

Development & Statistical validation of an Integrated Stock Trading Algorithm

Abstract

Many people and financial companies invest in the stock market for retirement, college or other financial goals. There are 3 commonly used techniques for such investments in stocks: Buy and Hold (lumpsum buy at the start of the investing period and hold it till the end of the investing period), Dollar Cost Averaging (monthly buys and then hold till the end of the investing period) and Game Theory based Active trading based on a 50 Day Moving Average buy-sell signal within the investing period. For the purposes of this study, I have looked at the performance of these investment methods by applying them to the S&P500 index (which is a collection of the roughly 500 large companies in the United States). After reviewing the performance of these 3 approaches based on actual data from www.Yahoo.com/Finance, I analyzed the strengths and weaknesses of each approach. Then I developed an Integrated Stock Trading Algorithm (ISTA) that builds on the strength of these 3 approaches to deliver an improved result. Using historical actual market data from www.Yahoo.com/Finance, I have conducted statistical analysis to validate that the results of the proposed algorithm. Using Minitab 19, I ran a Two Sample Equivalence Test with alpha of 0.05 comparing the mean returns from the Algorithm(ISTA) and the Buy and Hold (Lumpsum method) which was the second highest method. I obtained a p value of 0.013 which is less than 0.05 and therefore validated that ISTA gives statistically better mean performance than Buy and Hold (Lumpsum) method.

What is the S&P 500 ?

The Standard and Poor's 500 Index is commonly referred to as the S&P 500 is a grouping of the roughly 500 large US publicly traded companies. The main companies in the index currently are the top technology and financial businesses such as Microsoft, Apple, Samsung, JP Morgan, Chase, Goldman Sachs etc. The S&P 500 was chosen for this study since it is very popular and it broadly represents the overall US stock market. Also, there is good accurate data available on www.Yahoo.com/Finance for proper analysis going back over 50 years to be able to complete this project.

What are the common investment methods?

Buy and Hold (Lumpsum)



Figure 1

Buy and Hold (Lumpsum) refers to an investor buying (for example \$ 100 worth of the S&P500) and holding it for the entire investment period (for example 10 years) and then selling it at the end. This is a passive strategy, very simple to follow and implement. The logic applied here is that over the long term, the market tends to rise, so buying low and selling high should be possible using this approach.

Dollar Cost Averaging

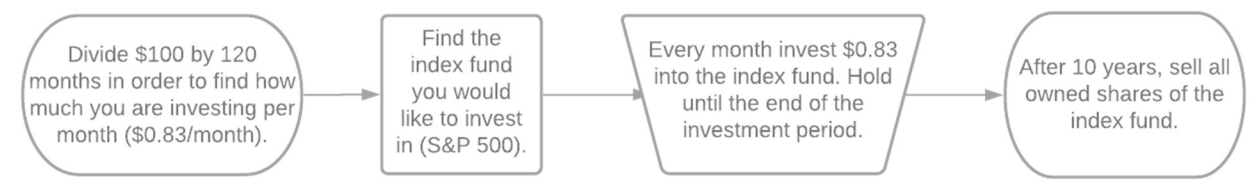


Figure 2

Buying the entire investment at 1 time (such as in the lumpsum method) carries a risk of possibly paying too much as value of the investment can change over time. To reduce this risk, the Dollar Cost Averaging method spreads the investment in smaller portions over the investment period. For example, the \$ 100 to be invested over 10 years can be spread into equal amounts over that time period meaning, over the 120 months over 10 years, one can invest equal amounts ($\$ 100 / 120 = \0.83 per month).

50 DMA

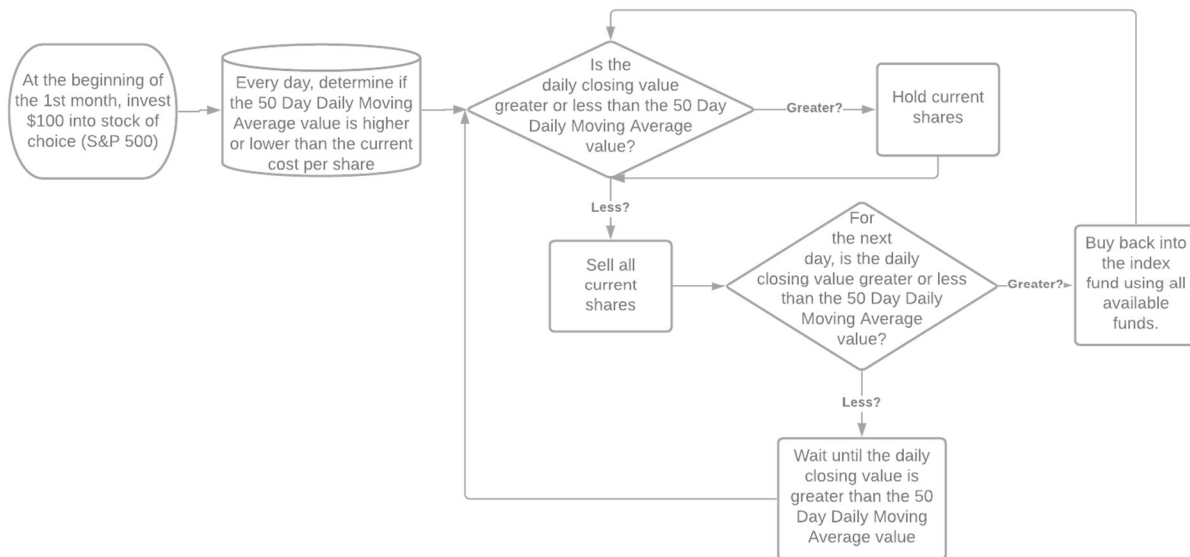


Figure 3

The 50 DMA is a popular metric used by investors and traders to determine buy and sell decisions. 50 DMA stands for 50 Day Moving Average. Basically, it is the average value for the last 50 days. The daily value is compared with the 50 DMA to determine the overall trend. If the Daily value falls below the 50 DMA value, the investor may determine that as a sell signal. Conversely, if the daily value breaks through the 50 DMA value, it may be used to determine a Buy signal. This is an active trading strategy and involves staying on top of the market happenings and making corresponding trades. It involves a Game Theory approach that considers the possible response of the market to these trend signals and tries to improve the outcome of the investment decision.

Study Approach

The initial aim of the study was to compare the performance of the 3 investment approaches.

After reviewing the performance of the approaches, the strengths and weaknesses of each approach were analyzed. Then leveraging the strengths, a better investment approach in the form of an Integrated Stock Trading Algorithm was generated to deliver improved returns.

Finally, data analysis was performed to confirm that the algorithm did provide improved returns. I reviewed the S&P 500 performance (% increase in value) over a period of 10year samples. These 10year samples were taken over a 40year period starting in 1970 to 2009 (both years included). This 40year time-frame provides thirty-one 10year time periods for this study. For example:1970-1979, 1971-1980 and 1972-1980 all the way till 2000 – 2009.

The data was taken from www.Yahoo.com/Finance which provides the historical daily, monthly, opening and closing values of the S&P 500.

The 10year time frame represents a long-term investing period which would be typical for retirement savings or college savings or building wealth over a long period of time.

To keep the analysis simple and focused on the differences of the approaches, the effects of Trading fees, Commissions, Dividends etc were not considered.

The investment amount for each investment time period (10years) was \$ 100.

Buy and Hold (Lumpsum) Method:

Buy and Hold (Lumpsum) investments were treated as follows:

For each 10year investment period, invest \$ 100 at the end of 1st month and hold till end of investment period (10 years).

Calculate the % increase in value of the S&P 500 over this period.

Based on it, determine the return of the \$100 investment. For example:

S&P500 value ending Jan 1970	92.06
S&P500 value ending Dec 1979	107.94
% change	17.25%

Therefore \$ 100 invested in Jan 1970 will give \$ 117.25 in 10 years (ending in Dec 1979). Similarly, performing calculations for the other 10year periods, the results are as below:

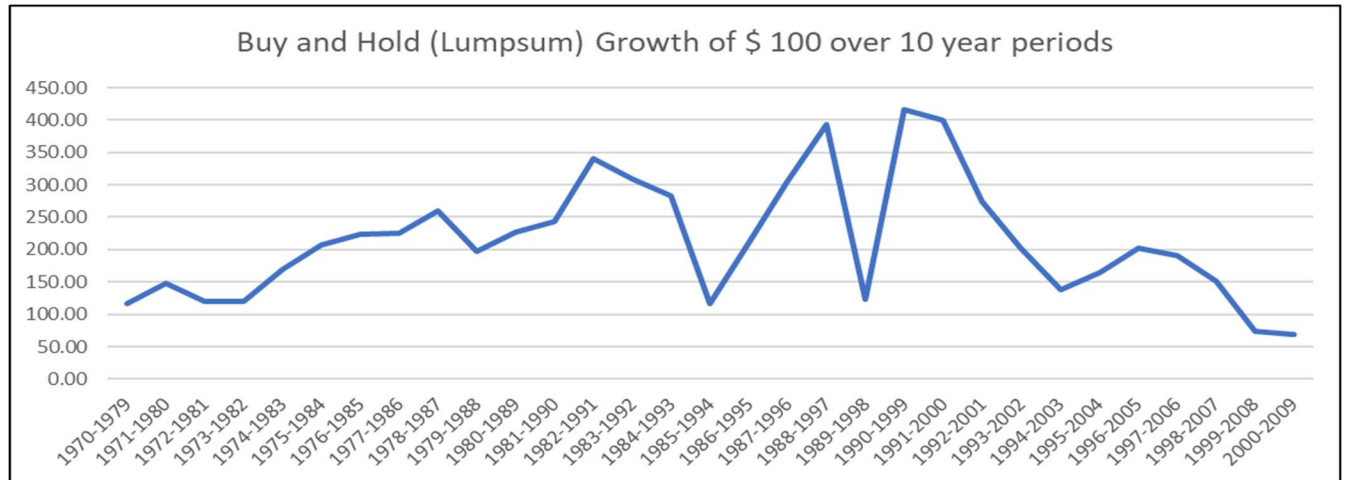


Figure 4

Dollar Cost Averaging Method:

Dollar Cost Averaging investments were treated as follows:

Every 10year period will consist of 120 months. Buy equal amount ($\$100/120 = \0.83) at the end of every month and hold till end of investment period (10 years).

At the end of the investment period based on the % increase in the S&P 500, calculate the return obtained with this method. For example:

Buy \$0.83 of S&P500 in Jan 1970 (when it's value was 92.06) and then sell it in December 1979 (when it's value was 107.94). The S&P 500 grew 17.25 % over that time period, so the initial \$0.83 would then be worth \$0.98 (17.25 % increase).

Then in Feb 1970 buy \$0.83 of S&P500 again (when it's value was 85.02) and then sell it in Dec 1979(when it's value was 107.94). Since the S&P500 grew 26.75% over that time frame, the initial investment of this \$ 0.83 will be worth \$1.05 (26.75%).

Do this for every month between Jan 1970 to Dec 1979. Then add all the final values in Dec 1979 to give the total investment performance for that time period. In this example, the total is \$ 113.45.

Following the same approach for the other 10 Year periods, I got the results as below:

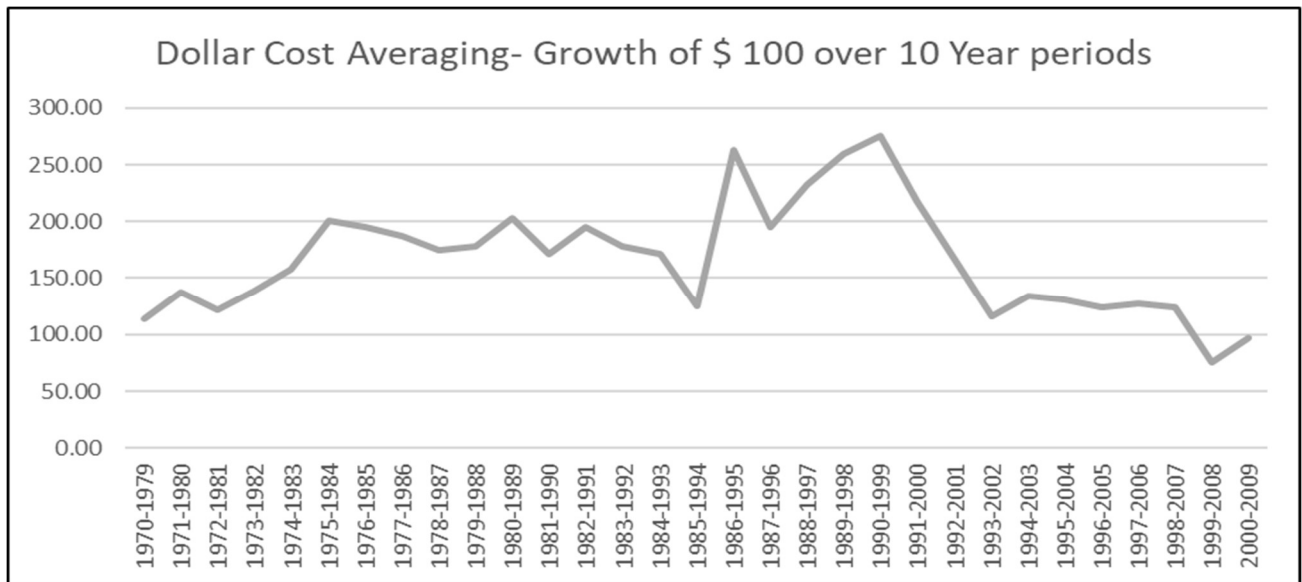


Figure 5

50 DMA investments were treated as follows. For each 10year period, in the 1st month start with an initial investment of \$ 100 in the S&P500. Then every day, compare the daily value of the S&P500 with the 50 DMA of the S&P 500 (50 DMA is simply the average of the previous 50 Days of the S&P500 values). If the daily value is greater than the 50DMA, do nothing (ie hold your investment). If the daily value goes below the 50 DMA, then sell all your investment. Then each following day, keep comparing the daily value with the 50 DMA. If the daily value exceeds the 50 DMA then buy the S&P500 with all the money available. At the end of the 10 year period, sell all the investments. At the end of 10 years, determine the value of the initial \$ 100 investment.

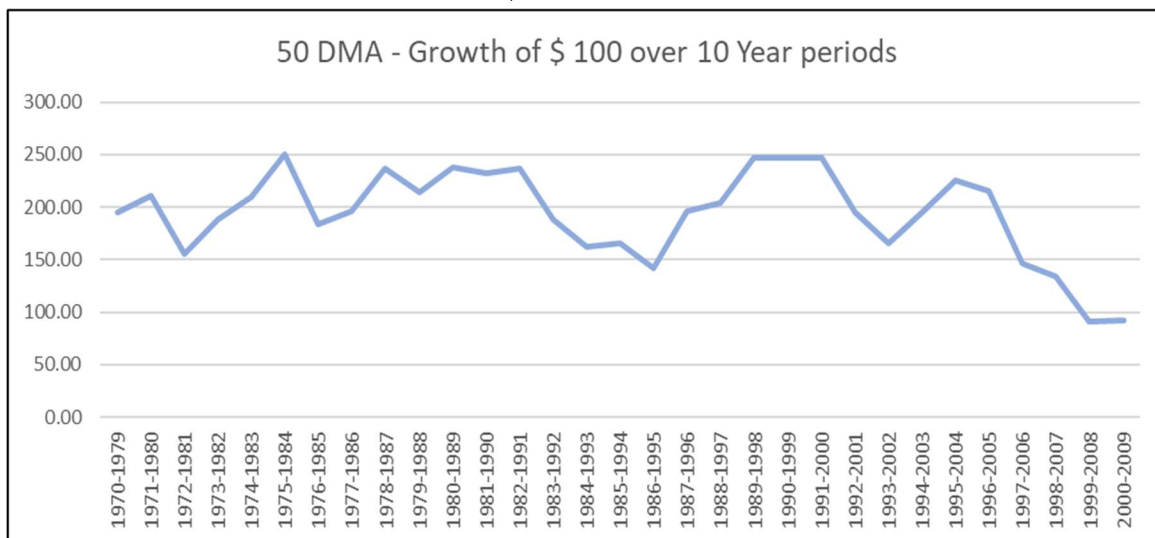


Figure 6

Analysis of the 3 Investment approaches:

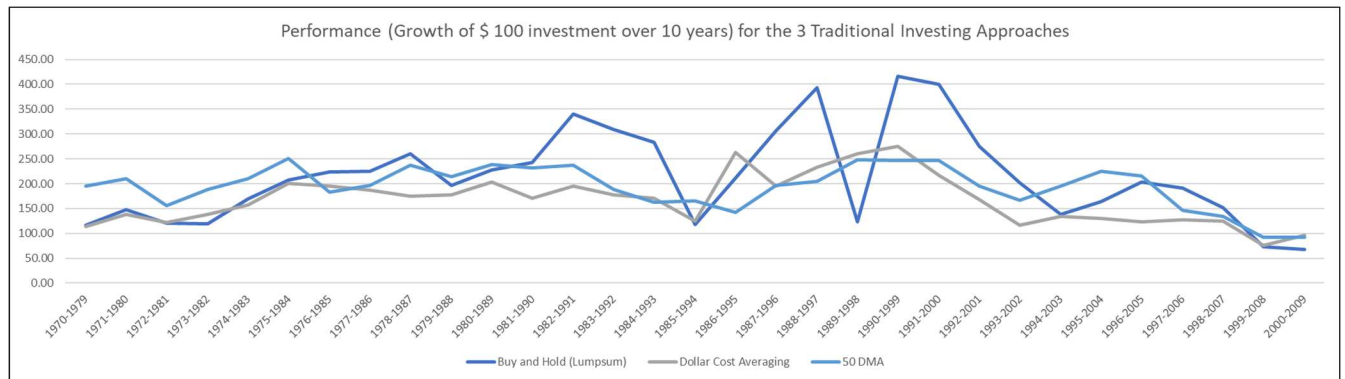


Figure 7

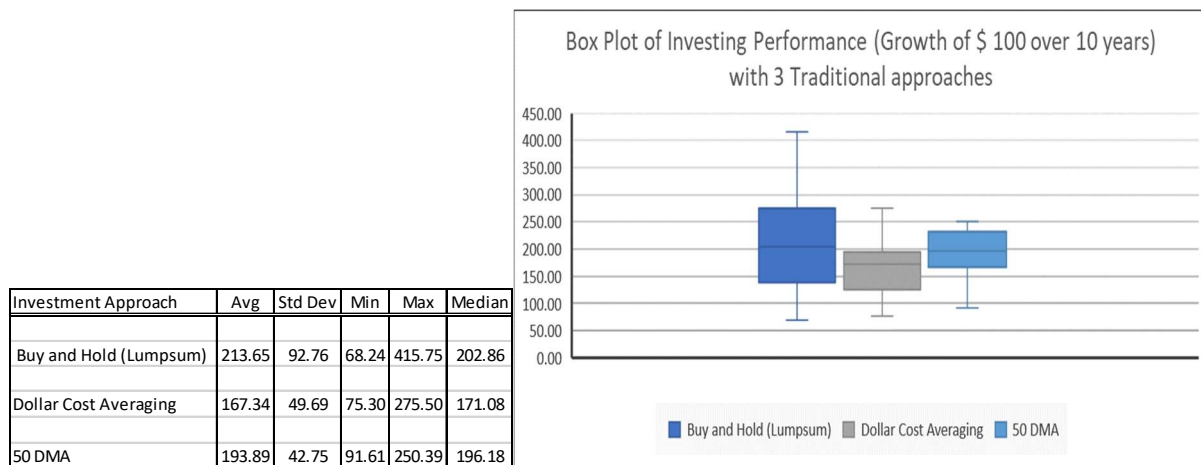


Figure 8

Key Observations from the data review:

1. Lumpsum Buy and Hold provides the highest average returns.
2. 50 DMA has the highest lowest return for the 10 year periods. The DMA method is helpful in reducing losses during the down market periods. Conversely, this approach has the lowest highest return for the 10 year periods, suggesting the performance tends to get capped due to sub-optimal market timing.
3. Across the 40 year period, there have been long stretches where one approach was vastly superior to the other two. For eg. during the 1970 – 1985 time frame, the 50 DMA performed far better.

Investment Approach	1970-1979	1971-1980	1972-1981	1973-1982	1974-1983	1975-1984
Lumpsum Buy and Hold	116.06	147.33	120.04	119.13	169.07	207.76
Dollar Cost Averaging	113.45	138.01	121.51	138.39	157.42	200.61
50 DMA	195.47	210.38	155.78	187.78	210.19	250.39

Similarly, during the 1981-1993 and the 1990- 2002 periods the Lumpsum Buy and Hold was vastly superior to the other 2 approaches.

Investment Approach	1981-1990	1982-1991	1983-1992	1984-1993	Investment Approach	1990-1999	1991-2000	1992-2001	1993-2002
Lumpsum Buy and Hold	243.22	340.29	309.78	282.87	Lumpsum Buy and Hold	415.75	399.84	275.30	201.93
Dollar Cost Averaging	171.46	195.32	177.66	171.08	Dollar Cost Averaging	275.50	217.22	167.75	116.19
50 DMA	231.98	236.61	188.87	162.81	50 DMA	246.99	246.99	194.88	166.14

Comparison of the 3 approaches: (Green = Strength, Pink= Weakness)

Lumpsum Investing and Hold	Monthly Buy and Hold	50 DMA
Invest \$ 100 end of 1st month and hold till end of investment period (10 years)	Buy prorated amount (\$100/120 = \$0.83) end of every month and hold till end of investment period (10 years)	Buy and Sell (starting with an initial amount of \$ 100) per the 50 DMA buy and sell signals
The entire amount stays invested the entire investment period. Since markets go up over longer periods of time, this results in favorable returns.	Due to the monthly buying pattern, the actual investment period is roughly half of the total investment period.	Ability to take advantage of the momentum shifts in the market
Passive strategy, Do not Need to stay on top of the market.	Monthly buying required.	Active strategy
Simple	Simple	Moderately complex
2 Trades per Investment period	121 Trades per Investment period	Frequent Trading
Need the entire investment amount available upfront.	Do not need the entire investment amount upfront.	Need the entire investment amount available upfront.
	Dollar Cost Averaging	

Devising an Algorithm that leverages the strengths of these 3 approaches:

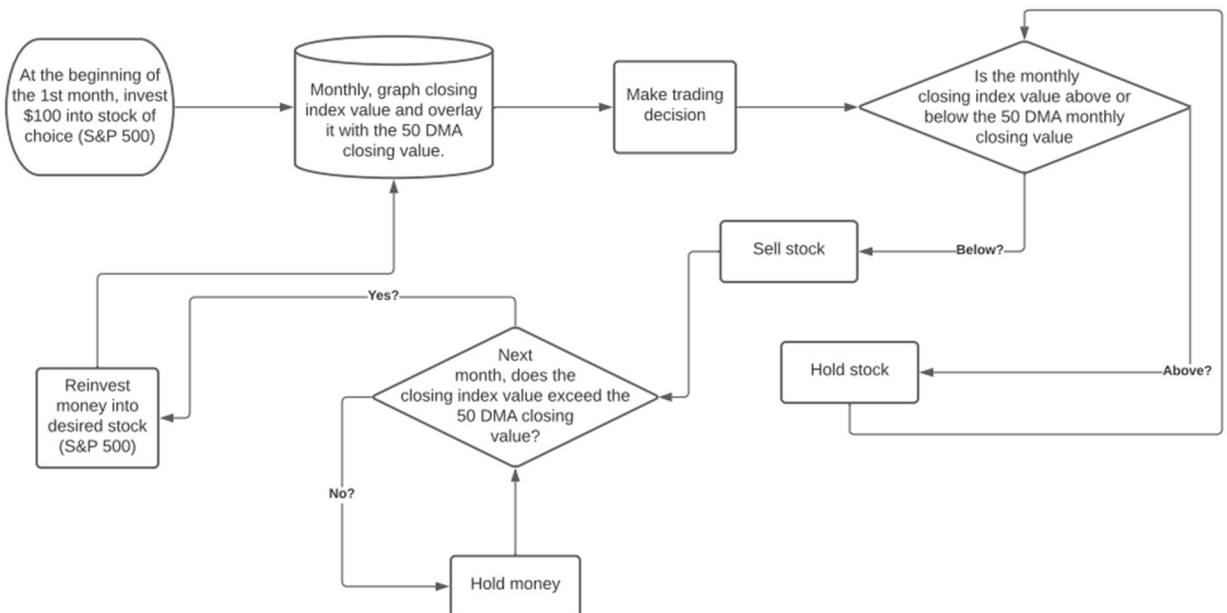
1. Ensure money stays invested for the maximum optimal amount of time possible within the 10year time period. To help achieve this, start by investing all money available at the start of the 10year period regardless of the status of the market.
2. Avoid excessive trading (as compared to the 50 DMA approach). Instill some features from Monthly Buy and Hold approach by reviewing the need

for buy or sell only once per month at an arbitrarily chosen time (end of month).

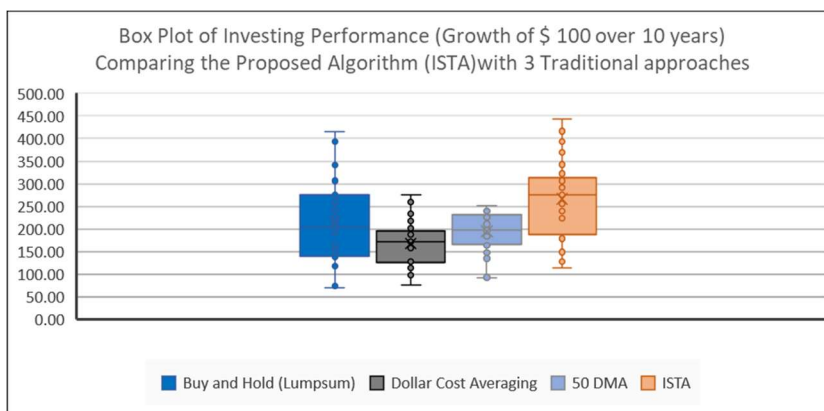
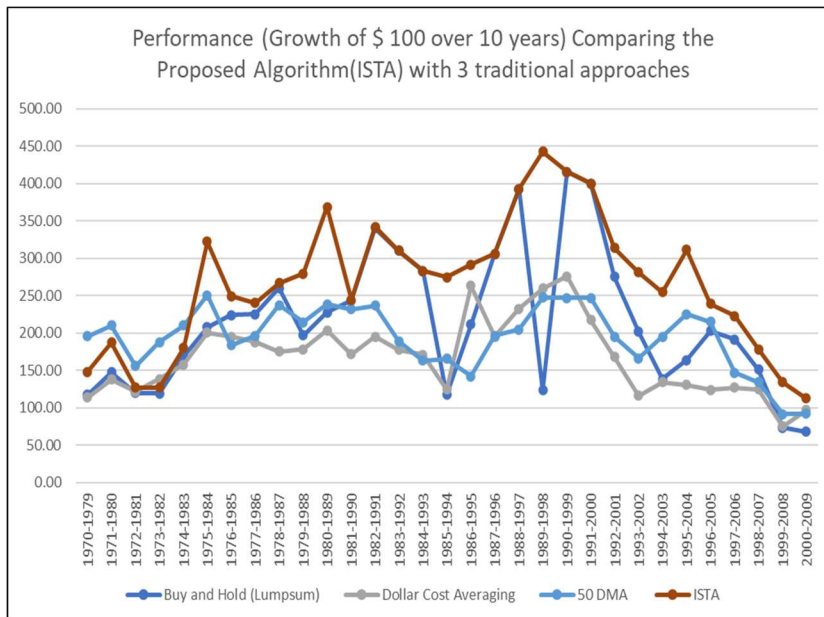
3. Do take advantage of market momentum changes (50DMA approach) but again do that only once per month at the end of the month.
4. Since the Buy Sell decisions are to be made only once per month, the values to consider will be the monthly averages.
5. Keep the process simple. The algorithm should be easy to implement without requiring difficult and complex analysis.

Based of these key points, the ISTA works as follows:

Integrated Trading Algorithm
<ol style="list-style-type: none">1. Invest \$ 100 end of 1st month.2. Make trading decisions only on a monthly basis.3. Graph monthly closing index value and overlay it with the 50 DMA monthly closing value. Sell, when the monthly closing index value dips below the 50 DMA monthly closing value. After the 1st sell, within the 10 year investment period Buy when the monthly closing index value exceeds the 50 DMA monthly closing value.



	Avg	Std Dev	Min	Max	Median
Lumpsum Buy and Hold	213.61	92.80	68.24	415.75	202.86
Monthly Buy and Hold	167.34	49.69	75.30	275.50	171.08
50 DMA	193.89	42.75	91.61	250.39	196.18
ISITA	265.95	88.54	112.38	442.61	274.65



Upon implementing the ISITA :

1. ISITA provides the highest average and median returns
2. ISITA has the highest Min return
3. ISITA has the highest Max return

The 2nd highest returns were from the Buy and Hold (Lumpsum) method.

Statistical validation of the ISTA having higher mean performance was conducted using a Two Sample Equivalence Test using Minitab software.

Two-Sample Equivalence Test: ISTA, Buy and Hold (Lumpsum)

Method

Test mean = mean of ISTA

Reference mean = mean of Buy and Hold (Lumpsum)

Equal variances were not assumed for the analysis.

Descriptive Statistics

Variable	N	Mean	StDev	SE Mean
ISTA	31	265.95	88.543	15.903
Buy and Hold (Lumpsum)	31	213.65	92.757	16.660

Difference: Mean(ISTA) - Mean(Buy and Hold (Lumpsum))

Difference	SE	95% Lower Bound	Lower Limit
52.303	23.031	13.815	0

Lower bound is greater than 0. Can claim Mean(ISTA) > Mean(Buy and Hold (Lumpsum)).

Test

Null hypothesis: Mean(ISTA) - Mean(Buy and Hold (Lumpsum)) ≤ 0

Alternative hypothesis: Mean(ISTA) - Mean(Buy and Hold (Lumpsum)) > 0

α level: 0.05

DF	T-Value	P-Value
59	2.2709	0.013

Conclusion : *P-Value ≤ 0.05 . Can claim Mean (ISTA) > Mean (Buy and Hold (Lumpsum)) Therefore, we have statistical validation that the proposed algorithm (ISTA) provides a higher mean performance than the Buy and Hold (Lumpsum) approach.*