Quantitative Investin Final Project Report

Course: FBE 551 - Quantitative Investing
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Introduction

Technical indicators are frequently used tools by investors and traders. They implement mathematically based formulas to analyze past data to identify future trading opportunities. Through analyzing historical data, technical analysts use indicators to try and create trading strategies. In this article, we use Python to explore a specific trading strategy based on a combination of 7 of the most commonly used indicators. We generate trading signals based on a defined set of rules, backtest our strategy, and form an optimally weighted portfolio. Our goal is to outperform a standard buy-and-hold strategy of the SPY ETF over a defined period of time.

Dataset

First, a list of Nasdaq-100 company tickers is obtained from Wikipedia. Then we use pandas datareader to get daily data from Yahoo Finance for each ticker from January 2000-01-01 to the present. The final dataset includes the following information, for every ticker, before further calculations.

Date	High	Low	Open	Close	Volume	Adj Close	ticker	returns
2000-01-03	1.375000	1.166667	1.312500	1.369792	7226400.0	1.214421	ATVI	NaN
2000-01-04	1.354167	1.187500	1.343750	1.328125	4262400.0	1.177480	ATVI	-0.030418
2000-01-05	1.364583	1.312500	1.317708	1.333333	3390000.0	1.182098	ATVI	0.003921
2000-01-06	1.333333	1.296875	1.322917	1.307292	2430000.0	1.159010	ATVI	-0.019531
2000-01-07	1.354167	1.291667	1.322917	1.343750	15549600.0	1.191333	ATVI	0.027888

In addition, daily trading information on the SPY ETF, which tracks the Standard & Poor's (S&P) 500 Index, is used to get benchmark stats.

```
df_spy
```

	Date	Open	High	Low	Close	Adj Close	Volume
0	1993-01-29	43.968750	43.968750	43.750000	43.937500	25.438095	1003200
1	1993-02-01	43.968750	44.250000	43.968750	44.250000	25.619024	480500
2	1993-02-02	44.218750	44.375000	44.125000	44.343750	25.673296	201300
3	1993-02-03	44.406250	44.843750	44.375000	44.812500	25.944683	529400
4	1993-02-04	44.968750	45.093750	44.468750	45.000000	26.053244	531500
...	...	...	...	...	...	...	...

Factors/Performance Indicators

We selected seven technical indicators for further strategy construction based on research:
- Simple Moving Average (Price)
- Simple Moving Average (Volume)
- Average True Range
- Stochastic Oscillator
- Relative Strength Index
- Moving Average Convergence/Divergence (MACD)

In this chapter, we include reason, calculation, and the trading signals for each indicator.

Since technical indicators work best in the short term, we use 5 days (1 trading week) and 20 days (1 trading months) as fast and slow signals respectively for every indicator.

a. **Simple Moving Average (Price)**

The reason for calculating the moving average of a stock is to help smooth out the price data by creating a constantly updated average price. By calculating the moving average, the impacts of random, short-term fluctuations on the price of a stock over a specified time frame are mitigated. We calculate the golden cross to track the trading signals. It is interpreted by analysts and traders as signaling a definitive upward turn in a market. We label buying signals when the golden cross occurs, namely, short term moving average crosses above long term. Below is our example plot that illustrates how we could trade Apple Stock from January 2022 to present if we adopt the above trading strategy based on simple moving average (price) signals only.

b. Simple Moving Average (Volume)

By smoothing out individual surges in the volume activity of an index, traders can use volume moving averages to help identify trend strength and changes in volume. We label buying signals when the golden cross occurs.
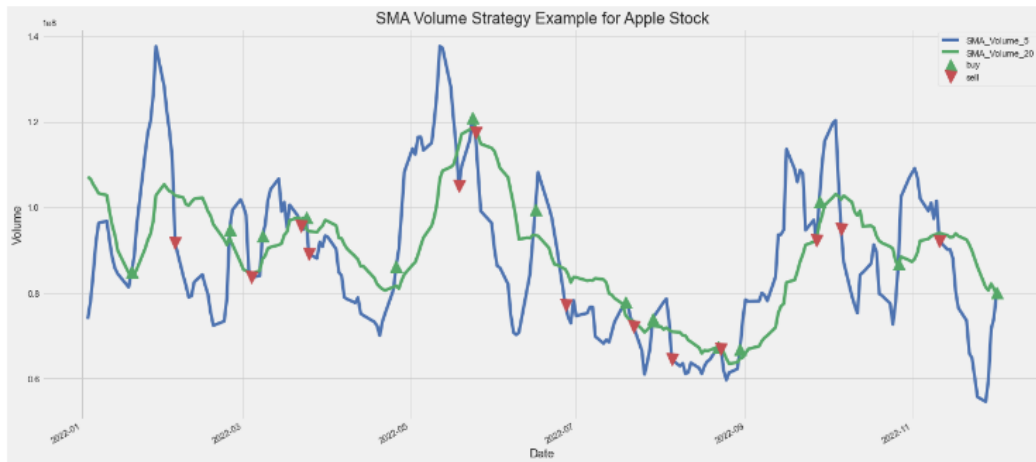
c. Average True Range (ATR)

A higher ATR of a company implies higher volatility of a stock. ATR is primarily used in identifying when to exit or enter a trade rather than the direction in which to trade the stock. We check for inflection and high volatility for signals. We label buying signals when short term ATR crosses above long term ATR.


d. Stochastic Oscillators

Stochastic Oscillator is a momentum-based leading indicator that is widely used to identify whether the market is in the state of overbought or oversold. A stock is said to be overbought when the market's trend seems to be extremely bullish and bound to consolidate. In this project, we adopt %K and %D as indicators to form buying or selling strategies. Specifically, $\%K\_20 = (C - L\_20) / (H\_20 - L\_20) \times 100$, where:

- C = The most recent closing price
- L_20 = The lowest price traded of the 20 previous trading sessions
- H_20 = The highest price traded during the same 20-day period
- %K = The current value of the stochastic indicator

%K is referred to sometimes as the fast stochastic indicator. The "slow" stochastic indicator is taken as %D = 3-period moving average of %K. The values of the Stochastic Oscillator always lie between 0 to 100 due to its normalization function. Since the general overbought and oversold levels are considered as 70 and 30 respectively, we label buying signals when %K_20 and %D_20 are both less than 30; selling signals if both are larger than 70.

Stochastic Oscillators Strategy Example for Apple Stock
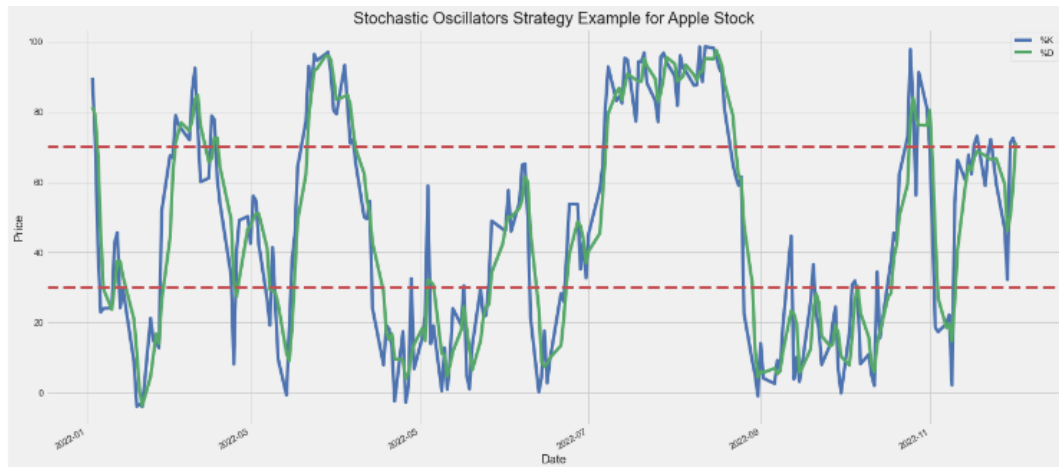
e. Relative Strength Index (RSI)

RSI is a momentum indicator aimed at quantifying price changes and the speed of such change. Relative strength (RS) is calculated by dividing the average of positive price changes by the average of negative price changes. RSI is then calculated by subtracting $100/(1 + RS)$ from 100. We label buying signals when the RSI over the 20 day period is less than 30; selling signals if it is larger than 70.

Relative Strength Index Strategy Example for Apple Stock
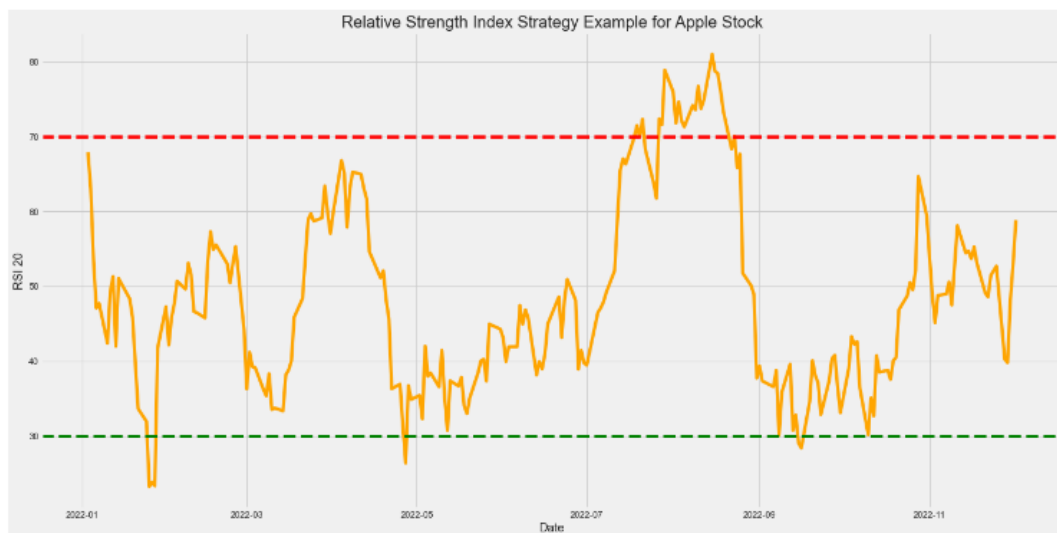
f. Moving Average Convergence Divergence (MACD)

Moving average convergence/divergence is a trend-following momentum indicator that shows the relationship between two exponential moving averages (EMAs) of a security's price. EMA is a type of moving average that places a greater weight and significance on the most recent data points. MACD is commonly calculated by subtracting 26-period EMA from the 12-period EMA. However, we calculated the MACD value by subtracting the 20-period EMA from the 5-period EMA to be more consistent with the other indicators. In addition to the MACD line, we will be calculating the MACD signal by taking the 5-period EMA of the MACD line itself. We label buying signals when MACD value is above the MACD signal and label the selling signals when MACD value is below the MACD signal.

MACD Strategy Example for Apple Stock
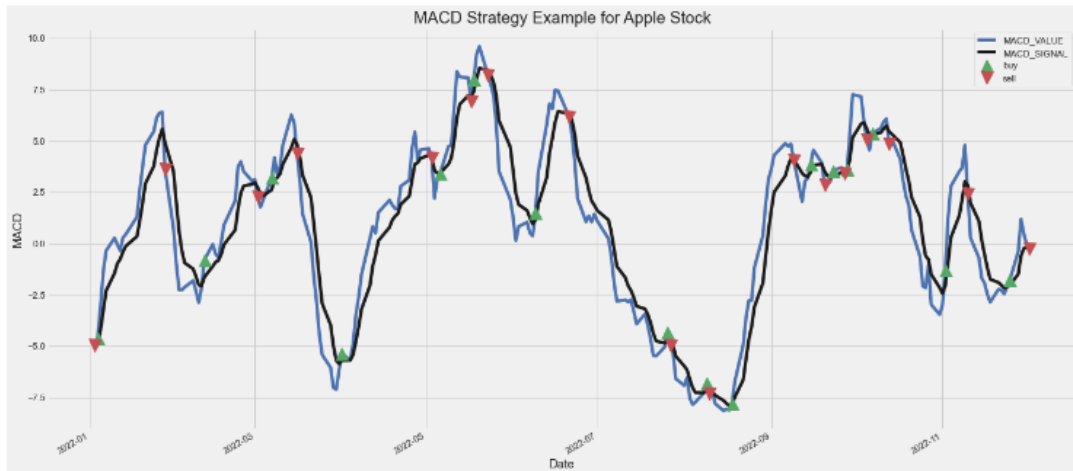
g. Bollinger Bands

Bollinger bands capture the volatility of a stock and are used to identify overbought and oversold stocks. It consists of three main elements: The simple moving average line, an upper bound which is 2 standard deviations above moving average and a lower bound which is 2 standard deviations below moving average. We label buying signals when adjusted close price is lower the lowerband; selling signals when adjusted close price is above the upper band.

Bollinger Bands Strategy Example for Apple Stock
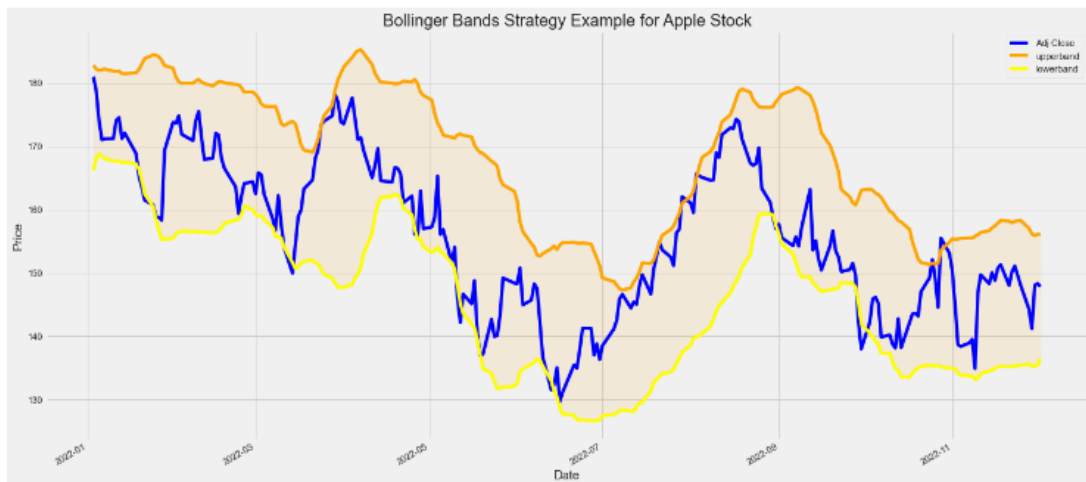
Trading Strategy

Our trading strategy makes use of all aforementioned indicators. We will buy the stock when all of the seven indicators show a buy signal, and will sell the same stock if just one of the indicators shows a sell signal. At any point in time in between, we are either holding or have no position in the stock. This methodology applies to all stocks in our portfolio.

# Risk-Managemnent, Weighting Strategy

In order to maximize the portfolio returns and minimize the portfolio risk, we used a portfolio optimization technique called efficient frontier to select the optimal weight of stocks to have in our portfolio.The efficient frontier graph allows investors to determine the investment portfolios that offer the highest expected return for a given level of risk. We will

be using the year returns for individual companies as our measure for expected returns and portfolio variance as the measure of risk level.

We will then plot the efficient frontier graph with returns on the Y-axis and volatility on the X-axis. This will show us the maximum return we can get for a given level of volatility and also the volatility we need to tolerate for a certain level of returns. Each point on the left line represents an optimal portfolio weight that maximizes the return for any given level of risk. In order to maximize the portfolio returns, we use Sharpe ratio to find the optimal risky portfolio. Sharpe ratio is the average return earned in excess of the risk-free rate per total risk. In this method, we defined the risk-free rate to be 0.01. Additionally, we define the optimal risky portfolio to be the portfolio with the highest Sharpe ratio.

In our efficient frontier graph, the red star indicates the most efficient portfolio with minimum volatility and the green star represents the optimal risky portfolio.

Efficient Frontier
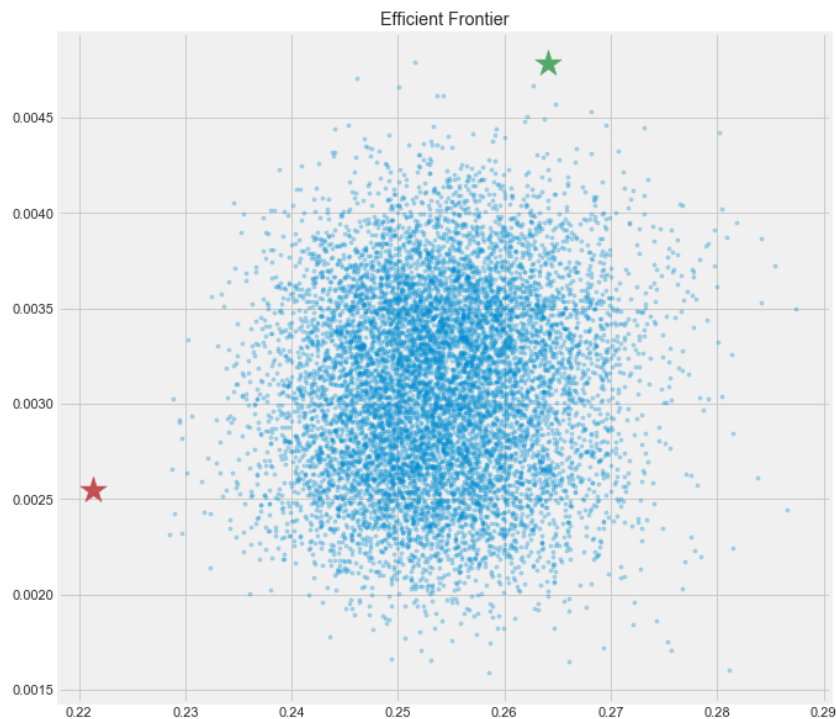
Implementation

1) Create function to get benchmark stats using imported SPY data
   ```
   def benchmark_stats(starting_date, total_investment_value):
   ```
2) Choose a start date (2020-01-01) and total investment value ($100,000)
3) Calculate benchmark stats in terms of profit and percentage gain
   ```
   Benchmark Stats from date 2000-01-01 to present day using an inital investment amount of $100000:
   Benchmark profit dollar amount $1436591.5
   Benchmark profit percentage amount: 1436%
   ```
4) Create empty dataframe to hold returns
5) Loop through all the NASDAQ 100 stocks, implement our trading strategy, create trading positions, and backtest everything.

```
def trading_strategy(prices, SMA_Ratio, SMA_Volume_Ratio, ATR_Ratio, Day20_K, Day20_D, RSI_20, MACD_Value,
                     MACD_Signal, upperband, lowerband):
```

6) Hold all results in the empty returns dataframe

	Ticker	Profit Gained	Profit Percentage	Benchmark Profit Comparison
0	ATVI	6138306.79	6138	4702
1	ADBE	1998368.74	1998	562
2	ADP	584739.58	584	-852
3	ABNB	-30203.61	-31	-1467
4	ALGN	1075594.90	1075	-361
...	...	...	...	...
97	WBA	120974.38	120	-1316
98	WDAY	251081.91	251	-1185
99	XEL	841346.74	841	-595
100	ZM	19843.72	19	-1417
101	ZS	290849.72	290	-1146

7) Add sector information for each ticker

	Ticker	Sector
0	ATVI	Communication Services
1	ADBE	Technology
2	ADP	Industrials
3	ABNB	Consumer Cyclical
4	ALGN	Healthcare
...	...	...
97	WBA	Healthcare
98	WDAY	Technology
99	XEL	Utilities
100	ZM	Technology
101	ZS	Technology

8) Sort the dataframe by profit (top 25 stocks)

	Ticker	Profit Gained	Profit Percentage	Benchmark Profit Comparison	Sector
69	MNST	1.157007e+08	115700	114264	Consumer Defensive
75	ODFL	3.123256e+07	31232	29796	Industrials
71	NFLX	2.668051e+07	26680	25244	Communication Services
72	NVDA	1.875471e+07	18754	17318	Technology
13	AAPL	1.724964e+07	17249	15813	Technology
70	NTES	1.381717e+07	13817	12381	Communication Services
51	ISRG	1.332601e+07	13326	11890	Healthcare
92	TSLA	1.213468e+07	12134	10698	Consumer Cyclical
47	IDXX	1.073984e+07	10739	9303	Healthcare
12	ANSS	9.183205e+06	9183	7747	Technology
74	ORLY	7.884933e+06	7884	6448	Consumer Cyclical
84	ROST	6.654322e+06	6654	5218	Consumer Cyclical
45	GILD	6.398834e+06	6398	4962	Healthcare
0	ATVI	6.138307e+06	6138	4702	Communication Services
83	REGN	6.123864e+06	6123	4687	Healthcare
40	ENPH	4.477335e+06	4477	3041	Technology
22	AVGO	4.398917e+06	4398	2962	Technology
89	SBUX	4.143812e+06	4143	2707	Consumer Cyclical
30	CPRT	4.032278e+06	4032	2596	Consumer Cyclical
6	GOOG	3.934513e+06	3934	2498	Communication Services
35	DXCM	3.924127e+06	3924	2488	Healthcare
5	GOOGL	3.899924e+06	3899	2463	Communication Services
62	MELI	3.322099e+06	3322	1886	Consumer Cyclical
27	CTSH	3.249096e+06	3249	1813	Technology
44	FTNT	3.125607e+06	3125	1689	Technology

9) Observe the best performing sectors (by relative frequency) in this list (Communication Services and Healthcare)

```
Top 25 Performing Sectors:
Technology                7
Consumer Cyclical         6
Healthcare                5
Communication Services    5
Consumer Defensive        1
Industrials               1
Name: Sector, dtype: int64

Total Inital Sector Counts:
Technology                39
Consumer Cyclical         15
Healthcare                14
Communication Services    13
Industrials               9
Consumer Defensive        7
Utilities                 4
Financial Services        1
Name: Sector, dtype: int64

Ratios to determine true best performing sectors:
Technology:              (7/39)= 0.1794871794871795
Consumer_Cyclical:       (6/15)= 0.4
Healthcare:              (5/14)= 0.35714285714285715
Communication_Services:  (5/13)= 0.38461538461538464
Consumer Defense:        (1/7)= 0.14285714285714285
Industrials:             (1/9)= 0.1111111111111111
```

10) Create a new portfolio with only Communication Services and Healthcare Stocks from the NASDAQ 100

	Ticker	Profit Gained	Profit Percentage	Benchmark Profit Comparison	Sector
0	ATVI	6138306.79	6138	4702	Communication Services
4	ALGN	1075594.90	1075	-361	Healthcare
5	GOOGL	3899924.16	3899	2463	Communication Services
6	GOOG	3934513.05	3934	2498	Communication Services
10	AMGN	505025.01	505	-931	Healthcare
16	AZN	679264.70	679	-757	Healthcare
19	BIDU	828615.39	828	-608	Communication Services
20	BIIB	861566.20	861	-575	Healthcare
24	CHTR	1021920.34	1021	-415	Communication Services
28	CMCSA	204602.65	204	-1232	Communication Services
35	DXCM	3924127.45	3924	2488	Healthcare
39	EA	429794.11	429	-1007	Communication Services
45	GILD	6398833.93	6398	4962	Healthcare
47	IDXX	10739843.20	10739	9303	Healthcare
48	ILMN	1016783.56	1016	-420	Healthcare
51	ISRG	13326008.88	13326	11890	Healthcare
61	MTCH	632585.48	632	-804	Communication Services
63	META	222954.90	222	-1214	Communication Services
67	MRNA	880320.03	880	-556	Healthcare
70	NTES	13817174.32	13817	12381	Communication Services
71	NFLX	26680509.00	26680	25244	Communication Services
83	REGN	6123863.50	6123	4687	Healthcare
85	SGEN	1340037.28	1340	-96	Healthcare
86	SIRI	-82962.53	-83	-1519	Communication Services
91	TMUS	235626.36	235	-1201	Communication Services
96	VRTX	1610982.48	1610	174	Healthcare
97	WBA	120974.38	120	-1316	Healthcare

11) Implement our risk-Managemnt, weighting Strategy and add these individuals weights to our final portfolio

	Ticker	Profit Gained	Profit Percentage	Benchmark Profit Comparison	Sector	Weight
0	ALGN	89.623339	0.089574	-0.03008	Healthcare	0.009128
1	AMGN	1136.844912	1.136789	-2.095743	Healthcare	0.047445
2	ATVI	5245.946844	5.245685	4.018444	Communication Services	0.029234
3	AZN	370.129717	0.369985	-0.412488	Healthcare	0.023343
4	BIDU	103.809883	0.103733	-0.076171	Communication Services	0.011193
5	BIIB	1041.800453	1.041116	-0.695286	Healthcare	0.034773
6	CHTR	288.767717	0.288508	-0.117268	Communication Services	0.016810
7	CMCSA	12.029083	0.011994	-0.072432	Communication Services	0.007668
8	DXCM	994.739534	0.994707	0.630691	Healthcare	0.015921
9	EA	1142.279976	1.140169	-2.676342	Communication Services	0.051553
10	GILD	36527.090174	36.52233	28.32507	Healthcare	0.075554
11	GOOG	666.835268	0.666748	0.42337	Communication Services	0.013019
12	GOOGL	9013.307310	9.011171	5.692361	Communication Services	0.048074
13	IDXX	2088.775909	2.088612	1.809326	Healthcare	0.013946
14	ILMN	64.030800	0.063981	-0.026449	Healthcare	0.007936
15	ISRG	113043.443938	113.043369	100.861898	Healthcare	0.092103
16	META	367.661227	0.366087	-2.001933	Communication Services	0.040608
17	MRNA	9024.551810	9.021271	-5.699803	Healthcare	0.101249
18	MTCH	11.025770	0.011016	-0.014013	Communication Services	0.004175
19	NFLX	15509.864716	15.509569	14.674796	Communication Services	0.024111
20	NTES	114.676653	0.114675	0.102757	Communication Services	0.002881
21	REGN	40910.320382	40.904552	31.311389	Healthcare	0.081734
22	SGEN	913.629435	0.913604	-0.065452	Healthcare	0.026111
23	SIRI	-74.802840	-0.074837	-1.3696	Communication Services	0.030027
24	TMUS	2076.121900	2.070603	-10.582103	Communication Services	0.093867
25	VRTX	2160.485457	2.159168	0.233351	Healthcare	0.036621
26	WBA	448.881642	0.445266	-4.883086	Healthcare	0.060914

12) Finally, calculate the total profit and percentage and compare it to our initial SPY buy and hold benchmark

Results and Conclusion

The results show that our trading strategy outperformed a buy and hold SPY strategy over the years 2000-01-01 to present day by 2235.51%. The addition of indicators, risk management, and weighting proved very useful in predicting buying and selling opportunities.

Improvements to our model and realistic next steps could include:

    a) Testing and comparing various time periods
    b) Expanding our dataset to include stocks outside the NASDAQ100
    c) Adding additional indicators
    d) Implementing more advanced smoothing techniques
    e) Incorporating more fundamental analysis
    f) Use machine learning techniques within our strategy

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