Can Technical Indicator-based Stock Trading Strategies Perform Better than Top-performing Mutual Funds?

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Introduction

Trading stocks has become a phenomenon that has only gained momentum in the last decade or so. Day trading is a concept where a person buys and sells stocks within a short time frame instead of holding the assets long term. People do this with the goal to make a small profit on each trade and hope the profits compound over time. Due to new tools like Robinhood and WealthSimple, investing in stocks has become extremely cheap and simple. But, without the proper knowledge of the stock market, it is highly likely that a novice investor will end up losing money instead of earning it. The stock market is extremely volatile and without the right expertise, it can be difficult to make informed decisions that are beneficial to an individual or an organization.

Now that we have a solid foundation upon which to base our paper, let's take a deeper look at our objectives. In this research paper, we want to study whether technical indicator-based stock trading strategies perform better than top-performing mutual funds. The mutual fund that we have decided to use for the purposes of our study is TDB908. TDB908 is managed by TD Asset Management Inc out of Toronto, Canada. In order to streamline and simplify our study, our team decided to focus on the top 10 stocks held in TDB908. In the next section, we will learn more about the stocks that were picked. The time frame for our analysis is ten years, December 2012 - November 2022.

The technical indicator that we used to build our trading strategy is called Moving Average Convergence Divergence (MACD). We use this indicator to define a strategy that buys and/or sells a particular stock if certain conditions are met. And finally, we compute the compounded profit to see the potential gains or losses that would have occurred over the ten year

period if we had traded in real life using said strategies. Now that we have a decent understanding of the goals of our study, we can dig deeper into the data.

Data and Model

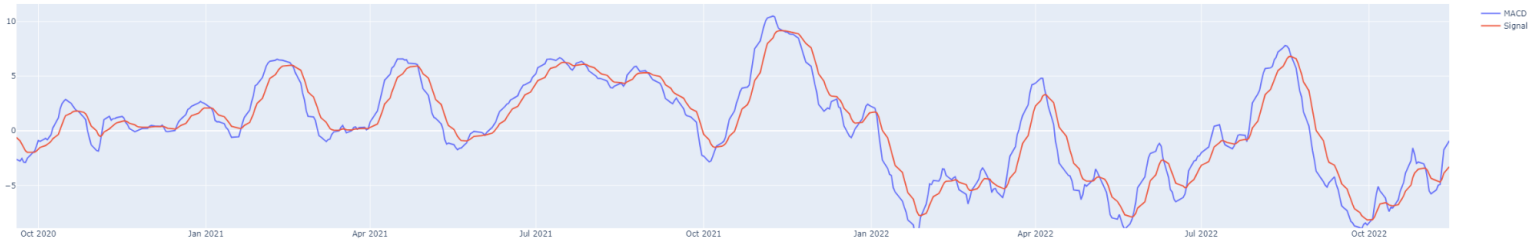
All the data that was used in this analysis was extracted from Yahoo Finance through an API. The analysis was done in Python using a number of different libraries. Yahoo Finance has a community built library in Python called 'yfinance'. This library was used to load the data for our ten stocks. TDB908 is a mutual fund comprising 25 stocks. We picked the top 10 stocks by their weightage in the mutual fund. The ten stocks that we selected from TDB908 are Apple, Microsoft, Amazon, Tesla, Google, Meta, Nvidia, Pepsi, Costco and Broadcom Inc. The default investment value for each stock was kept at $10,000.

From the Python library yfinance, the data that we loaded was on a daily basis for a period of ten years. The metrics that were available to us were the stock's opening and closing prices, the highest and lowest price of the day, adjusted close and trade volume. For our research, the metric that we incorporated into our strategies was the closing price. Some of the other libraries that we used were pandas, numpy, plotly, matplotlib, datetime and for the purposes of backtesting, we used the backtesting library.

As mentioned in the introduction, the technical indicator that we used to develop our strategies is MACD. The MACD is an indicator that consists of the MACD line, the signal line and Histogram. The MACD line is the difference between a fast Exponential Moving Average (EMA) line and a slow EMA line. The signal line is the EMA line of the MACD. The histogram is the difference between the MACD and Signal Line. The user has the option to define the periods of the fast and slow moving averages. The most common values are 12 and 26 for fast

and slow respectively and 9 for the period of the Signal Line. And we use these values for our default analysis.

Moving on, we will now explain the strategy that was designed to determine when to buy a stock and when to sell it. When the MACD line crosses above its signal line, a buy signal is generated by the system. On the other hand, when the MACD line crosses below the signal line, the system generates a signal to sell the stock held.



This is a visualization of Microsoft Stock since January 2022. This figure helps us visualize what it means for the MACD line (shown in blue) to cross over the signal line (shown in red) and vice versa.

The backtesting library was also used to define a function that allowed us to generate the returns, among a variety of other metrics for our list of stocks. The periods selected in the original run are the default periods defined earlier. The backtesting library is further utilized at the end to optimize position entrance and exit signal strategies. Additionally, we also implemented our strategy into the backtesting model after creating it in Python.

For the optimization model, we let the model select the periods for our fast, slow and signal lengths. The range we selected was between 5 and 100 in steps of 10, this was due to time constraints as computer power was limited and the recreation of our results was important. The model iterates over all possibilities and at the end shows the best possible combination of periods for each stock within our range. We also believe that obtaining the optimal MACD parameters

for each individual stock is important as the default parameters do not work universally. Specific MACD parameters for individual stocks allowed for curated signals that allowed us to refine our results and maximize the total return on investment.

Results and Analysis

In this section, we will go over the results that are model generated. To start off, we will review the performance of the ten stocks with the default parameters of 12, 26, 9. Then, we will see the results after optimization and the optimized periods for each stock.

Apple

Apple (AAPL)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	53.59555
Equity Final [$]	58594.027072
Equity Peak [$]	66549.039157
Return [%]	485.940271
Buy & Hold Return [%]	689.893852
Return (Ann.) [%]	19.364959
Volatility (Ann.) [%]	22.337199
Sharpe Ratio	0.866938
Sortino Ratio	1.542529
Calmar Ratio	0.720732
Max. Drawdown [%]	-26.868475
Avg. Drawdown [%]	-3.505225
Max. Drawdown Duration	521 days 00:00:00
Avg. Drawdown Duration	42 days 00:00:00
# Trades	84
Win Rate [%]	53.571429
Best Trade [%]	26.334044
Worst Trade [%]	-11.226189
Avg. Trade [%]	2.129043
Max. Trade Duration	77 days 00:00:00
Avg. Trade Duration	22 days 00:00:00
Profit Factor	2.513099
Expectancy [%]	2.365268
SQN	2.441819
_strategy	MACDCross

In the case of Apple, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 485.94%. This amounted to a total equity of $58,594.03 by the end of the ten year period. Additionally, the return per year was 19.36%. There were a total of 84 trades that were conducted by our model. The best trade earned us a return of 26.33% and the worst trade lost us 11.23%. The average trade percentage was 2.13% which means that for every trade, we earned 2.13% on average. Lastly, the average trade duration is 22 days which means that we held the stock for 22 days on average before selling it.

```
Apple (AAPL) - Optimized

/usr/local/lib/python3.8/dist-packages/backtest
  output = _optimize_grid()
Backtest.optimize:   0%|          | 0/4 [00:00<
Start                     2012-11-15 00:00:00
End                       2022-11-14 00:00:00
Duration                   3651 days 00:00:00
Exposure Time [%]                   54.628526
Equity Final [$]                102906.597145
Equity Peak [$]                 112789.203773
Return [%]                         929.065971
Buy & Hold Return [%]              689.893852
Return (Ann.) [%]                   26.288846
Volatility (Ann.) [%]               22.576841
Sharpe Ratio                         1.164416
Sortino Ratio                        2.291733
Calmar Ratio                         1.290158
Max. Drawdown [%]                  -20.376452
Avg. Drawdown [%]                   -2.807437
Max. Drawdown Duration      311 days 00:00:00
Avg. Drawdown Duration       31 days 00:00:00
# Trades                                   89
Win Rate [%]                        49.438202
Best Trade [%]                       44.75743
Worst Trade [%]                    -10.867385
Avg. Trade [%]                       2.655474
Max. Trade Duration          97 days 00:00:00
Avg. Trade Duration          21 days 00:00:00
Profit Factor                        3.513454
Expectancy [%]                       2.935923
SQN                                  2.467243
_strategy                 MACDCross(fast=5...
```

After optimization, we see that the total return has improved to 929.07%. The return per year has increased to 26.29%. The total number of trades conducted during the 10 year period have increased to 89 trades. The best trade now earns us a return of 44.76%. The worst trade now loses us 10.87%. The average trade percentage has increased to 2.66%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 5, slow = 45, signal = 15.

Microsoft

```
Microsoft (MSFT)

Start                     2012-11-15 00:00:00
End                       2022-11-14 00:00:00
Duration                   3651 days 00:00:00
Exposure Time [%]                   55.145014
Equity Final [$]                11834.445705
Equity Peak [$]                 17631.466473
Return [%]                         18.344457
Buy & Hold Return [%]             806.039026
Return (Ann.) [%]                   1.700599
Volatility (Ann.) [%]              18.264566
Sharpe Ratio                        0.093109
Sortino Ratio                       0.135056
Calmar Ratio                        0.050931
Max. Drawdown [%]                  -33.390479
Avg. Drawdown [%]                   -5.343304
Max. Drawdown Duration      897 days 00:00:00
Avg. Drawdown Duration      119 days 00:00:00
# Trades                                  109
Win Rate [%]                        44.036697
Best Trade [%]                      24.478446
Worst Trade [%]                    -10.905005
Avg. Trade [%]                      0.151993
Max. Trade Duration          61 days 00:00:00
Avg. Trade Duration          17 days 00:00:00
Profit Factor                       1.173363
Expectancy [%]                      0.285377
SQN                                 0.277414
_strategy                          MACDCross
```

In the case of Microsoft, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 18.34%. This amounted to a total equity of $11,834.45 by the end of the ten year period. Additionally, the return per year was 1.70%. There were a total of 109 trades that were conducted by our model. The best trade earned us a

return of 24.48% and the worst trade lost us 10.91%. The average trade percentage was 0.15% which means that for every trade, we earned 0.15% on average. Lastly, the average trade duration is 17 days which means that we held the stock for 17 days on average before selling it.

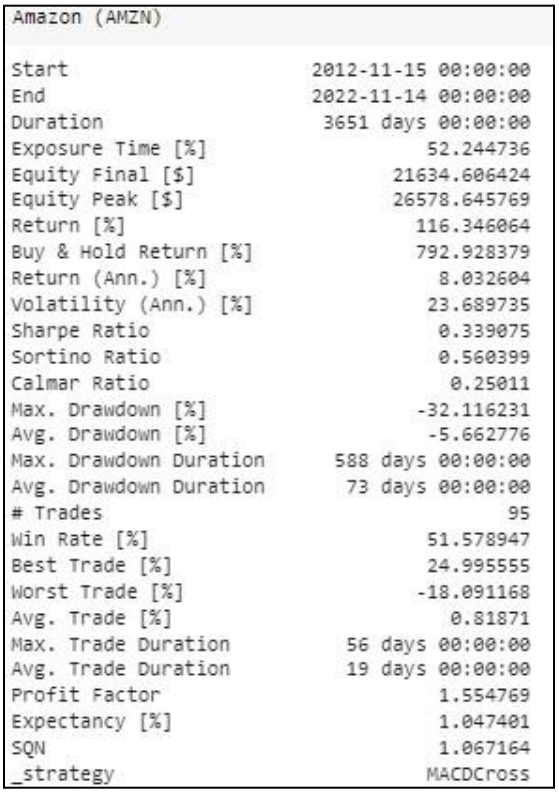
```
Microsoft (MSFT) - Optimized

/usr/local/lib/python3.8/dist-packages/backtes
  output = _optimize_grid()
Backtest.optimize:   0%|          | 0/4 [00:00
Start                     2012-11-15 00:00:00
End                       2022-11-14 00:00:00
Duration                   3651 days 00:00:00
Exposure Time [%]                   49.940405
Equity Final [$]                21150.755764
Equity Peak [$]                 27197.097225
Return [%]                        111.507558
Buy & Hold Return [%]             806.039026
Return (Ann.) [%]                   7.788236
Volatility (Ann.) [%]              17.1878
Sharpe Ratio                        0.453126
Sortino Ratio                       0.727908
Calmar Ratio                        0.313579
Max. Drawdown [%]                 -24.836594
Avg. Drawdown [%]                  -4.063634
Max. Drawdown Duration     1318 days 00:00:00
Avg. Drawdown Duration       74 days 00:00:00
# Trades                                  50
Win Rate [%]                          40.0
Best Trade [%]                      22.067039
Worst Trade [%]                   -14.463946
Avg. Trade [%]                      1.510186
Max. Trade Duration         123 days 00:00:00
Avg. Trade Duration          35 days 00:00:00
Profit Factor                       1.982791
Expectancy [%]                      1.789481
SQN                                 1.212045
_strategy                 MACDCross(fast=3...
```

After optimization, we see that the total return has improved to 111.51%. The return per year has increased to 7.79%. The total number of trades conducted during the 10 year period have decreased to 50 trades. The best trade now earns us a return of 22.07%. The worst trade now loses us 14.46%. The average trade percentage has increased to 1.51%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 35, slow = 75, signal = 15.

Amazon

In the case of Amazon, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 116.35%. This amounted to a total equity of $21,634.61 by the end of the ten year period. Additionally, the return per year was 8.03%. There were a total of 95 trades that were conducted by our model. The best trade earned us a return of 25.00% and the worst trade

lost us 18.09%. The average trade percentage was 0.82% which means that for every trade, we earned 0.82% on average. Lastly, the average trade duration is 19 days which means that we held the stock for 19 days on average before selling it.



Amazon (AMZN)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	52.244736
Equity Final [$]	21634.606424
Equity Peak [$]	26578.645769
Return [%]	116.346064
Buy & Hold Return [%]	792.928379
Return (Ann.) [%]	8.032604
Volatility (Ann.) [%]	23.689735
Sharpe Ratio	0.339075
Sortino Ratio	0.560399
Calmar Ratio	0.25011
Max. Drawdown [%]	-32.116231
Avg. Drawdown [%]	-5.662776
Max. Drawdown Duration	588 days 00:00:00
Avg. Drawdown Duration	73 days 00:00:00
# Trades	95
Win Rate [%]	51.578947
Best Trade [%]	24.995555
Worst Trade [%]	-18.091168
Avg. Trade [%]	0.81871
Max. Trade Duration	56 days 00:00:00
Avg. Trade Duration	19 days 00:00:00
Profit Factor	1.554769
Expectancy [%]	1.047401
SQN	1.067164
_strategy	MACDCross

Amazon (AMZN) - Optimized	
/usr/local/lib/python3.8/dist-packages/backtest	
output = _optimize_grid()	
Backtest.optimize: 0%|	| 0/4 [00:00
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	50.417163
Equity Final [$]	55152.10926
Equity Peak [$]	73288.903037
Return [%]	451.521093
Buy & Hold Return [%]	792.928379
Return (Ann.) [%]	18.643677
Volatility (Ann.) [%]	24.469654
Sharpe Ratio	0.76191
Sortino Ratio	1.460464
Calmar Ratio	0.539424
Max. Drawdown [%]	-34.562184
Avg. Drawdown [%]	-3.860133
Max. Drawdown Duration	803 days 00:00:00
Avg. Drawdown Duration	42 days 00:00:00
# Trades	33
Win Rate [%]	51.515152
Best Trade [%]	55.545104
Worst Trade [%]	-10.129653
Avg. Trade [%]	5.31414
Max. Trade Duration	166 days 00:00:00
Avg. Trade Duration	55 days 00:00:00
Profit Factor	4.449609
Expectancy [%]	6.145332
SQN	1.549424
_strategy	MACDCross(fast=2...

After optimization, we see that the total return has improved to 451.52%. The return per year has increased to 18.64%. The total number of trades conducted during the 10 year period have decreased to 33 trades. The best trade now earns us a return of 55.55%. The worst trade now loses us 10.13%. The average trade percentage has increased to 5.31%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 25, slow = 65, signal = 35.

Tesla

Tesla (TSLA)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	56.21772
Equity Final [$]	257463.133304
Equity Peak [$]	404252.297122
Return [%]	2474.631333
Buy & Hold Return [%]	9193.476623
Return (Ann.) [%]	38.433005
Volatility (Ann.) [%]	59.560557
Sharpe Ratio	0.645276
Sortino Ratio	1.524542
Calmar Ratio	0.76705
Max. Drawdown [%]	-50.10493
Avg. Drawdown [%]	-8.28
Max. Drawdown Duration	569 days 00:00:00
Avg. Drawdown Duration	59 days 00:00:00
# Trades	96
Win Rate [%]	43.75
Best Trade [%]	144.464949
Worst Trade [%]	-16.132367
Avg. Trade [%]	3.442121
Max. Trade Duration	73 days 00:00:00
Avg. Trade Duration	20 days 00:00:00
Profit Factor	2.575823
Expectancy [%]	5.172994
SQN	1.256643
_strategy	MACDCross

In the case of Tesla, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 2,474.63%. This amounted to a total equity of $257,463.13 by the end of the ten year period. Additionally, the return per year was 38.43%. There were a total of 96 trades that were conducted by our model. The best trade earned us a return of 144.46% and the worst trade lost us 16.13%. The average trade percentage was 3.44% which means that for every trade, we earned 3.44% on average. Lastly, the average trade duration is 20 days which means that we held the stock for 20 days on average before selling it.

```
Tesla (TSLA) - Optimized

/usr/local/lib/python3.8/dist-packages/backtest
  output = _optimize_grid()
```

Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	52.443385
Equity Final [$]	1073117.725123
Equity Peak [$]	1307728.491541
Return [%]	10631.177251
Buy & Hold Return [%]	9193.476623
Return (Ann.) [%]	59.700681
Volatility (Ann.) [%]	64.914514
Sharpe Ratio	0.919682
Sortino Ratio	2.511069
Calmar Ratio	1.769802
Max. Drawdown [%]	-33.732971
Avg. Drawdown [%]	-6.96412
Max. Drawdown Duration	854 days 00:00:00
Avg. Drawdown Duration	43 days 00:00:00
# Trades	45
Win Rate [%]	57.777778
Best Trade [%]	140.835299
Worst Trade [%]	-11.630981
Avg. Trade [%]	10.950316
Max. Trade Duration	167 days 00:00:00
Avg. Trade Duration	42 days 00:00:00
Profit Factor	6.271398
Expectancy [%]	14.906985
SQN	1.739358
_strategy	MACDCross(fast=2...

After optimization, we see that the total return has improved to 10,631.18%. The return per year has increased to 59.70%. The total number of trades conducted during the 10 year period have decreased to 45 trades. The best trade now earns us a return of 140.84%. The worst trade now loses us 11.63%. The average trade percentage has increased to 10.95%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 25, slow = 75, signal = 15.

Google

Google (GOOGL)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	53.198252
Equity Final [$]	12749.432745
Equity Peak [$]	22539.561079
Return [%]	27.494327
Buy & Hold Return [%]	490.824656
Return (Ann.) [%]	2.461724
Volatility (Ann.) [%]	18.719607
Sharpe Ratio	0.131505
Sortino Ratio	0.20769
Calmar Ratio	0.056636
Max. Drawdown [%]	-43.465921
Avg. Drawdown [%]	-4.463266
Max. Drawdown Duration	824 days 00:00:00
Avg. Drawdown Duration	83 days 00:00:00
# Trades	109
Win Rate [%]	38.53211
Best Trade [%]	23.210372
Worst Trade [%]	-11.757359
Avg. Trade [%]	0.222343
Max. Trade Duration	54 days 00:00:00
Avg. Trade Duration	17 days 00:00:00
Profit Factor	1.2253
Expectancy [%]	0.358217
SQN	0.355471
_strategy	MACDCross

In the case of Google, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 27.49%. This amounted to a total equity of $12,749.43 by the end of the ten year period. Additionally, the return per year was 2.46%. There were a total of 109 trades that were conducted by our model. The best trade earned us a return of 23.21% and the worst trade lost us 11.76%. The average trade percentage was 0.22% which means that for every trade, we earned 0.22% on average. Lastly, the average trade duration is 17 days which means that we held the stock for 17 days on average before selling it.

Google (GOOGL) - Optimized	
/usr/local/lib/python3.8/dist-packages/backtest	
output = _optimize_grid()	
Backtest.optimize: 0%|	| 0/4 [00:00
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	51.609058
Equity Final [$]	29494.139091
Equity Peak [$]	35392.63015
Return [%]	194.941391
Buy & Hold Return [%]	490.824656
Return (Ann.) [%]	11.437038
Volatility (Ann.) [%]	18.646091
Sharpe Ratio	0.613375
Sortino Ratio	1.04133
Calmar Ratio	0.641747
Max. Drawdown [%]	-17.821716
Avg. Drawdown [%]	-3.349474
Max. Drawdown Duration	506 days 00:00:00
Avg. Drawdown Duration	46 days 00:00:00
# Trades	17
Win Rate [%]	76.470588
Best Trade [%]	54.740317
Worst Trade [%]	-10.815791
Avg. Trade [%]	6.575648
Max. Trade Duration	328 days 00:00:00
Avg. Trade Duration	110 days 00:00:00
Profit Factor	7.715196
Expectancy [%]	7.439178
SQN	1.543615
_strategy	MACDCross(fast=4...

After optimization, we see that the total return has improved to 194.94%. The return per year has increased to 11.44%. The total number of trades conducted during the 10 year period have decreased to 17 trades. The best trade now earns us a return of 54.74%. The worst trade now loses us 10.82%. The average trade percentage has increased to 6.58%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 45, slow = 85, signal = 85.

Meta

Meta (META)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	53.436631
Equity Final [$]	7199.515989
Equity Peak [$]	22132.781492
Return [%]	-28.00484
Buy & Hold Return [%]	415.200725
Return (Ann.) [%]	-3.236109
Volatility (Ann.) [%]	25.788914
Sharpe Ratio	0.0
Sortino Ratio	0.0
Calmar Ratio	0.0
Max. Drawdown [%]	-68.498869
Avg. Drawdown [%]	-11.407427
Max. Drawdown Duration	1029 days 00:00:00
Avg. Drawdown Duration	163 days 00:00:00
# Trades	105
Win Rate [%]	36.190476
Best Trade [%]	53.288371
Worst Trade [%]	-27.361584
Avg. Trade [%]	-0.322918
Max. Trade Duration	67 days 00:00:00
Avg. Trade Duration	18 days 00:00:00
Profit Factor	1.022035
Expectancy [%]	0.06184
SQN	-0.241397
_strategy	MACDCross

In the case of Meta, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was -28.04%. This amounted to a total equity of $7,199.52 by the end of the ten year period. Additionally, the return per year was -3.24%. There were a total of 105 trades that were conducted by our model. The best trade earned us a return of 53.29% and the worst trade lost us 27.36%. The average trade percentage was -0.32% which means that for every trade, we lost -0.32% on average. Lastly, the average trade duration is 18 days which means that we held the stock for 18 days on average before selling it.

Meta (META) - Optimized

```
/usr/local/lib/python3.8/dist-packages/backtest
  output = _optimize_grid()
```

Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	51.17203
Equity Final [$]	31059.272827
Equity Peak [$]	58220.201538
Return [%]	210.592728
Buy & Hold Return [%]	415.200725
Return (Ann.) [%]	12.015415
Volatility (Ann.) [%]	28.411047
Sharpe Ratio	0.422913
Sortino Ratio	0.73719
Calmar Ratio	0.257554
Max. Drawdown [%]	-46.652069
Avg. Drawdown [%]	-5.258731
Max. Drawdown Duration	596 days 00:00:00
Avg. Drawdown Duration	55 days 00:00:00
# Trades	44
Win Rate [%]	50.0
Best Trade [%]	99.441566
Worst Trade [%]	-19.92566
Avg. Trade [%]	2.614953
Max. Trade Duration	138 days 00:00:00
Avg. Trade Duration	41 days 00:00:00
Profit Factor	2.445658
Expectancy [%]	3.775078
SQN	0.830878
_strategy	MACDCross(fast=1...

After optimization, we see that the total return has improved to 210.59%. The return per year has increased to 12.02%. The total number of trades conducted during the 10 year period have decreased to 44 trades. The best trade now earns us a return of 99.44%. The worst trade now loses us 19.93%. The average trade percentage has increased to 2.61%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 15, slow = 35, signal = 95.

Nvidia

Nvidia (NVDA)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	54.628526
Equity Final [$]	43797.297585
Equity Peak [$]	59143.368767
Return [%]	337.972976
Buy & Hold Return [%]	5523.813453
Return (Ann.) [%]	15.936767
Volatility (Ann.) [%]	34.935011
Sharpe Ratio	0.456183
Sortino Ratio	0.801603
Calmar Ratio	0.288658
Max. Drawdown [%]	-55.20981
Avg. Drawdown [%]	-6.053538
Max. Drawdown Duration	931 days 00:00:00
Avg. Drawdown Duration	66 days 00:00:00
# Trades	108
Win Rate [%]	41.666667
Best Trade [%]	49.961145
Worst Trade [%]	-25.295482
Avg. Trade [%]	1.377628
Max. Trade Duration	55 days 00:00:00
Avg. Trade Duration	17 days 00:00:00
Profit Factor	1.798136
Expectancy [%]	1.899084
SQN	1.128165
_strategy	MACDCross

In the case of Nvidia, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 337.97%. This amounted to a total equity of $43,797.30 by the end of the ten year period. Additionally, the return per year was 15.94%. There were a total of 108 trades that were conducted by our model. The best trade earned us a return of 49.96% and the worst trade lost us 25.30%. The average trade percentage was 1.38% which means that for every trade, we earned 1.38% on average. Lastly, the average trade duration is 17 days which means that we held the stock for 17 days on average before selling it.

Nvidia (NVDA) - Optimized	
/usr/local/lib/python3.8/dist-packages/backtest	
output = _optimize_grid()	
Backtest.optimize: 0% | | 0/4 [00:00<	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	55.661502
Equity Final [$]	137396.085067
Equity Peak [$]	185546.415679
Return [%]	1273.960851
Buy & Hold Return [%]	5523.813453
Return (Ann.) [%]	29.996922
Volatility (Ann.) [%]	37.825189
Sharpe Ratio	0.793041
Sortino Ratio	1.610353
Calmar Ratio	0.661367
Max. Drawdown [%]	-45.355927
Avg. Drawdown [%]	-4.461984
Max. Drawdown Duration	523 days 00:00:00
Avg. Drawdown Duration	40 days 00:00:00
# Trades	149
Win Rate [%]	50.33557
Best Trade [%]	42.888005
Worst Trade [%]	-14.893751
Avg. Trade [%]	1.775049
Max. Trade Duration	49 days 00:00:00
Avg. Trade Duration	13 days 00:00:00
Profit Factor	2.257972
Expectancy [%]	2.063998
SQN	1.484981
_strategy	MACDCross(fast=5...

After optimization, we see that the total return has improved to 1,273.96%. The return per year has increased to 30.00%. The total number of trades conducted during the 10 year period have increased to 149 trades. The best trade now earns us a return of 42.89%. The worst trade now loses us 14.90%. The average trade percentage has increased to 1.78%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 5, slow = 55, signal = 5.

PepsiCo

PepsiCo (PEP)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	52.920143
Equity Final [$]	18124.728401
Equity Peak [$]	18380.382881
Return [%]	81.247284
Buy & Hold Return [%]	159.172884
Return (Ann.) [%]	6.134831
Volatility (Ann.) [%]	11.293415
Sharpe Ratio	0.543222
Sortino Ratio	0.85392
Calmar Ratio	0.36487
Max. Drawdown [%]	-16.813768
Avg. Drawdown [%]	-2.994237
Max. Drawdown Duration	1410 days 00:00:00
Avg. Drawdown Duration	81 days 00:00:00
# Trades	101
Win Rate [%]	44.554455
Best Trade [%]	14.466063
Worst Trade [%]	-7.307055
Avg. Trade [%]	0.592955
Max. Trade Duration	55 days 00:00:00
Avg. Trade Duration	18 days 00:00:00
Profit Factor	1.681465
Expectancy [%]	0.650585
SQN	1.729116
_strategy	MACDCross

In the case of PepsiCo, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 81.25%. This amounted to a total equity of $18,124.73 by the end of the ten year period. Additionally, the return per year was 6.13%. There were a total of 101 trades that were conducted by our model. The best trade earned us a return of 14.47% and the worst trade lost us 7.31%. The average trade percentage was 0.59% which means that for every trade, we earned 0.59% on average. Lastly, the average trade duration is 18 days which means that we held the stock for 18 days on average before selling it.

PepsiCo (PEP) - Optimized

```
/usr/local/lib/python3.8/dist-packages/backtest
  output = _optimize_grid()
```

Backtest.optimize: 0%

Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	52.205006
Equity Final [$]	18565.066658
Equity Peak [$]	18931.746407
Return [%]	85.650667
Buy & Hold Return [%]	159.172884
Return (Ann.) [%]	6.390213
Volatility (Ann.) [%]	11.0016
Sharpe Ratio	0.580844
Sortino Ratio	0.920884
Calmar Ratio	0.372257
Max. Drawdown [%]	-17.16615
Avg. Drawdown [%]	-2.237578
Max. Drawdown Duration	1541 days 00:00:00
Avg. Drawdown Duration	73 days 00:00:00
# Trades	74
Win Rate [%]	45.945946
Best Trade [%]	16.737938
Worst Trade [%]	-4.509647
Avg. Trade [%]	0.844506
Max. Trade Duration	79 days 00:00:00
Avg. Trade Duration	25 days 00:00:00
Profit Factor	1.954101
Expectancy [%]	0.918147
SQN	2.09178
_strategy	MACDCross(fast=1...

After optimization, we see that the total return has improved to 85.65%. The return per year has increased to 6.39%. The total number of trades conducted during the 10 year period have decreased to 74 trades. The best trade now earns us a return of 16.74%. The worst trade now loses us 4.51%. The average trade percentage has increased to 0.85%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 15, slow = 25, signal = 15.

Costco

Costco (COST)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	53.794199
Equity Final [$]	26876.180695
Equity Peak [$]	26876.180695
Return [%]	168.761807
Buy & Hold Return [%]	432.580992
Return (Ann.) [%]	10.404794
Volatility (Ann.) [%]	14.701788
Sharpe Ratio	0.707723
Sortino Ratio	1.155427
Calmar Ratio	0.493593
Max. Drawdown [%]	-21.079718
Avg. Drawdown [%]	-3.249376
Max. Drawdown Duration	477 days 00:00:00
Avg. Drawdown Duration	59 days 00:00:00
# Trades	96
Win Rate [%]	43.75
Best Trade [%]	17.416145
Worst Trade [%]	-6.276882
Avg. Trade [%]	1.042857
Max. Trade Duration	71 days 00:00:00
Avg. Trade Duration	20 days 00:00:00
Profit Factor	2.020978
Expectancy [%]	1.154254
SQN	2.09578
strategy	MACDCross

In the case of Costco, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 168.76%. This amounted to a total equity of $26,876.18 by the end of the ten year period. Additionally, the return per year was 10.40%. There were a total of 96 trades that were conducted by our model. The best trade earned us a return of 17.42% and the worst trade lost us 6.28%. The average trade percentage was 1.04% which means that for every trade, we earned 1.04% on average. Lastly, the average trade duration is 20 days which means that we held the stock for 20 days on average before selling it.

Costco (COST) - Optimized	
/usr/local/lib/python3.8/dist-packages/backtest output = _optimize_grid()	
Backtest.optimize: 0%	0/4 [00:00<
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	53.75447
Equity Final [$]	36968.403114
Equity Peak [$]	37647.761757
Return [%]	269.684031
Buy & Hold Return [%]	432.580992
Return (Ann.) [%]	13.985799
Volatility (Ann.) [%]	14.398559
Sharpe Ratio	0.971333
Sortino Ratio	1.617948
Calmar Ratio	0.799735
Max. Drawdown [%]	-17.488042
Avg. Drawdown [%]	-2.426002
Max. Drawdown Duration	407 days 00:00:00
Avg. Drawdown Duration	38 days 00:00:00
# Trades	65
Win Rate [%]	46.153846
Best Trade [%]	17.535432
Worst Trade [%]	-5.98266
Avg. Trade [%]	2.045674
Max. Trade Duration	103 days 00:00:00
Avg. Trade Duration	29 days 00:00:00
Profit Factor	3.497714
Expectancy [%]	2.187501
SQN	3.035791
_strategy	MACDCross(fast=5...

After optimization, we see that the total return has improved to 269.68%. The return per year has increased to 13.99%. The total number of trades conducted during the 10 year period have decreased to 65 trades. The best trade now earns us a return of 17.54%. The worst trade now loses us 5.98%. The average trade percentage has increased to 2.05%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 5, slow = 25, signal = 75.

Broadcom Inc

Broadcom Inc (AVGO)	
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	54.231228
Equity Final [$]	48467.335716
Equity Peak [$]	62213.801323
Return [%]	384.673357
Buy & Hold Return [%]	1491.379754
Return (Ann.) [%]	17.1188
Volatility (Ann.) [%]	27.127271
Sharpe Ratio	0.631055
Sortino Ratio	1.17975
Calmar Ratio	0.520901
Max. Drawdown [%]	-32.863845
Avg. Drawdown [%]	-5.024422
Max. Drawdown Duration	346 days 00:00:00
Avg. Drawdown Duration	49 days 00:00:00
# Trades	96
Win Rate [%]	44.791667
Best Trade [%]	21.959272
Worst Trade [%]	-10.347525
Avg. Trade [%]	1.662047
Max. Trade Duration	55 days 00:00:00
Avg. Trade Duration	20 days 00:00:00
Profit Factor	2.024648
Expectancy [%]	1.931298
SQN	1.612599
_strategy	MACDCross

In the case of Broadcom Inc, we can see that the time frame for our analysis is from 15th November 2012 till 14th November 2022. Our investment was $10,000 and our total return over the ten year period was 384.67%. This amounted to a total equity of $48,467.34 by the end of the ten year period. Additionally, the return per year was 17.12%. There were a total of 96 trades that were conducted by our model. The best trade earned us a return of 21.96% and the worst trade lost us 10.35%. The average trade percentage was 1.66% which means that for every trade, we earned 1.66% on average. Lastly, the average trade duration is 20 days which means that we held the stock for 20 days on average before selling it.

Broadcom (AVGO) - Optimized	
/usr/local/lib/python3.8/dist-packages/backtest	
output = _optimize_grid()	
Backtest.optimize: 0%|	| 0/4 [00:00<
Start	2012-11-15 00:00:00
End	2022-11-14 00:00:00
Duration	3651 days 00:00:00
Exposure Time [%]	52.483115
Equity Final [$]	72429.816154
Equity Peak [$]	78275.163017
Return [%]	624.298162
Buy & Hold Return [%]	1491.379754
Return (Ann.) [%]	21.925412
Volatility (Ann.) [%]	26.727053
Sharpe Ratio	0.820345
Sortino Ratio	1.638328
Calmar Ratio	1.058013
Max. Drawdown [%]	-20.723198
Avg. Drawdown [%]	-4.47667
Max. Drawdown Duration	322 days 00:00:00
Avg. Drawdown Duration	44 days 00:00:00
# Trades	50
Win Rate [%]	56.0
Best Trade [%]	20.665298
Worst Trade [%]	-8.724939
Avg. Trade [%]	4.048329
Max. Trade Duration	99 days 00:00:00
Avg. Trade Duration	37 days 00:00:00
Profit Factor	4.316942
Expectancy [%]	4.345421
SQN	2.872991
_strategy	MACDCross(fast=1...

After optimization, we see that the total return has improved to 624.30%. The return per year has increased to 21.93%. The total number of trades conducted during the 10 year period have decreased to 50 trades. The best trade now earns us a return of 20.67%. The worst trade now loses us 8.72%. The average trade percentage has increased to 4.05%. Furthermore, our model estimates these periods to be the best performing parameters: fast = 15, slow = 25, signal = 55.

Conclusion

In this research paper, we created strategies to buy and sell stock using MACD. We ran two versions of our model. In the first model, we used default periods for MACD. And in the second version, we ran the same model but optimized the periods. And we learned that by optimizing the parameters of MACD, we can improve our returns.

If we look at the average return for our ten stocks across the 10 year period, we get an overall average return of 406.74%. And once we optimize the MACD parameters, we get an overall average return of 1,459.67%. Moreover, the average return per year for the 10 stocks is 11.63%. And after optimization, the average return per year comes out to 20.82%.

According to Market & Research, the 10 year return for TDB908 was 15.92%. By using our optimized strategy, we were able to beat those returns by achieving 20.82%. In order to improve our strategies, we would need to run more variations of this model with more stocks and a larger data set. Additionally, we can create new strategies by incorporating other metrics such as RSI and Bollinger Bands. We learned a great deal about trading strategies and programming in this project and also this course as a whole.

References

TDB908 Performance & Returns | TD NASDAQ Index - e. https://ycharts.com/mutual_funds/M:TDB908.TO/performance. Accessed 9 Dec. 2022.

Pat Tong Chio. (2022). A comparative study of the MACD-base trading strategies: evidence from the US stock market. arXiv.org.

Bhandari, B. (2011). Trading stocks with MACD. Futures (Cedar Falls, Iowa), 40(12), 32–.

Mutual Funds Profile Performance & Risk. https://marketsandresearch.td.com/tdwca/Public/MutualFundsProfile/PerformanceAndRisk/ca/TDB908. Accessed 9 Dec. 2022.

Backtesting: Backtest Trading Strategies in Python. OS Independent. PyPI, https://kernc.github.io/backtesting.py/. Accessed 9 Dec. 2022.