-MAShort: 21.12%
- GE-MAShort: 9.01%
- GOLD-MAFlat: 12.39%
- INTC-BB: 7.98%
- SPY-MAFlat: 6.52%

Observations:

- The Minimum Volatility Portfolio prioritizes stability with concentrated weights in low-risk assets like FBNDX-MAShort and SPY-MAFlat.
- The Maximum Sharpe Portfolio seeks higher returns by diversifying more into growth assets like AAPL-MAFlat and FBNDX-MAShort.





Maximum Sharpe Portfolio



Performance Statistics:


- Max Sharpe Portfolio offers superior risk-adjusted returns compared to any individual strategy:
 - Sharpe Ratio: 1.352 (higher than any single strategy).
 - Average Annual Return: 0.111
 - Annual Risk: 0.082
 - Max Drawdown: -0.125
 - Success Ratio: 0.549

Comparison with Individual Strategies (Example Stats):

- AAPL-MAFlat: Sharpe = 1.018 Avg Return = 0.280
- FBNDX-MAShort: Sharpe = 0.404, Avg Return = 0.015
- SPY-MAFlat: Sharpe = 0.543, Avg Return = 0.058

Performance Statistics:

	AAPL-MAFlat	AMZN-MAFlat	EUR-MAShort	FBNDX-MAShort	GE-MAShort	GOLD-MAFlat	INTC-BB	SPY-MAFlat	Max Sharpe Portfolio
Average Annual Return	0.279595	0.219618	0.024583	0.015420	0.125548	0.063500	0.118114	0.057765	0.111012
Annual Risk	0.274548	0.331070	0.100898	0.038145	0.310752	0.144342	0.266639	0.106285	0.082109
Sharpe Ratio	1.018386	0.663359	0.243639	0.404243	0.404015	0.439929	0.442973	0.543493	1.352016
Max Drawdown	-0.560454	-0.547177	-0.287990	-0.126006	-0.906678	-0.395251	-0.503874	-0.194994	-0.124966
Success Ratio	0.659006	0.668729	0.515580	0.642431	0.518232	0.683978	0.738343	0.695691	0.548508





Maximum Sharpe Portfolio

Beta to S&P 500:

- Beta: 0.112 (relative to the S&P 500)
 - The low beta value indicates the Max Sharpe Portfolio has low sensitivity to market movements.
 - For every 1% move in the S&P 500, the portfolio is expected to move only 0.112%, making it defensive and less volatile.
 - This suggests the portfolio is ideal for risk-averse investors seeking stability during market downturns.

Salient Features:

- The Max Sharpe Portfolio strikes a balance between return and risk, offering consistent performance with minimal drawdown.
- It provides better risk-adjusted returns than any individual strategy, making it more efficient.





Strategy Portfolio Comparison

How We Created the Variations:

- We constructed four variations of equal-weighted portfolios using the benchmark, MAFlat, MAShort, and Bollinger Band strategies for all the selected instruments.
- These variations helped us evaluate how each strategy contributes to the overall portfolio's performance and compare it with the Max Sharpe Portfolio.

Variations of the Equal-Weighted Portfolio:

- Equal Weighted Benchmark Portfolio: Sharpe Ratio = 0.379
- Equal Weighted MAFlat Strategy Portfolio: Sharpe Ratio = 0.773
- Equal Weighted MAShort Strategy Portfolio: Sharpe Ratio = 0.566
- Equal Weighted Bollinger Band Strategy Portfolio: Sharpe Ratio = 0.098

Comparison with MaxSharpe Portfolio:

- Max Sharpe Portfolio: Sharpe Ratio = 1.35
- None of the Equal-Weighted portfolios outperform the Max Sharpe Portfolio, which has the highest risk-adjusted return.





Conclusion

Best Performing Strategy:

The Max Sharpe Portfolio, with a Sharpe Ratio of 1.35, significantly outperformed all other portfolios and individual strategies, offering the best risk-adjusted return.

Correlation Insights:

We observed that equity instruments tend to be more correlated, while bonds, commodities, and currencies provided crucial diversification, leading to a more stable portfolio.

Diversification Benefits

The portfolio effectively balanced risk by combining low-correlated strategies (e.g., FBNDX-BB, GOLD-MAShort, EUR-MAShort) with higher-performing equities (e.g., AAPL-MAFlat), reducing overall volatility.

Importance of Optimization

Through Mean-Variance Optimization, we identified optimal weights that maximized the portfolio's Sharpe ratio while keeping risk at manageable levels.

Conclusion

Our final Max Sharpe Portfolio achieved a Sharpe ratio of 1.35, compared to the 1.285 of the equal-weight portfolio, showcasing the power of strategic asset allocation and diversification in enhancing portfolio performance.

