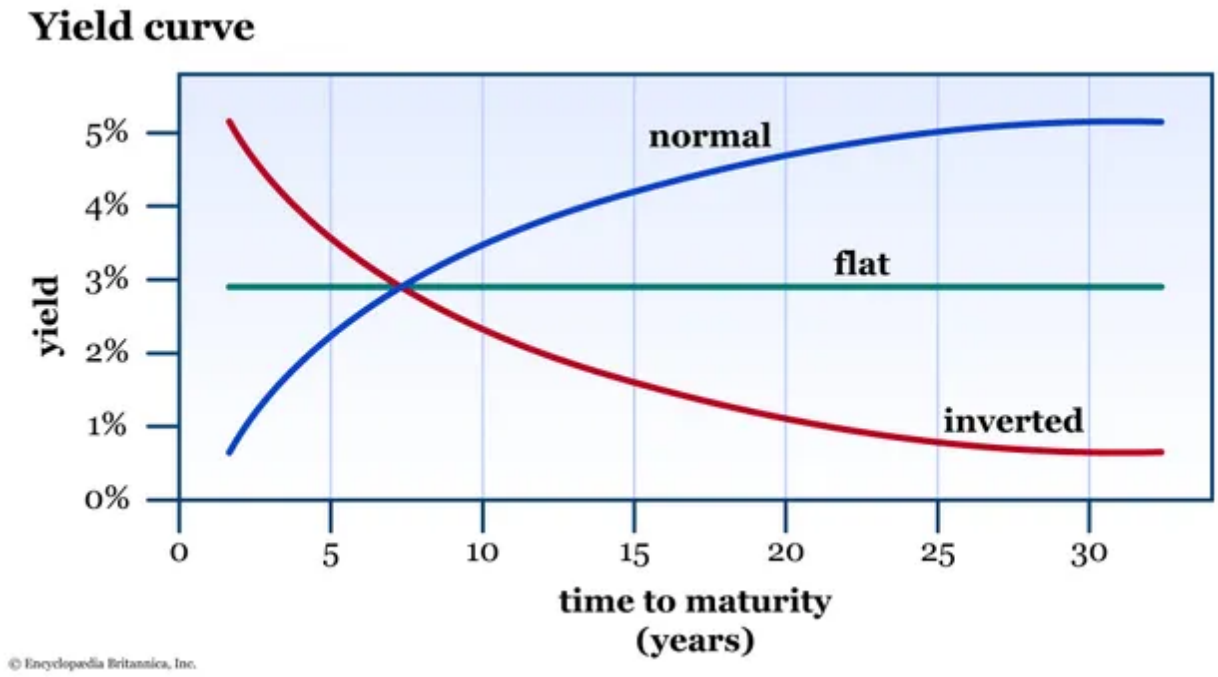
Using Yield Curve inversion to generate signals that predict recession and hence creating a portfolio of equity and commodity indices

Yield Curve: The yield curve refers to the graphical representation of interest rates or yields of similar debt securities, typically bonds, plotted against their respective maturities. It illustrates the relationship between the interest rate (or yield) and the time to maturity for a range of debt instruments. The yield curve can take different shapes, such as upward-sloping (normal), flat, or downward-sloping (inverted), based on the relative yields of short-term and long-term debt securities.



Yield Spread: Yield spread, on the other hand, is the difference between the yields of two different debt securities or indices. In the context of the yield curve, the yield spread commonly refers to the difference between the yields of longer-dated Treasury securities (such as the 10-year or 30-year Treasury bonds) and shorter-term Treasury securities (such as the 2-year or 3-month Treasury bills). It indicates the premium or additional yield that investors demand for holding longer-term debt securities compared to shorter-term ones.

The yield spread provides valuable insights into market expectations for future interest rates, inflation, and economic conditions. It is often used as an indicator of market sentiment, risk appetite, and expectations for economic growth. Changes in the yield spread can impact borrowing costs, lending practices, investment decisions, and asset pricing across various financial markets.

Prediction of a recession using yield curve: The yield curve predicts recessions through the occurrence of an inversion, where short-term yields surpass long-term yields. This inversion signifies a negative outlook on the economy and reflects market expectations of lower future interest rates. Historical patterns have shown that yield curve inversions often precede economic downturns, with a recession typically materializing within 12 to 24 months. As a leading indicator, the yield curve provides valuable insights into market sentiment and helps policymakers and investors anticipate and prepare for potential recessions, although it is important to consider other economic indicators for a comprehensive assessment.

Our research included looking at the basics of how a yield curve predicts an upcoming recession, hence trying to figure out the time lag between the signal of a yield curve inversion and the signal when the markets start to go down. We came across a paper which used regression analysis to backtest the strategy.

Our strategy is to use the yield curve to predict uptrend/downtrend in the US market and thus make a portfolio using the S&P 500, QQQ, and gold. For reference, we have used a paper that analyzes the association between the yield spread and the S&P 500. Following is the summary of that paper:

An Analysis of Association between Yield Curve and S&P 500
https://ionides.github.io/531w16/midterm_project/project23/531-MidProject.html

Yield Curve: The yield curve represents the difference in yields between longer-term and shorter-term Treasury securities. In this analysis, the focus is on the difference between the US Treasury's 10-year zero-coupon yield and the 2-year zero-coupon yield, which indicates the slope of the yield curve.

A positively sloped yield curve, where the 10-year yield is higher than the 2-year yield, is considered steep or positively sloped. Conversely, when the yields are equal, the yield curve is flat, and when the 10-year yield is lower than the 2-year yield, the yield curve is inverted.

The shape of the yield curve is widely recognized as a leading indicator of the economy. A steep yield curve is generally viewed as positive for the economy, as it encourages financial institutions to lend by allowing them to borrow at low short-term costs and lend at higher rates, capturing the spread. This increased lending and subsequent investment contribute to economic growth. Therefore, the yield curve provides insights into interest rate expectations and inflation. Conversely, when the yield difference is negative, it may suggest a potential recession in the near future.

S&P 500: On the other hand, the Standard & Poor's 500 (S&P 500) is an American stock market index that represents the market capitalizations of 500 large companies listed on the NYSE or NASDAQ. The S&P 500 serves as a leading indicator for general economic conditions, reflecting economic expectations and providing insight into business conditions and investor confidence.

The analysis aims to explore the association between the S&P 500 and the yield curve. While the yield curve reflects the profitability of fixed income securities, the S&P 500 corresponds to the performance of the stock market. The analysis seeks to demonstrate the relationship between these two variables.

Methodology: In the analysis conducted, a regression analysis was employed to explore the relationship between the yield spread and the selected indices. The purpose of this regression analysis was to quantify the association between the yield spread and the indices of interest.

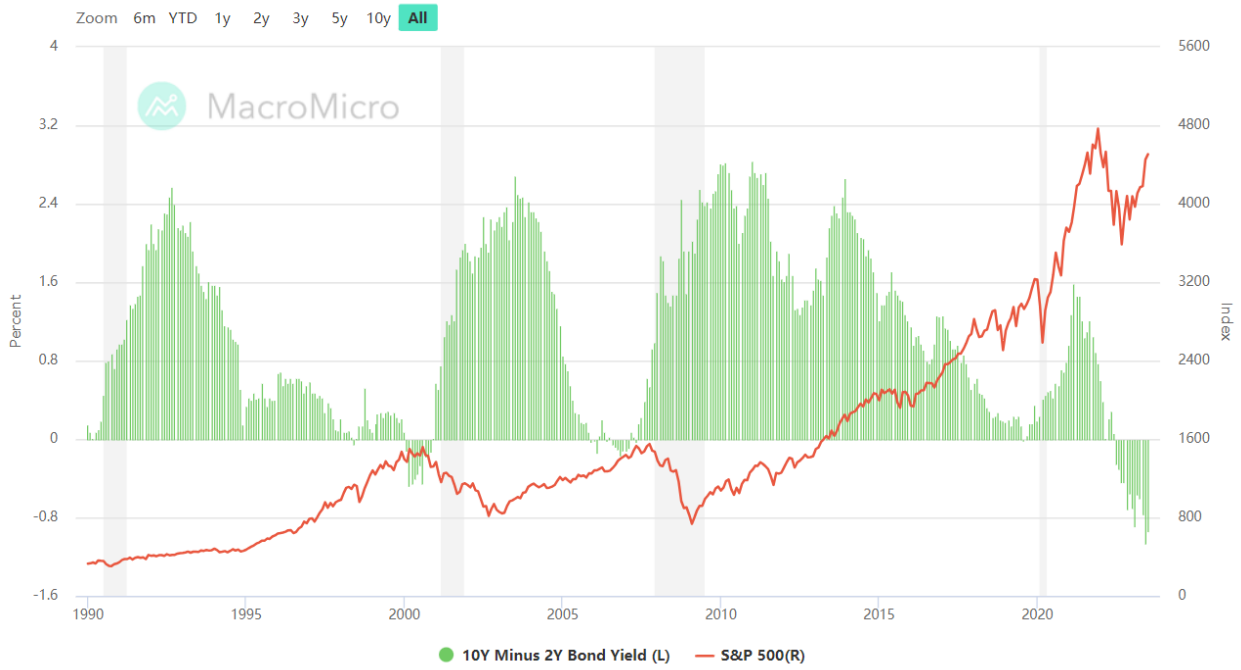
While more advanced techniques such as ARMA methods, band pass filters, and HP filters were utilized in the reference paper to extract cyclical components, remove trends, and address time-series properties, a simpler approach was chosen in this analysis. Specifically, a regression model was employed to directly examine the relationship between the yield spread and the indices.

By conducting a regression analysis, it becomes possible to estimate the impact of the selected indices on the yield spread and assess the statistical significance of

these relationships. This approach simplifies the analysis while still allowing for a clear and interpretable understanding of the association between the variables.

The decision to use a regression analysis and plot the results aims to provide a straightforward and accessible representation of the relationship between the yield spread and the indices. This approach facilitates a clear visualization of the findings and enhances the overall understanding of the association between these variables.

$$Yield_n^{HP*} = \alpha + \beta sp500_n^{HP*} + \epsilon_n,$$



https://en.macromicro.me/collections/34/us-stock-relative/398/us-10-2-yield-curve-gspc

Alpha term: The term "alpha" refers to the lag parameter, which represents the duration between a yield curve inversion and the occurrence of an economic recession. It signifies the average time it takes for a recession to hit following a yield curve inversion. By calculating the average of the alpha coefficients obtained from the regressions between the yield spread and different indices, such as S&P 500, QQQ, and gold, a comprehensive measure of the portfolio's risk-adjusted

performance is derived. This average alpha coefficient provides insights into the lead time between yield curve inversions and economic recessions.

Beta term: The beta coefficients obtained from the regression analysis were utilized as weights in the portfolio construction process. These beta coefficients represent the estimated effect of changes in the yield spread on the selected indices. By assigning weights based on these coefficients, we aimed to create a portfolio that captures the potential impact of yield spread fluctuations on the performance of the indices. This approach acknowledges the relationships identified in the regression analysis and enables the portfolio to be dynamically adjusted in response to changes in the yield spread. By incorporating the beta coefficients as weights, we sought to optimize the portfolio's performance and enhance its responsiveness to market conditions, leveraging the anticipated influence of the yield spread on the selected indices. This methodology provides a framework for managing the portfolio based on the expected relationship between the yield spread and index performance, potentially leading to improved investment outcomes.

Indices used: In our analysis, three indices were considered: S&P 500 (SNP), QQQ, and gold. These indices were selected to represent different asset classes and provide diversification within the portfolio. The S&P 500 index reflects the performance of the broader stock market and serves as a benchmark for overall economic conditions. QQQ represents the Nasdaq-100 index, which includes non-financial companies primarily in the technology sector. Gold, on the other hand, is a widely recognized safe haven asset that often exhibits a negative correlation with equity markets.

The inclusion of these indices allows for exposure to various sectors and asset types, reducing the risk associated with relying on a single index. Additionally, these indices offer different risk-return profiles, enabling the portfolio to potentially benefit from diverse market conditions. By incorporating multiple indices, the analysis aims to enhance portfolio performance through increased diversification and potential risk mitigation.

It is important to note that additional indices can be included in the portfolio if deemed necessary. The selection of indices depends on the investment objectives, risk tolerance, and market outlook. The flexibility to include more indices provides an opportunity to further diversify the portfolio and capture the

performance of specific sectors or markets. This adaptability ensures that the portfolio can be tailored to suit changing market dynamics and investor preferences.

Strategy:

The strategy implemented in the provided code is a yield spread strategy that aims to allocate a portfolio across S&P 500 (SPY), QQQ, and gold based on the yield spread between the 10-year and 2-year Treasury yields.

The strategy involves the following steps:

1. **Data Preparation:**
    - The code reads yield spread data from a CSV file and downloads historical price data for SPY, QQQ, and gold from Yahoo Finance.
    - The data is merged and preprocessed to align the dates and handle missing values.

2. **Linear Regression:**
    - The code calculates the slope (beta) and intercept (alpha) coefficients for the yield spread vs S&P, yield spread vs QQQ, and yield spread vs gold relationships using linear regression.
    - The regression results are printed, providing insights into the relationships between the yield spread and each asset.

3. **Portfolio Weight Calculation:**
    - The code calculates the proportions or weights of each asset (S&P, QQQ, and gold) based on the absolute values of the beta coefficients.
    - The weights are adjusted to ensure they add up to 1.

4. **Strategy Execution:**
    - The strategy is implemented as a class named YieldSpreadStrategy, which is a subclass of the bt.Strategy class from the 'backtrader' library.
    - The strategy uses the calculated alpha values to determine a lag duration and an alpha value for trading.

- During each trading period, the strategy checks the yield spread and executes the following actions:
- If the yield spread is greater than 0, it buys the specified assets (S&P, QQQ, and gold) using the allocated weights and a fraction of available cash.
- If the yield spread is less than 0, it initiates a timer (lag duration) before checking the 200 day SMA and hence buying or selling the assets based on that.

5. **Backtesting and Evaluation:**
    - The strategy is integrated into the 'backtrader' framework using the bt.Cerebro class.
    - Data feeds for yield spread, S&P, QQQ, and gold are created and added to the cerebro instance.
    - The portfolio's initial cash amount, commission rate, and the strategy itself are set.
    - The backtest is run, and the profit percentage is calculated and printed.

This strategy aims to capitalize on the relationship between the yield spread and asset prices by allocating the portfolio dynamically based on the yield spread's direction. It buys assets when the yield spread is positive and sells them after a specified lag duration when the yield spread turns negative. The weights of the assets are determined by the beta coefficients, reflecting their historical sensitivity to the yield spread.

The buy/sell algorithm is as follows:

1. **Initialization:**
    At the beginning of the trading period, buy S&P, QQQ, and gold based on the allocated weights.

2. **Holding Period:**
    While the yield spread remains positive: Hold the positions in S&P, QQQ, and gold without making any changes.

3. **Yield Spread Turns Negative:**
    If the closing price is below the 200 day moving average:

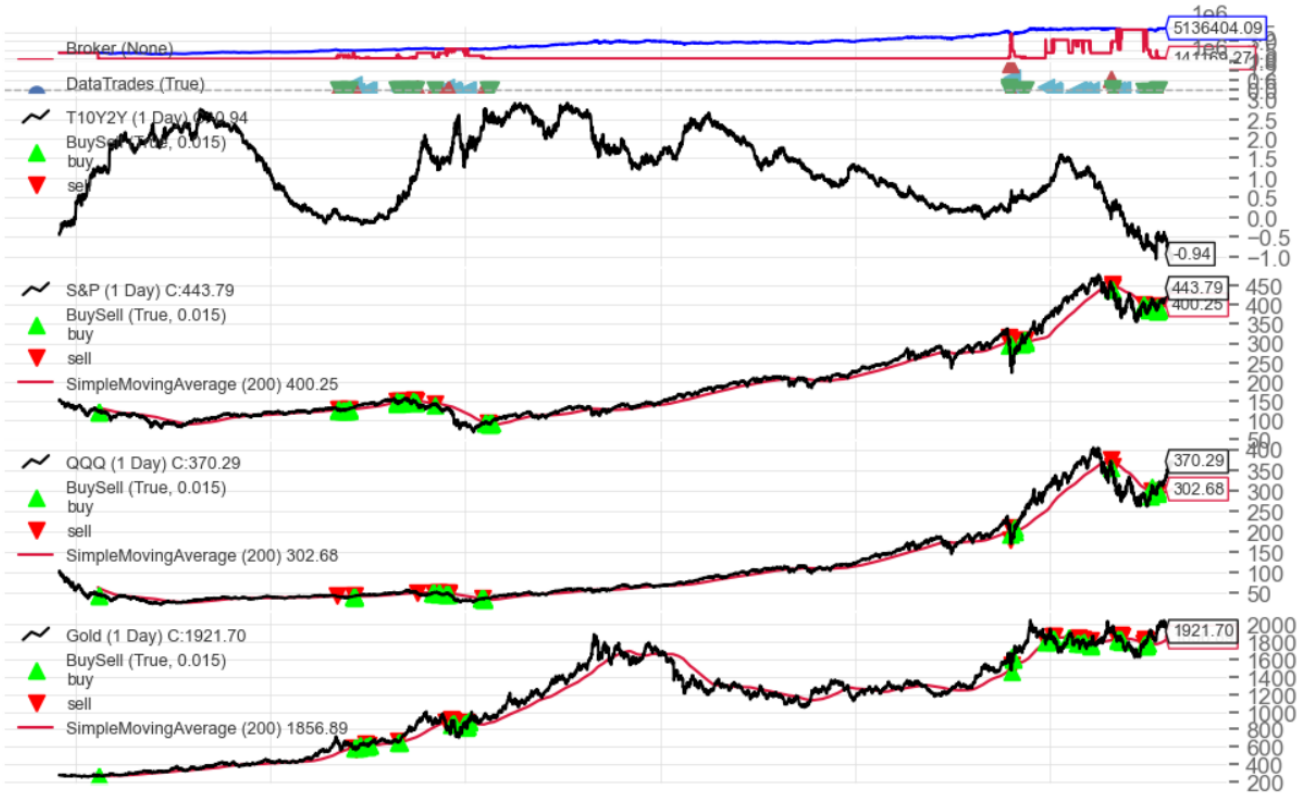
Sell the position of that asset.

4. **Waiting for Signal to Buy:**
   After selling the positions:
   Wait for the closing price of each asset to cross above its moving average. then buy the asset again.

5. **Yield Spread Becomes Positive Again:**
   Repeat the process from Step 2, holding the positions without making any changes.

6. **Repeat:**
   Continue repeating Steps 2-5 for each subsequent trading period.

Results:



The final portfolio value is **5136404.09** which gives a profit of **413.64%.**

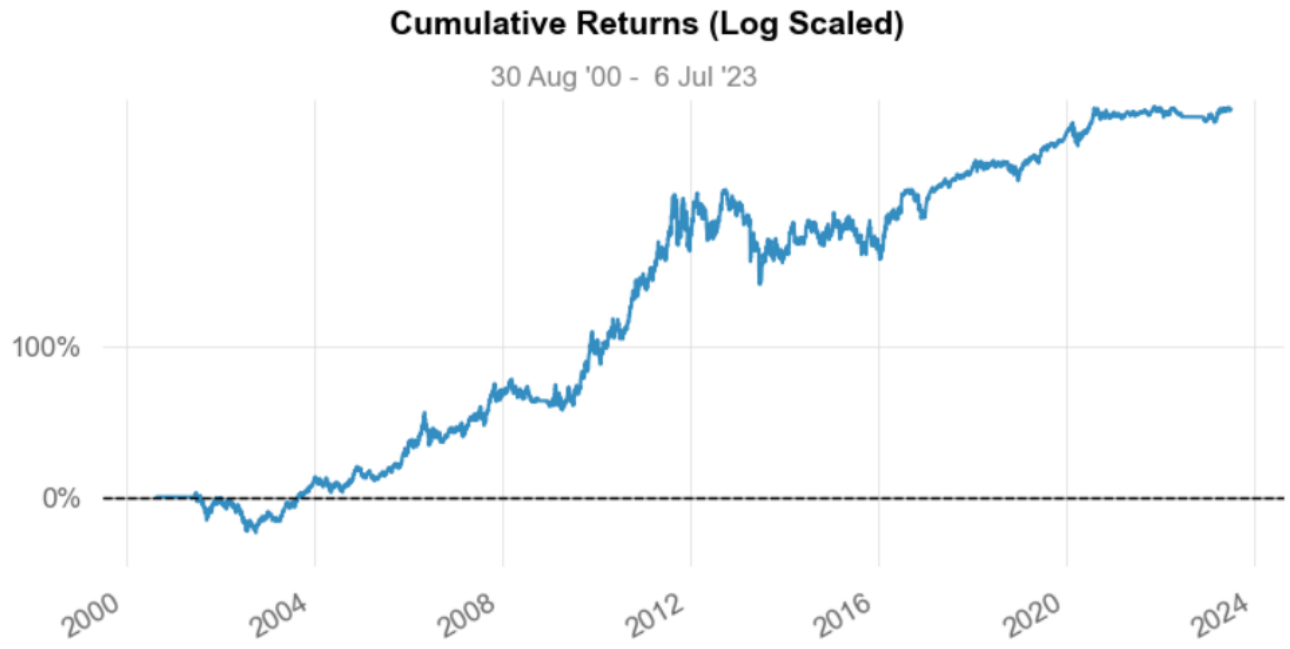
Here, the green triangles represent buy signals and the red triangles represent sell signals.

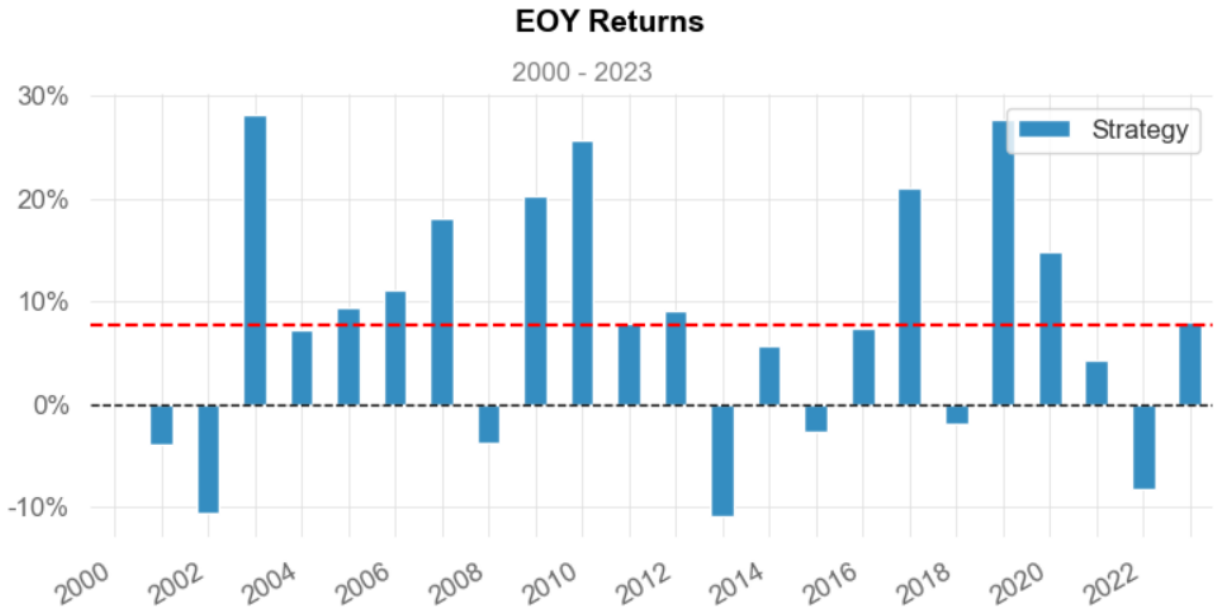
	Strategy
Start Period	2000-08-30
End Period	2023-07-06
Risk-Free Rate	0.0%
Time in Market	93.0%
Cumulative Return	413.64%
CAGR%	7.42%
Sharpe	0.66
Prob. Sharpe Ratio	99.91%
Smart Sharpe	0.65
Sortino	0.92
Smart Sortino	0.91
Sortino/√2	0.65
Smart Sortino/√2	0.64
Omega	1.13
Max Drawdown	-25.84%
Longest DD Days	1600
Volatility (ann.)	11.95%
Calmar	0.29
Skew	-0.48
Kurtosis	4.39

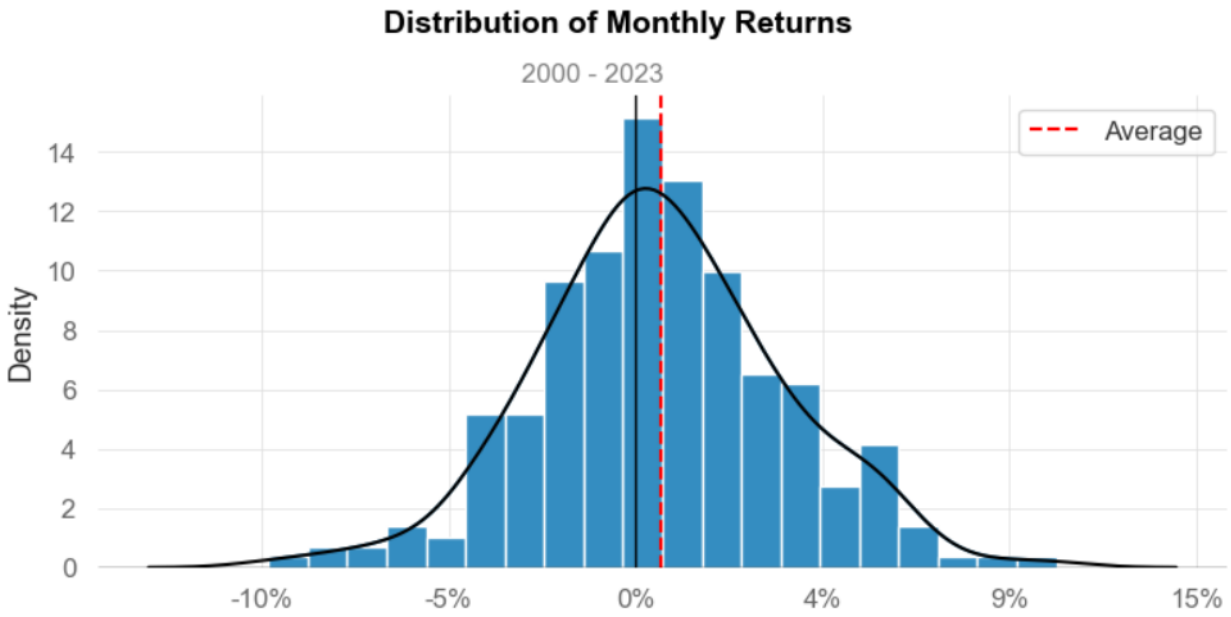
Best Day	5.37%
Worst Day	-6.94%
Best Month	11.25%
Worst Month	-9.83%
Best Year	28.17%
Worst Year	-10.97%
Avg. Drawdown	-2.12%
Avg. Drawdown Days	51
Recovery Factor	16.01
Ulcer Index	0.07
Serenity Index	3.03
Avg. Up Month	2.92%
Avg. Down Month	-2.46%
Win Days %	54.89%
Win Month %	58.46%
Win Quarter %	69.66%
Win Year %	69.57%

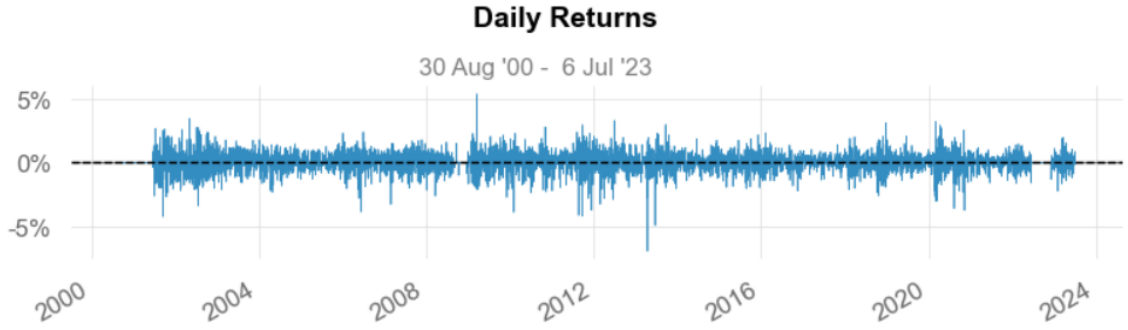
Expected Daily %	0.03%
Expected Monthly %	0.59%
Expected Yearly %	7.06%
Kelly Criterion	6.19%
Risk of Ruin	0.0%
Daily Value-at-Risk	-1.21%
Expected Shortfall (cVaR)	-1.21%
Max Consecutive Wins	13
Max Consecutive Losses	10
Gain/Pain Ratio	0.13
Gain/Pain (1M)	0.69
Payoff Ratio	0.93
Profit Factor	1.13
Common Sense Ratio	1.06
CPC Index	0.57
Tail Ratio	0.94
Outlier Win Ratio	4.0
Outlier Loss Ratio	3.46
MTD	0.08%
3M	0.58%
6M	7.34%
YTD	7.95%
1Y	5.48%
3Y (ann.)	0.1%
5Y (ann.)	7.52%
10Y (ann.)	7.8%
All-time (ann.)	7.42%


Cumulative Returns
30 Aug '00 - 6 Jul '23
400%
300%
200%
100%
0%
2000
2004
2008
2012
2016
2020
2024

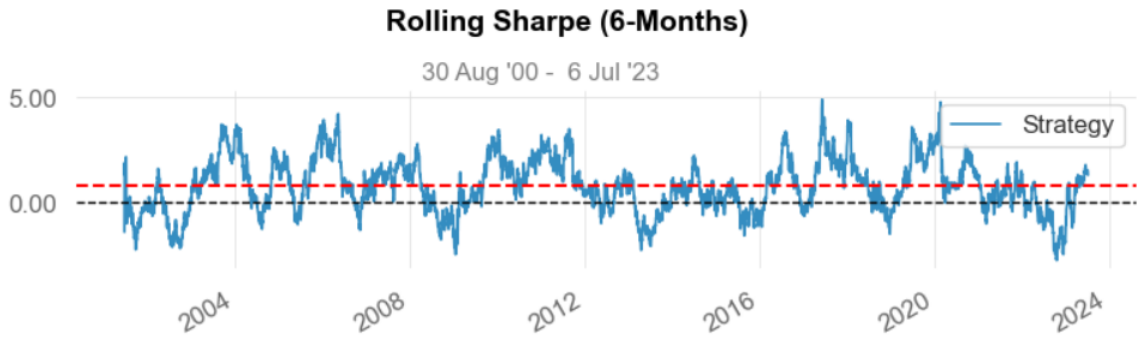

Cumulative Returns (Log Scaled)
30 Aug '00 - 6 Jul '23
100%
0%
2000
2004
2008
2012
2016
2020
2024


EOY Returns
2000 - 2023
30%
20%
10%
0%
-10%
Strategy
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022

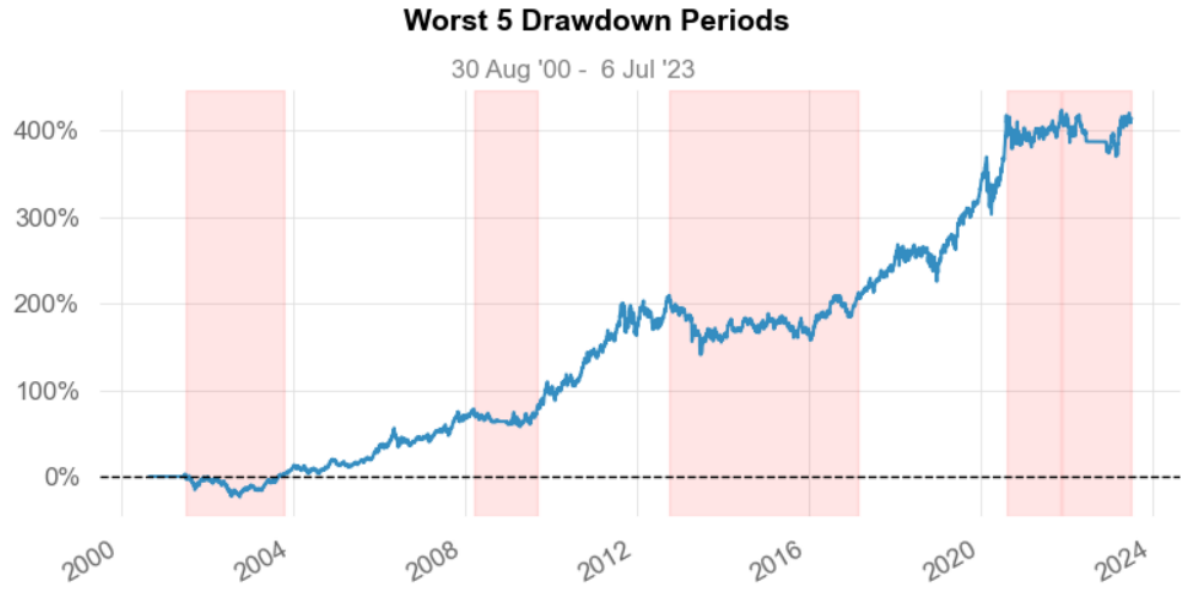

Distribution of Monthly Returns
2000 - 2023
Average
Density
14
12
10
8
6
4
2
0
-10%
-5%
0%
4%
9%
15%


Daily Returns
30 Aug '00 - 6 Jul '23
5%
0%
-5%
2000
2004
2008
2012
2016
2020
2024

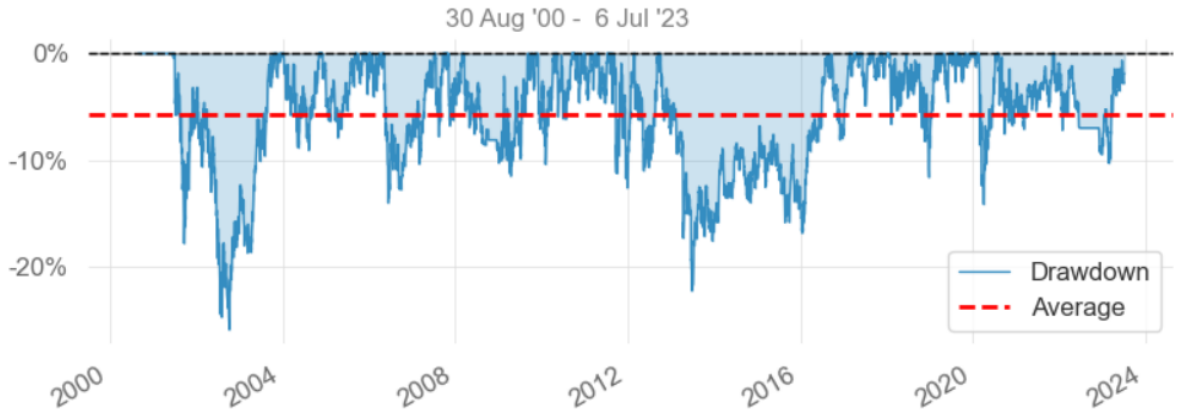

Rolling Volatility (6-Months)
30 Aug '00 - 6 Jul '23
0.20
0.10
0.00
Strategy
2004
2008
2012
2016
2020
2024


Rolling Sharpe (6-Months)
30 Aug '00 - 6 Jul '23
5.00
0.00
Strategy
2004
2008
2012
2016
2020
2024


Rolling Sortino (6-Months)
30 Aug '00 - 6 Jul '23
20.00
10.00
0.00
Strategy
2004
2008
2012
2016
2020
2024

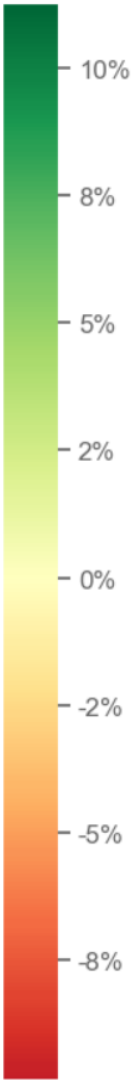

Worst 5 Drawdown Periods
30 Aug '00 - 6 Jul '23
400%
300%
200%
100%
0%
2000
2004
2008
2012
2016
2020
2024

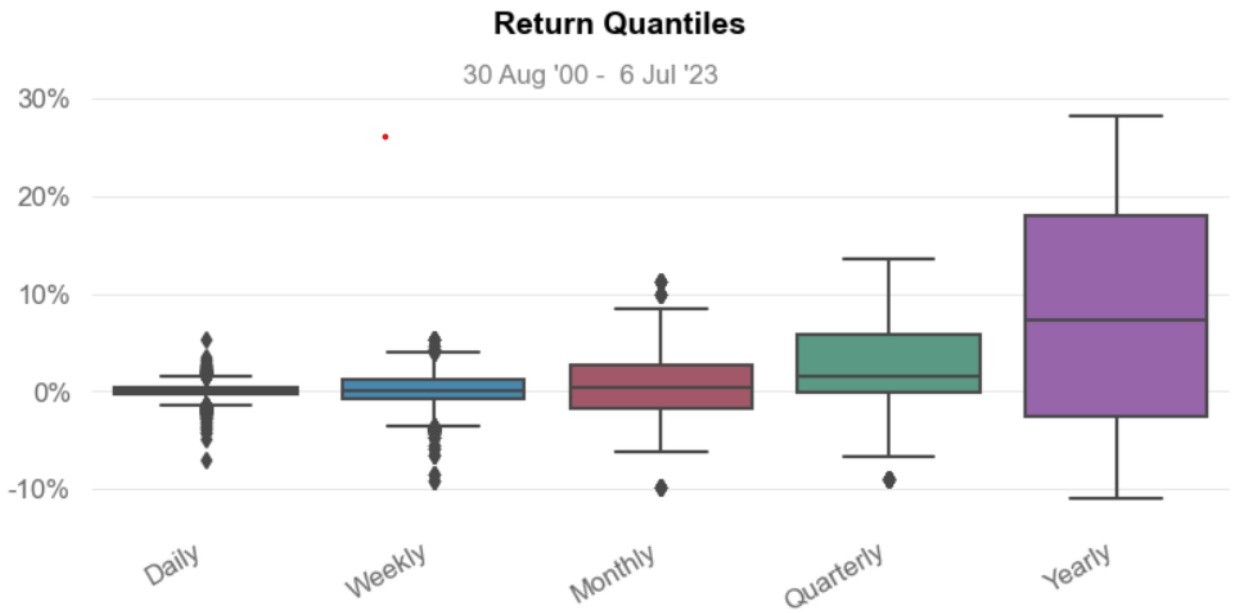
Underwater Plot



Monthly Returns (%)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00	2.81	-3.89	-5.09	-6.95	3.08	6.81	0.07
2002	-0.22	-2.62	3.69	-4.63	0.69	-7.49	-6.01	1.25	-4.31	5.30	4.68	-0.54
2003	2.31	-2.23	-2.00	4.86	7.17	-2.05	3.15	4.67	0.01	3.54	1.91	4.25
2004	-0.51	-0.62	2.45	-5.70	2.65	1.14	-3.17	1.66	1.93	2.72	5.18	-0.20
2005	-3.94	2.05	-1.90	-0.96	1.06	1.13	2.38	-0.27	4.09	-1.42	5.75	1.45
2006	6.68	-1.19	2.61	6.39	-2.73	-2.92	1.07	-0.76	-2.34	2.21	3.03	-0.93
2007	1.38	-1.08	0.33	4.45	2.23	-0.69	-0.74	1.38	6.30	5.97	-4.27	1.99
2008	1.30	2.30	-2.54	-2.49	1.71	-0.36	-0.58	-2.71	1.11	-1.03	0.00	-0.30
2009	1.16	1.06	-1.40	-2.40	6.42	-3.54	3.97	0.41	5.49	1.35	11.25	-4.08
2010	-2.45	3.46	1.69	4.71	-0.27	0.31	-1.95	2.62	6.47	4.23	1.43	3.16
2011	-3.64	4.85	1.31	6.53	-1.24	-2.16	6.24	7.66	-9.83	7.26	0.37	-7.87
2012	9.95	0.31	-0.54	-0.55	-6.18	2.79	0.59	4.54	3.88	-3.41	0.03	-1.72
2013	0.25	-3.38	1.59	-4.60	-2.57	-8.71	6.69	3.68	-1.80	1.62	-2.10	-1.32
2014	0.92	5.70	-2.61	0.51	-0.71	4.58	-1.51	2.17	-3.79	-0.68	2.07	-0.64
2015	3.28	0.04	-2.41	0.76	1.26	-2.02	-1.54	-1.56	-1.92	6.18	-3.10	-1.22
2016	-0.62	4.89	2.82	1.24	-1.51	3.54	4.09	-1.31	0.95	-2.37	-3.73	-0.45
2017	4.75	3.90	0.50	1.94	1.95	-2.27	2.88	2.78	-1.37	1.61	1.34	1.43
2018	5.46	-1.68	-1.92	0.03	2.14	-1.24	0.65	2.22	-0.51	-4.14	0.31	-2.93
2019	6.12	1.38	1.16	2.59	-3.77	7.45	1.72	1.87	-1.19	3.58	0.79	3.53
2020	3.25	-4.02	-5.87	5.93	3.62	3.46	8.47	3.12	-4.40	-1.26	-0.34	2.97
2021	-1.80	-0.23	0.73	2.05	0.28	-1.21	0.96	1.63	-2.91	2.67	0.32	1.88
2022	-4.06	0.73	2.76	-1.11	-2.60	-1.79	0.00	0.00	0.00	0.00	0.00	-2.29
2023	4.11	-4.42	6.27	0.96	0.76	0.26	0.08	0.00	0.00	0.00	0.00	0.00





Mistakes/Dead-Ends:

We tried using a simple one step strategy by incorporating the time lag between yield inversion and the start of a recession, i.e. the indices will be shorted after that duration from a yield inversion. However, this seemed inconsistent with our data in that we cannot always use the same hard figure of ~550 days to wait to short our stocks. Instead, we can include another layer of filtration (using some technical indicator). In our case, we firstly tried to do the same with the RSI Indicator, and then switched over to moving averages.

A simple moving average crossover between the duration that the yield curve stays negative provided slightly better results than our current strategy, however to incorporate the results of the regression, specifically the alpha term we needed to check for moving average crossovers within the alpha duration from the yield inversion signal.

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