# Copula Pairs Trading combined with the CAPM Model.

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**Aim:** We implement a copula pairs trading strategy combined with the CAPM model for Asset allocation. The trades took place on a live simulator using QuantConnect and Interactive Brokers. The time period for trading was from 1st February 2024 to 30th April 2024.

**Methodology:**

**1. Dynamic Universe Selection**

The universe selection is a crucial component as it defines the scope and opportunities available for the algorithm to trade. The methodology employs two layers of selection:

- **Manual Selection**: A predefined set of symbols, including major sector ETFs and prominent technology stocks, is selected. This ensures the strategy has exposure across various sectors and benefits from the growth and volatility of tech stocks.
- **Dow 30 Constituents**: An automated selection model dynamically picks constituents of the Dow 30 index. This model adapts to changes in the index, ensuring that the strategy always trades the most representative and significant stocks in the market.

**2. Pairs Trading Using Copula Functions**

This strategy focuses on identifying and exploiting statistical relationships between pairs of stocks. The methodology involves:

- **Selection of Stock Pairs**: The pairs are chosen based on historical price data and expected future performance, derived from their statistical relationships.
- **Copula Functions**: These are used to model the dependency structure between the returns of the selected pairs. Different types of copulas (e.g., Clayton, Frank, Gumbel) are tested to find the best fit based on the Akaike Information Criterion (AIC). Copulas help in understanding and capturing the joint behavior of asset returns beyond mere correlation, allowing for more nuanced trading strategies based on the likelihood of extreme co-movements.
- **Trading Signals**: Signals are generated by assessing the mispricing indexed through the selected copula. The algorithm places trades based on predicted convergence or divergence within the pair, aiming to profit from the temporary inefficiencies in their price relationship.

**3. CAPM-Based Stock Ranking**

Another layer of alpha generation is achieved through a CAPM-based model, which operates as follows:

- **Historical Data and Returns**: The model fetches historical price data of selected stocks and calculates their returns.

- **Linear Regression Analysis**: CAPM asserts that the returns of a stock are related to its risk relative to the overall market. By performing linear regression of stock returns against a market benchmark (like the SPY or DIA ETF), we can estimate the alpha (intercept) and beta (slope) for each stock.
- **Stock Selection**: Stocks are ranked and selected based on their alpha, with a preference for stocks demonstrating higher than expected returns given their beta. This suggests these stocks are undervalued or have superior risk-adjusted performance prospects.

**4. Portfolio Construction and Risk Management**

The selected stocks and pairs are assigned equal weights in the portfolio to avoid concentration risks:

- **Equal Weighting Scheme**: Each asset or pair is given an equal portion of the capital, simplifying the portfolio management process and reducing bias.
- **Rebalancing Strategy**: The portfolio is rebalanced based on the timing logic defined in the strategy, which may consider factors like the arrival of new trading signals, expiration of old signals, or shifts in the trading universe.
- **Risk Control**: Minimal active risk management is implemented, focusing primarily on execution risks and liquidity considerations. The primary risk control is through diversification and the inherent risk-limiting nature of pairs trading.

**5. Execution Model**

- **Immediate Execution**: Ensures that trades are executed as soon as signals are generated, minimizing slippage and capturing the optimal entry and exit points as predicted by the models.

**Results:**
Our final holding as of  April 30th was $1,109,326.76 at closing.

| **Final asset allocation (as of 30th April 2024)** | |
|---|---|
| **Walt Disney Co. [DIS]** | 19.4% |
| **Apple Inc. [AAPL]** | 21.2% |
| **Alerian MLP ETF [AMLP]** | 21% |
| **Nvidia Corp [NVDA]** | 20.3% |
| **Netflix Inc [NFLX** | 18% |

**Table 1.1: Final Asset Allocation**

| Portfolio Statistics (as of 30th April 2024) | |
|---|---|
| **Sharpe ratio** | 1.36 |
| **Drawdown** | 5.55% |
| **Standard Deviation** | 6.17% |
| **Returns (3 months)** | 11.09% |
| **Returns (annualized)** | 54.28% |

**Table 1.2: Portfolio Statistics**

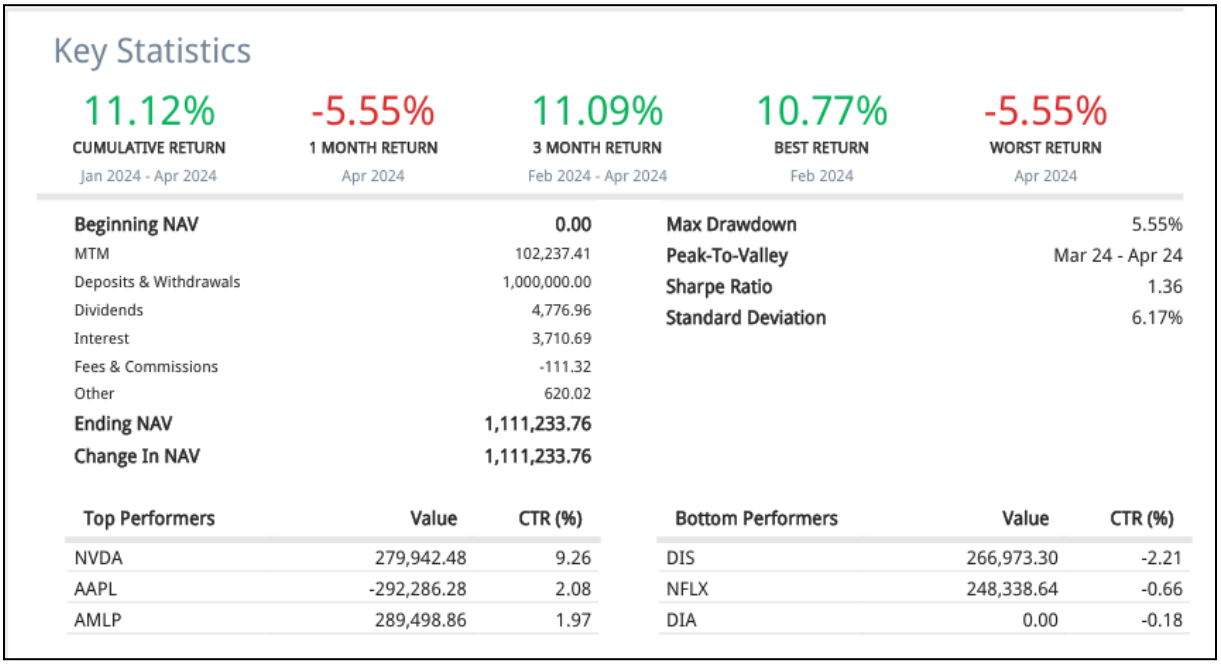



**Figure 1.1: Important portfolio statistics**

The data shows a cumulative return of 11.12% from January to April 2024, as well as a one-month return of -5.55% in April, suggesting a decline in that month. The three-month return up to April was 11.09%, with the best return being 10.77%.

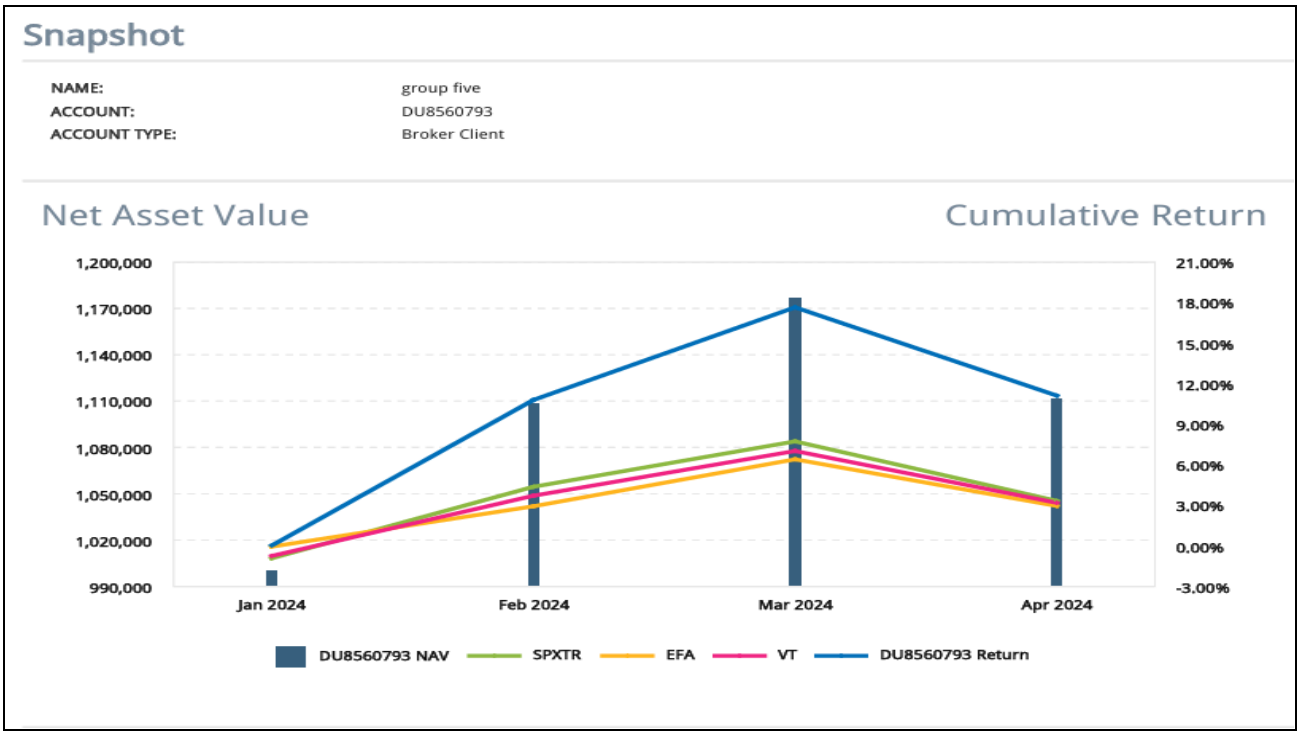



**Figure 1.2: NAV for Portfolio**

The blue line, which represents the NAV (Net Asset Value) of the portfolio labeled DUB560793, shows a strong increase from around $1,020,000 in January to a peak of around $1,200,000 in March before falling sharply to just over $1,110,000 by April. Concurrently, the Cumulative Return, given as a percentage on the right axis, follows this pattern, peaking at around 21% in March before dropping back as the month proceeds. This shows a high initial performance followed by a period of volatility that reduced returns.

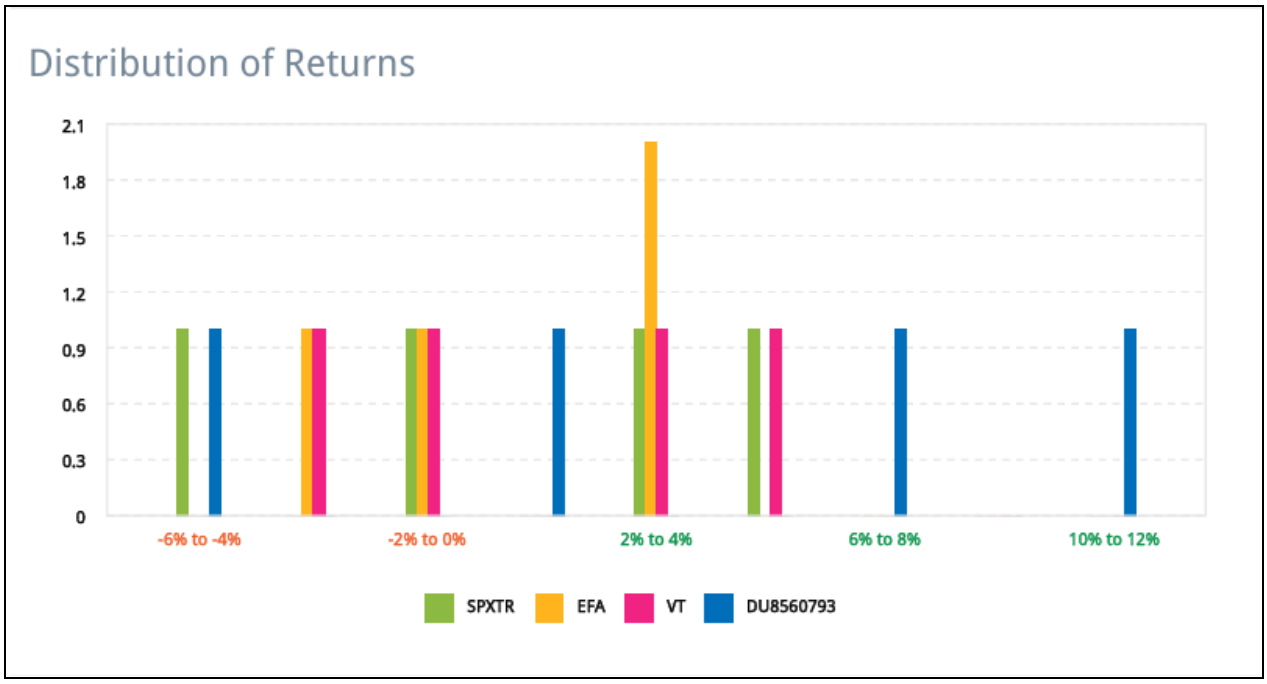
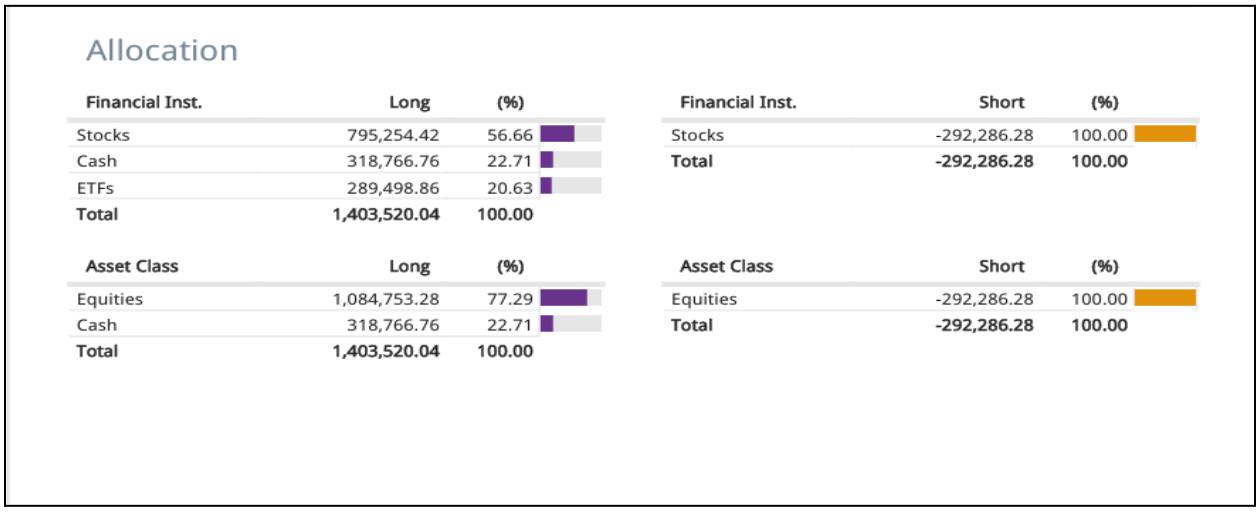



**Figure 1.3: Portfolio vs Benchmark Comparison**

The portfolio excels at generating moderate gains, especially in the 2% to 4% return region, where it outperforms all comparable benchmarks. This suggests a strategic emphasis on obtaining stable, modest returns rather than seeking higher-risk alternatives that may result in larger gains. Notably, the portfolio avoids substantial losses, with no returns below -6%, demonstrating its conservative risk management strategy. The absence of very high returns (over 10%) emphasizes the portfolio's conservative investment strategy, which seeks steady good outcomes while reducing exposure to catastrophic downturns.



Allocation

| Financial Inst. | Long | (%) |
|---|---|---|
| Stocks | 795,254.42 | 56.66 |
| Cash | 318,766.76 | 22.71 |
| ETFs | 289,498.86 | 20.63 |
| **Total** | **1,403,520.04** | **100.00** |

| Financial Inst. | Short | (%) |
|---|---|---|
| Stocks | -292,286.28 | 100.00 |
| **Total** | **-292,286.28** | **100.00** |

| Asset Class | Long | (%) |
|---|---|---|
| Equities | 1,084,753.28 | 77.29 |
| Cash | 318,766.76 | 22.71 |
| **Total** | **1,403,520.04** | **100.00** |

| Asset Class | Short | (%) |
|---|---|---|
| Equities | -292,286.28 | 100.00 |
| **Total** | **-292,286.28** | **100.00** |

**Figure 1.4: Asset Allocation**

The allocation of the portfolio's long and short sides to various asset classes is detailed. On the long side, the portfolio has a significant investment in equities ($795,254.42), which accounts for 56.66% of the assets, followed by ETFs and cash, demonstrating a diverse approach to asset allocation. On the short side, it is entirely made up of shares worth -$292,286.28. This strategic posture in both long and short equities demonstrates a balanced attempt to mitigate risks while capitalizing on potential market gains.

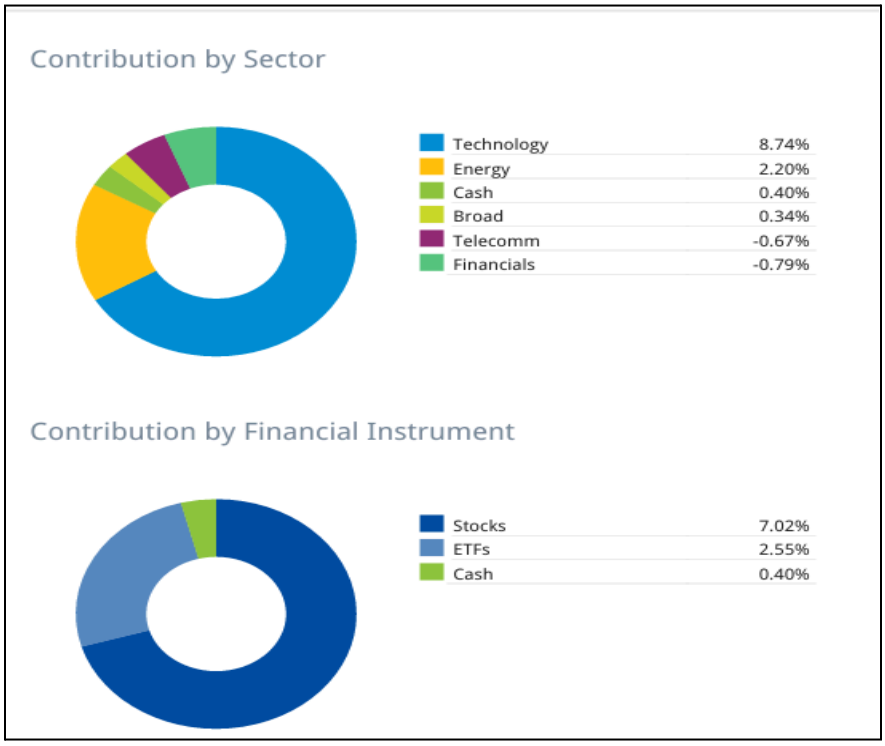



**Figure 1.5: Sector and Asset Contribution**

The graph shows the portfolio's contributions broken down by sector and financial instrument. The sector pie graphic shows that the technology sector contributes the most (8.74%), followed by energy and other sectors with negligible inputs, including a slight negative influence from financials. Meanwhile, the financial instruments chart indicates a high reliance on stocks, accounting for 7.02% of the portfolio, supplemented by ETFs at 2.55% and a tiny role for cash holdings at 0.40%, demonstrating a diversified but stock-centric investing strategy.

## Conclusion

The portfolio created using Copula Pairs Trading and the CAPM model exemplifies a deliberate approach to attaining stable, moderate returns while efficiently limiting risks. The portfolio performs well in the technology sector, with large contributions, and maintains a diverse asset allocation that includes shares, ETFs, and cash. Despite a dip in April, the portfolio returned an

amazing 11.12% from January to April 2024, with a Sharpe ratio of 1.36 showing positive risk-adjusted returns.

The emphasis on keeping a balanced mix of long and short positions in equities represents a cautious yet opportunistic investment approach that seeks to capitalize on market gains while hedging against potential downturns. The lack of significant losses or high volatility demonstrates the success of the risk management methods in place, particularly the use of pairs trading to reduce exposure. Moving forward, the portfolio may benefit from continued use of dynamic asset selection and rebalancing procedures to handle market shifts and enhance performance.