Investigation of the Elliott Wave Oscillator Trading Strategies in the Stock Market

COMP 4971C - Independent Work

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Abstract

This research investigates the trading strategy using the Elliott Wave Oscillator in the stock market based on a daily chart. The initial Elliott Wave Oscillator trading strategy is first defined with three filters that determine a current price trend of a security and generate a buy signal to enter a trade; the corresponding filters have the conditions using the value of the Elliott Wave Oscillator, the slope of the Elliott Wave Oscillator, and a longer-term simple moving average, respectively. The initial strategy is backtested on SPDR S&P 500 ETF Trust, and several modifications and optimizations of crucial parameters and conditions are then introduced one by one to the initial strategy, backtested on two different time frames, and compared with the buy and hold strategy. The result of the research indicates that, after modifications, the Elliott Wave Oscillator trading strategy with four filters generates more reactive buy signals in certain conditions than the initial strategy with three filters and outperforms the buy and hold strategy: in the time frames of 9 and 32 years, the strategy with four filters resulted in a CAGR of 13.13% and 7.886% while the buy and hold strategy resulted in a CAGR of 11.44% and 7.004%, respectively.

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1. Introduction

1.1 Elliott Wave Theory

The Elliott Wave theory, developed by Ralph Nelson Elliott in the 1930s after examining 75 years of stock market behavior, is a theory on which the Elliott Wave Oscillator is based. It suggests that investor psychology causes the price to move up and down repeatedly in the market, eventually forming fractal wave patterns of the price; due to its fractal nature, the price chart shows similar wave patterns regardless of the different time frames, e.g. hourly, daily, and weekly charts, and those patterns can be divided into two basic types of waves: motive and corrective waves.

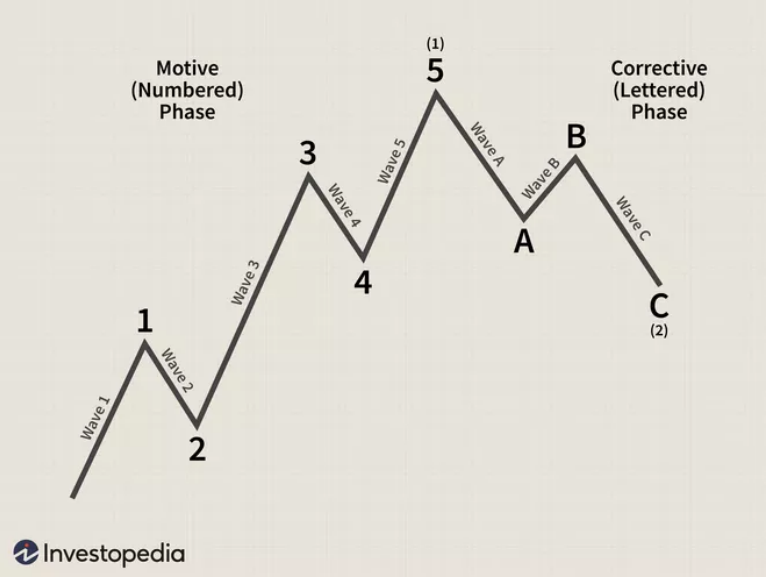

Figure 1. *Elliott Wave Theory*

As seen in the figure, five sub-waves, three of which are motive waves themselves and two of which are corrective waves, are numbered from 1 to 5 to form a motive wave. After a motive wave, a corrective wave pattern, generally composed of three sub-waves (A, B, and C),

occurs and finishes a cycle. Generally, there are only a few rules to find the representative wave pattern, which means that trading opportunities based on the theory could be quite subjective.

1.2 Elliott Wave Oscillator

To reduce subjectivity and difficulty in utilizing the Elliott Wave theory in algorithmic trading, the Elliott Wave Oscillator (EWO) was later introduced. Although it is developed based on the theory, it may help investors make trading decisions, if accompanied by other criteria, without having to focus on identifying different wave patterns themselves in the chart. In general, the EWO refers to the difference between the short-term/fast simple moving average and the long-term/slow simple moving average. A simple moving average (SMA) refers to the average value of the closing prices of a given period and is calculated as follows:

$$SMA_n = \frac{1}{n}\sum_{k=0}^{n-1} CP_k,$$

where n *= length of a period and*

CP_k *= Closing price of k days before the given day*

The EWO is calculated as follows:

$$EWO = SMA_{fast} - SMA_{slow},$$

where fast < slow

By taking the difference between fast SMA and slow SMA, the oscillator shows if the current price is in an uptrend or downtrend judging from the sign of its value. For instance, if 5-day and 35-day SMAs are used to calculate the EWO on around 2019-02, the oscillator has a positive value and the price is in an uptrend because a 5-day SMA is above a 35-day SMA.

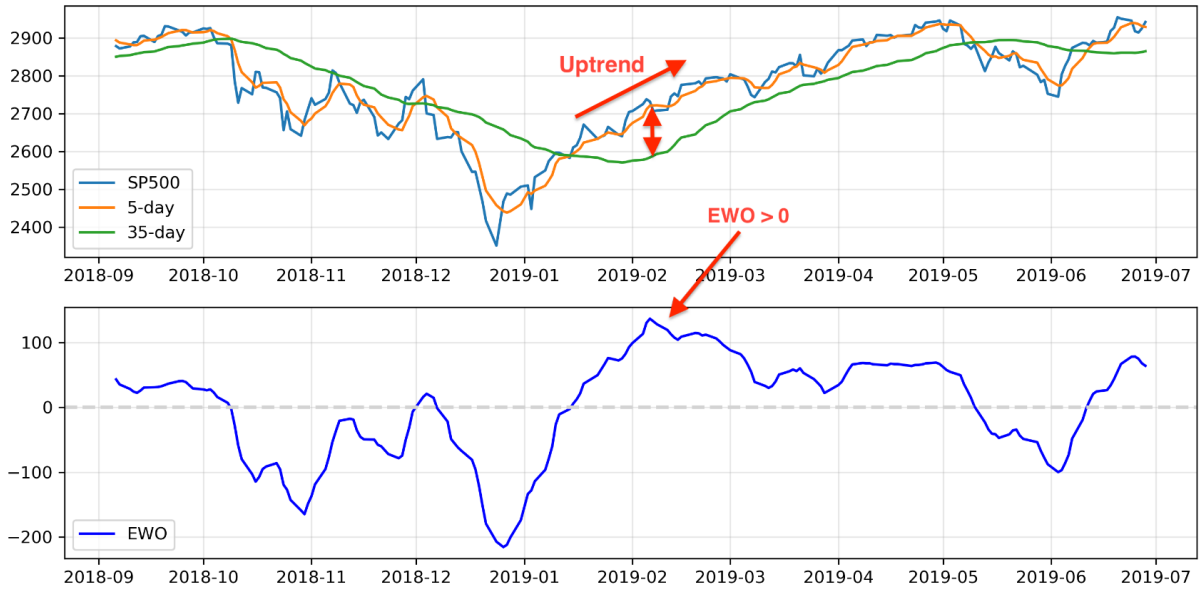

Figure 2. *Example of S&P 500 Index and the corresponding EWO chart*

Although 5-day and 35-day SMAs are used as an illustration, there is no restriction as to what periods should be used. Therefore, different combinations of SMA periods are tested in a later chapter.

1.3 Slope of the EWO

On top of the sign of the EWO value, to better understand the price variation, the slope, or the rate of change, of the EWO should also be considered since it shows how the current price trend is changing. For instance, if both the value of the EWO and its slope are positive, then the price is in an uptrend and that uptrend is continuing or strengthening. However, if the value of the EWO is positive but its slope is negative, then the price is in a weak uptrend or even switched to a downtrend. Therefore, taking a long position at the lowest point (local minimum) of the oscillator (i.e. when the slope of the oscillator has changed from negative to positive) and clearing a position when the uptrend is done (i.e. when the slope of the

oscillator has changed from positive to negative) could be one of the profitable strategies using the oscillator.

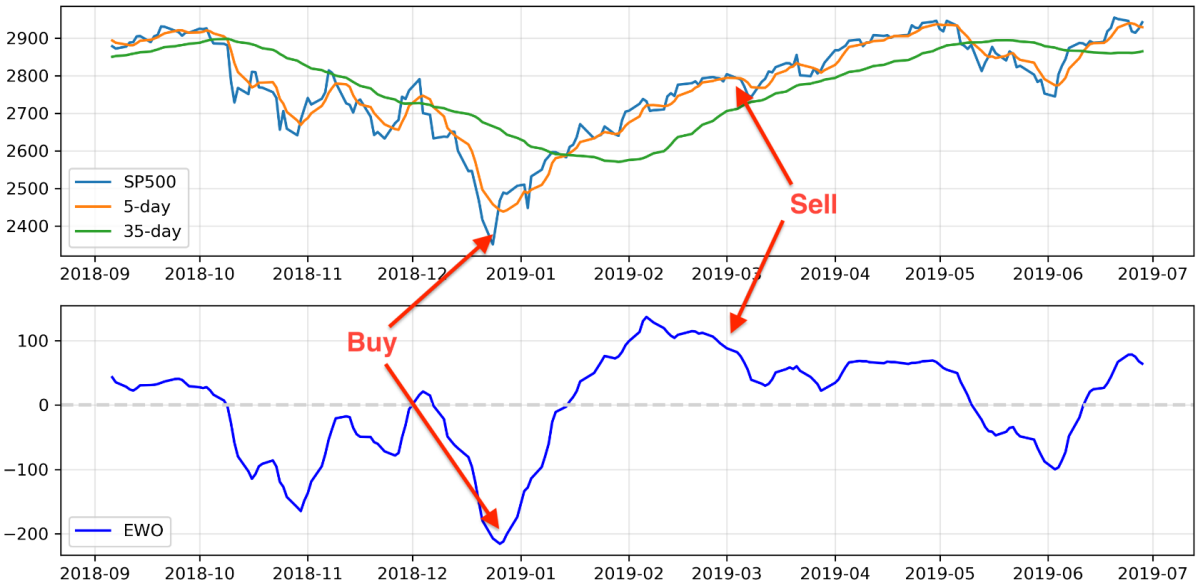

Figure 3. *Example of a potential trading strategy using the EWO*

1.3.1 Ordinary Least Squares

There exist various ways of defining the slope of discrete data, such as the value of the EWO and the closing price of a security, on a given day (e.g. the slope of the EWO on 2019-01-01); for the purpose of this report, the slope of such data refers to the slope of the line of best fit of the series of data, and it is calculated under ordinary least squares (OLS) linear regression. As the name implies, OLS uses the method of least squares by minimizing the total sum of the squares of the differences between the actual value and the value predicted by the line of best fit, and sklearn.linear_model.LinearRegression Python library is used for this purpose. The slope of discrete data in this report is denoted as follows:

$$n\text{-}day\ X_{slope} = Slope\ of\ X\ considering\ n\ most\ recent\ days$$

For instance, to calculate 5-day EWO_{slope} each day, EWO values of the five most recent days are considered each day for the line of best fit's slope.

1.4 Longer-Term SMA

In addition to the potential strategy using the EWO, for the trade to be more reliable, other technical analysis tools can be utilized. Since the Elliott Wave Oscillator is the trend following strategy, taking a long position only when the price is in the longer-term uptrend could be an indicator that supports the EWO strategy. More specifically, when the EWO chart indicates a long trade signal, the current price should also be above a longer-term SMA to buy a security. Similar to SMA periods for calculating the EWO, there is no fixed number for a longer-term SMA period, which will also be tested in a later chapter.

2. Methodology & Initial Backtesting

2.1 Methodology

2.1.1 Libraries

Python 3.9.7 is used throughout the project with several libraries as follows:

Table 1. *Python Library Used*

Library	Usage
pandas_datareader	Import stock data from Yahoo Finance
numpy	Manipulate & analyze imported stock data
pandas	Manipulate & analyze imported stock data
sklearn.linear_model. LinearRegression	Calculate the slope of the line of best fit corresponding to stock data
matplotlib.pyplot	Visualize stock data with 2D graph and 3D heatmap
dataframe_image	Save the image of pandas dataframes as PNG files.
seaborn	Visualize stock data with 2D heatmap
pylab	Visualize stock data with 3D heatmap

2.1.2 Initial Strategy

SPDR S&P 500 ETF Trust (SPY) is investigated throughout the project. To start with, a simple strategy is tested to check how the EWO can be utilized. For this initial strategy, the EWO is defined as the difference between SMA_5 and SMA_{35}, a 5-day period is used for EWO_{slope}, and SMA_{50} and 50-day $Closing\ Price_{slope}$ are used as filters to judge whether the price of the security is in the longer-term uptrend or downtrend.

2.1.2.1 Buy Signal

Three filters, i.e. conditions that have to match simultaneously to take/exit a trade, exist to start a trade and are explained as follows:

$$\textit{Filter 1: EWO} > \textit{1\% of } SMA_5,$$

$$\textit{Filter 2: 5-day } EWO_{slope} > 0, \textit{ AND}$$

$$\textit{Filter 3: Current closing price of a security} > SMA_{50},$$

Filter 1 refers to the place where the actual uptrend has possibly started, so to reduce false signals generated from the EWO moving close to its zero line, the EWO has to reach a certain positive value (1% of SMA_5 is arbitrarily used for the purpose of this report), not zero. Filter 2 checks whether the uptrend is strengthening, and filter 3 monitors whether the price is in a longer-term uptrend.

For filter 3, checking whether the 50-day $Closing\ Price_{slope}$ is positive, which is another way of determining the longer-term uptrend, was initially used; however, as seen in the figure below, using the 50-day $Closing\ Price_{slope}$ for filter 3 occasionally produces less efficient buy signals at the local maximum. This phenomenon is often occurred when the prices of the security have been under SMA_{50} (i.e. downtrend) for a period of time and suddenly start to increase. Therefore, the current price of a security and SMA_{50} are compared to judge the longer-term trend for filter 3.

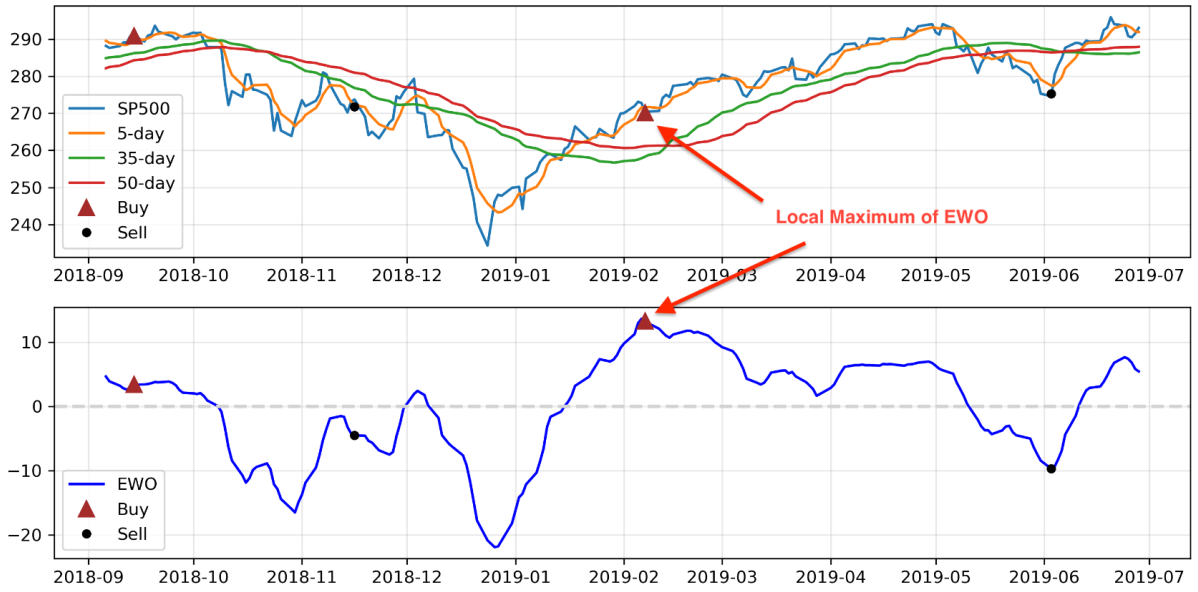

Figure 4. *Example of a less efficient buy signal when "Filter 3=50-day* $Closing\ Price_{slope} > 0$*"*

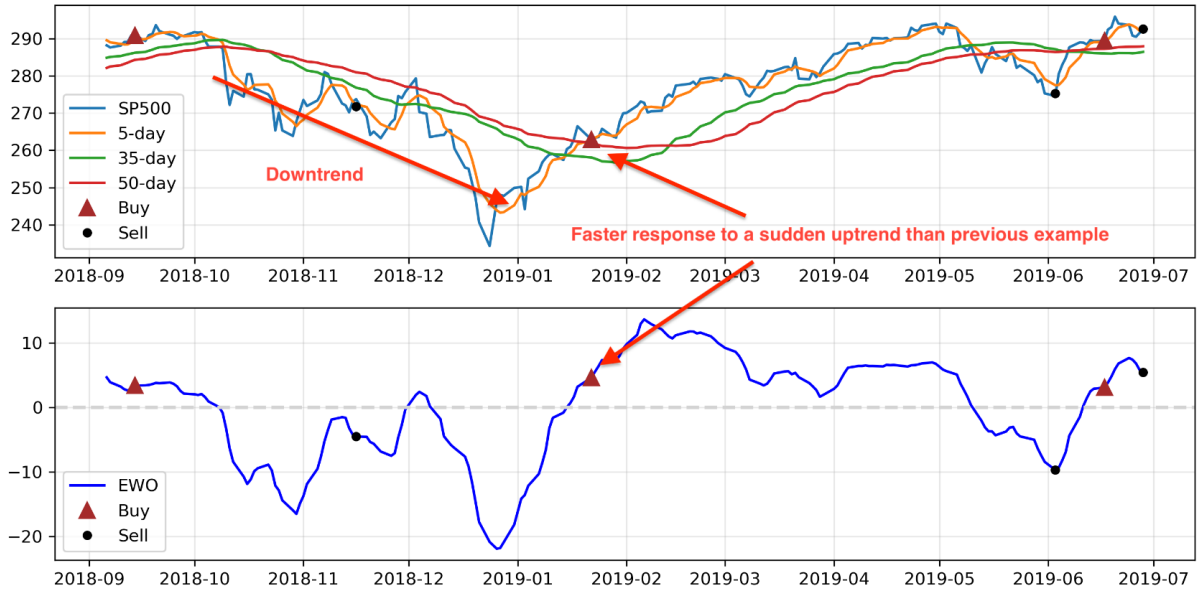

Figure 5. *Example of a more efficient buy signal when "Filter 3 = Current price of a security >* SMA_{50}*"*

If all three filters are satisfied on a given day, a buy signal is generated, and SPY is bought at the opening price of the next morning as many as possible for a given budget.

2.1.2.2 Sell Signal

There are also two conditions that generate a sell signal:

$$\textit{Exit 1: 5-day } EWO_{slope} < 0 \textit{ AND}$$

$$\textit{Exit 2: 50-day } Closing\ Price_{slope} < 0$$

When both exit conditions are met on a given day, it demonstrates that the trend has reversed and the current long trade does not match with the current trend, so all the securities are cleared at the opening price of the next morning. In case of consecutive buy signals without a sell signal, to understand the profitability of the strategy more clearly, a second buy signal is ignored, and a current position does not change until a sell signal appears. On the last day of the trade, all remaining positions are cleared at the opening price and converted into cash balance.

Below are the tables and a visualization showing SPY data of buy and sell signals. For better understanding, explanations for some column names are as follows:

- 5-day, 35-day, and 50-day represent SMAs corresponding to each time frame.
- EWO represents the EWO value of the day.
- Filter1, Filter2, Filter3: for each column, ‘1’ represents that each condition is satisfied, and ‘0’ represents that each is not.
- Exit1 and Exit 2: for each column, ‘-1’ represents that each condition is satisfied, and ‘0’ represents that each is not

Table 2. *Example of SPY data*

Day	Date	Open	Close	5-day	35-day	50-day	EWO	Filter1	Filter2	Filter3	Exit1	Exit2
50	2010-09-07	110.370003	109.639999	108.753999	109.358000	108.450400	-0.604001	0	1	1	0	0
51	2010-09-08	109.860001	110.410004	109.774001	109.413143	108.508000	0.360858	0	1	1	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...
2266	2019-06-27	291.309998	291.500000	292.074005	286.229143	287.830399	5.844863	1	0	1	-1	-1
2267	2019-06-28	292.579987	293.000000	291.874005	286.410285	287.901399	5.463720	1	0	1	-1	-1

Table 3. *Example of SPY's buy signals*

Day	Date	Open	Close	5-day	35-day	50-day	EWO	Filter1	Filter2	Filter3	Exit1	Exit2
55	2010-09-14	112.500000	112.650002	111.636002	109.678000	109.2156	1.958001	1	1	1	0	0
211	2011-04-27	135.050003	135.669998	134.195999	131.542571	131.8196	2.653428	1	1	1	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...
2157	2019-01-22	264.820007	262.859985	262.721997	258.076856	262.1102	4.645141	1	1	1	0	-1
2258	2019-06-17	289.519989	289.369995	289.100000	285.986285	287.2258	3.113715	1	1	1	0	-1

Table 4. *Example of SPY's sell signals*

Day	Date	Open	Close	5-day	35-day	50-day	EWO	Filter1	Filter2	Filter3	Exit1	Exit2
202	2011-04-13	132.080002	131.460007	132.314005	131.315429	131.652400	0.998576	0	0	0	-1	-1
240	2011-06-08	128.759995	128.419998	129.713998	133.452284	133.141799	-3.738286	0	0	0	-1	-1
...	...	...	...	...	...	...	...	...	...	...	...	...
2248	2019-06-03	275.309998	274.570007	277.457996	287.134571	286.370600	-9.676576	0	0	0	-1	-1
2267	2019-06-28	292.579987	293.000000	291.874005	286.410285	287.901399	5.463720	1	0	1	-1	-1

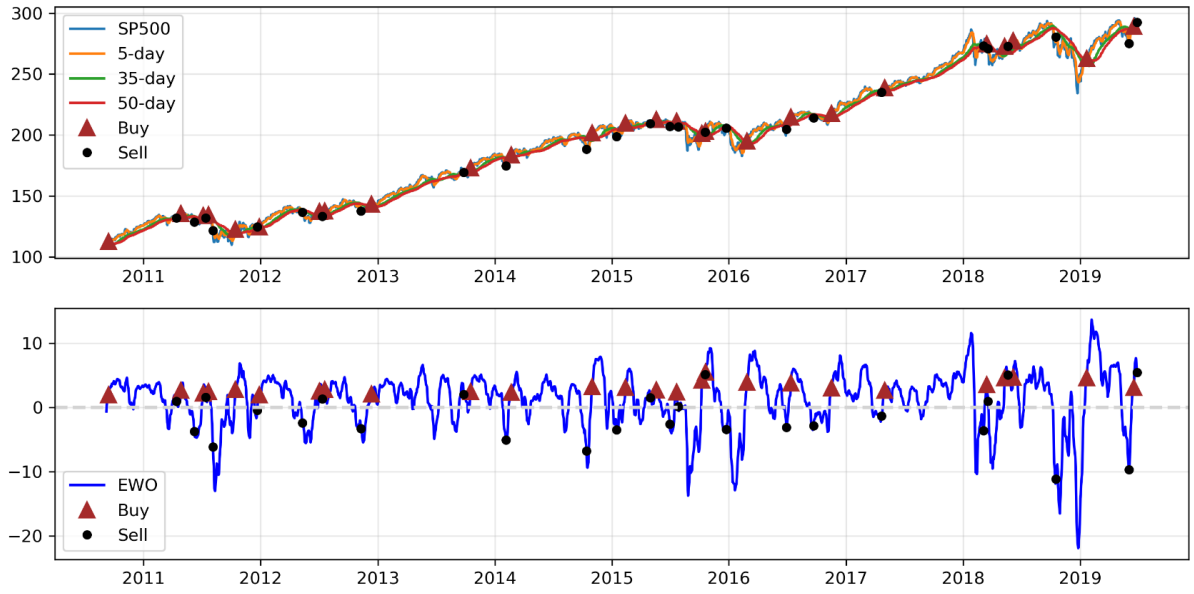

Figure 6. *Visualization of buy and sell signals of SPY for 9 years*

2.2 Evaluation Criteria

To evaluate strategies for trading, a number of criteria are used.

2.2.1 Compound Annual Growth Rate

The Compound Annual Growth Rate (CAGR), which is defined as

$$CAGR = [(\frac{Ending\ Value}{Beginning\ Value})^{\frac{1}{n}} - 1] \times 100\%\,,$$

where n = number of years,

is the rate of annual return given that the profits are reinvested every year.

2.2.2 Number of Trades

The number of trades refers to the number of buy/sell signals generated for a period of time.

2.2.3 Percentage Increase

Percentage increase, which is defined as

$$Percentage\ Increase = \frac{Ending\ Value - Beginning\ Value}{Beginning\ Value} \times 100\%,$$

represents how much the value has increased over a period of time.

2.3 Initial Backtesting

Based on the strategy mentioned in 2.1, initial backtesting of the EWO strategy using SMA_5 and SMA_{35} with SMA_{50}, 5-day EWO_{slope}, and 50-day $Closing\ Price_{slope}$ as other filters is completed on SPY from 2010-09-07 to 2019-06-28 and compared with the buy and hold strategy. The following table compares the results of two strategies:

Table 5. *EWO and Buy and Hold strategies comparison*

Strategies	Initial Cash	Final Cash	CAGR	Number of Trades	Percentage Increase
EWO	100,000 USD	171,826 USD	6.199%	26	+71.83%
Buy and Hold	100,000 USD	265,073 USD	11.44%	1	+165.1%

The table shows that there is no advantage of the initial EWO trading strategy in this setting in terms of the profit generated compared to the buy and hold strategy.

3. Initial Strategy Modification

3.1 Parameters and Ranges

For the initial EWO strategy backtested above, there are five parameters related to time periods that are initially and arbitrarily chosen:

Table 6. *Five parameters and their initial conditions*

Parameters Related to Time Periods	Used in Initial Strategy
SMA_{fast}	SMA_{5}
SMA_{slow}	SMA_{35}
n-day EWO_{slope}	5-day EWO_{slope}
$SMA_{longer-term}$	SMA_{50}
n-day $Closing\ Price_{slope}$	50-day $Closing\ Price_{slope}$

To better evaluate the initial EWO strategy compared to the buy and hold strategy, different combinations of the parameters are backtested on SPY from 2010-09-07 to 2019-06-28 in this chapter. The ranges of each parameter tested are as follows:

Table 7. *Five parameters and their ranges tested*

Parameters Related to Time Periods	Ranges
SMA_{fast}	fast: 2~10 days
SMA_{slow}	slow: 20~50 days
n-day EWO_{slope}	n: 3~5 days
$SMA_{longer-term}$	longer-term: 50~130 days
n-day $Closing\ Price_{slope}$	n: 50~130 days

Since there are five parameters in total, it can be challenging to test all their combinations due to the limitation of computer time. It can also be challenging to visually represent the results of all combinations of five parameters. Therefore, all combinations of three parameters, SMA_{fast}, SMA_{slow}, and n-day EWO_{slope}, are first tested (EWO Revision 1), and the combination or a range of combinations with the most final cash is analyzed. Then, all combinations of the two remaining parameters, $SMA_{longer-term}$ and n-day $Closing\ Price_{slope}$, are tested with three previous parameters fixed as one of their combinations with the most final cash (EWO Revision 2).

3.2 EWO Revision 1

For testing three parameters, SMA_{50} and 50-day $Closing\ Price_{slope}$ are used, and a total of 837 combinations are backtested. The combination with the most final cash is analyzed as follows:

Table 8. *Three parameters and their combination with the highest profit*

Parameters	Combination with the Highest Profit
SMA_{fast}	SMA_{2}
SMA_{slow}	SMA_{45}
n-day EWO_{slope}	5-day EWO_{slope}

Table 9. *EWO Revision 1 and Buy and Hold strategies comparison*

Strategies	Initial Cash	Final Cash	CAGR	Number of Trades	Percentage Increase
EWO Revision 1	100,000 USD	209,861 USD	8.585%	30	+109.9%
Buy and Hold	100,000 USD	265,073 USD	11.44%	1	+165.1%

The table above shows that compared to the initial EWO strategy, EWO Revision 1 has improved but is less effective than the buy and hold strategy in terms of the profit generated. Below are the 3D heatmaps showing final cash and the number of trades corresponding to each combination of three parameters:

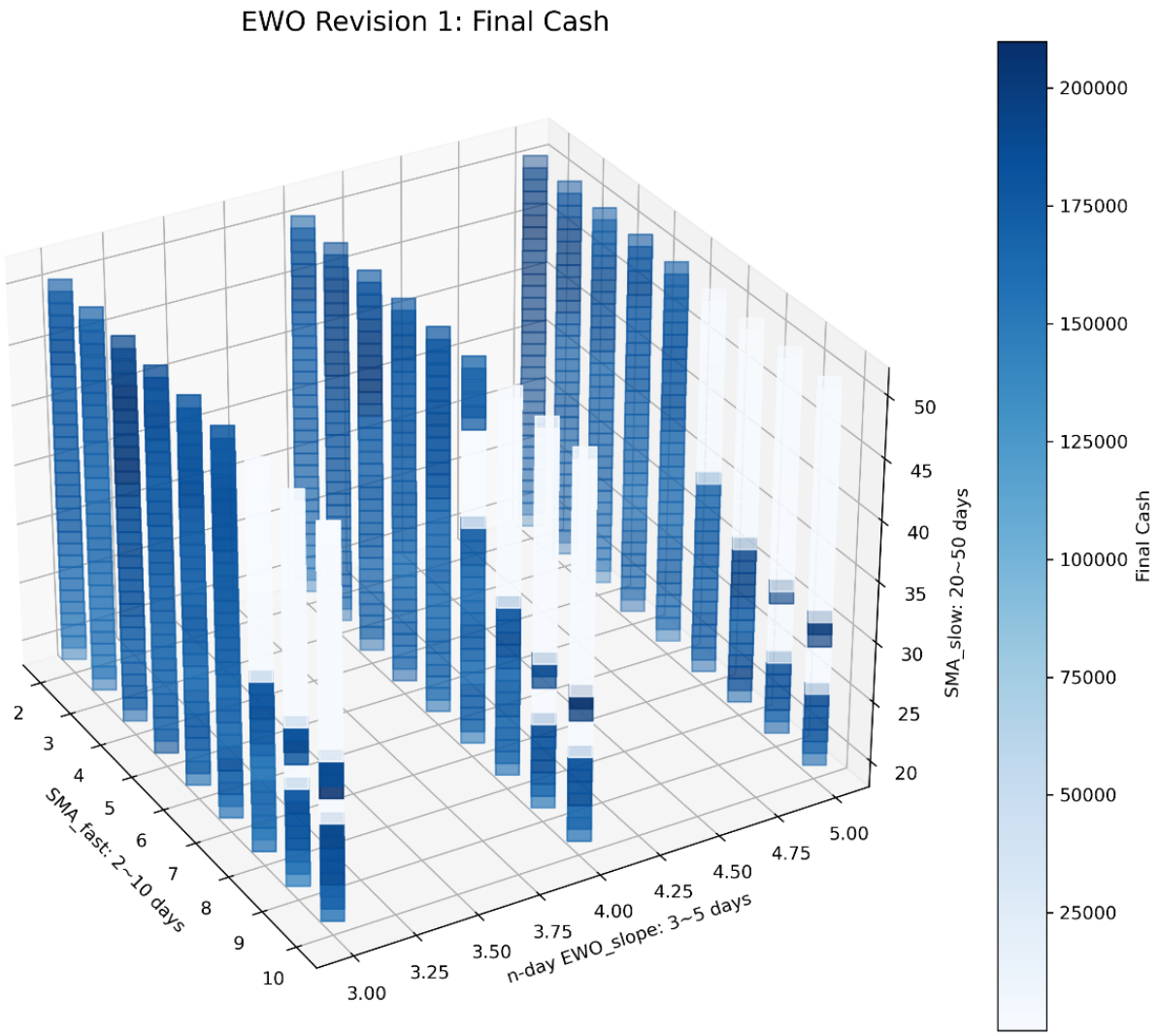

Figure 7. *EWO Revision 1 3D heatmap showing final cash of different combinations of three parameters*

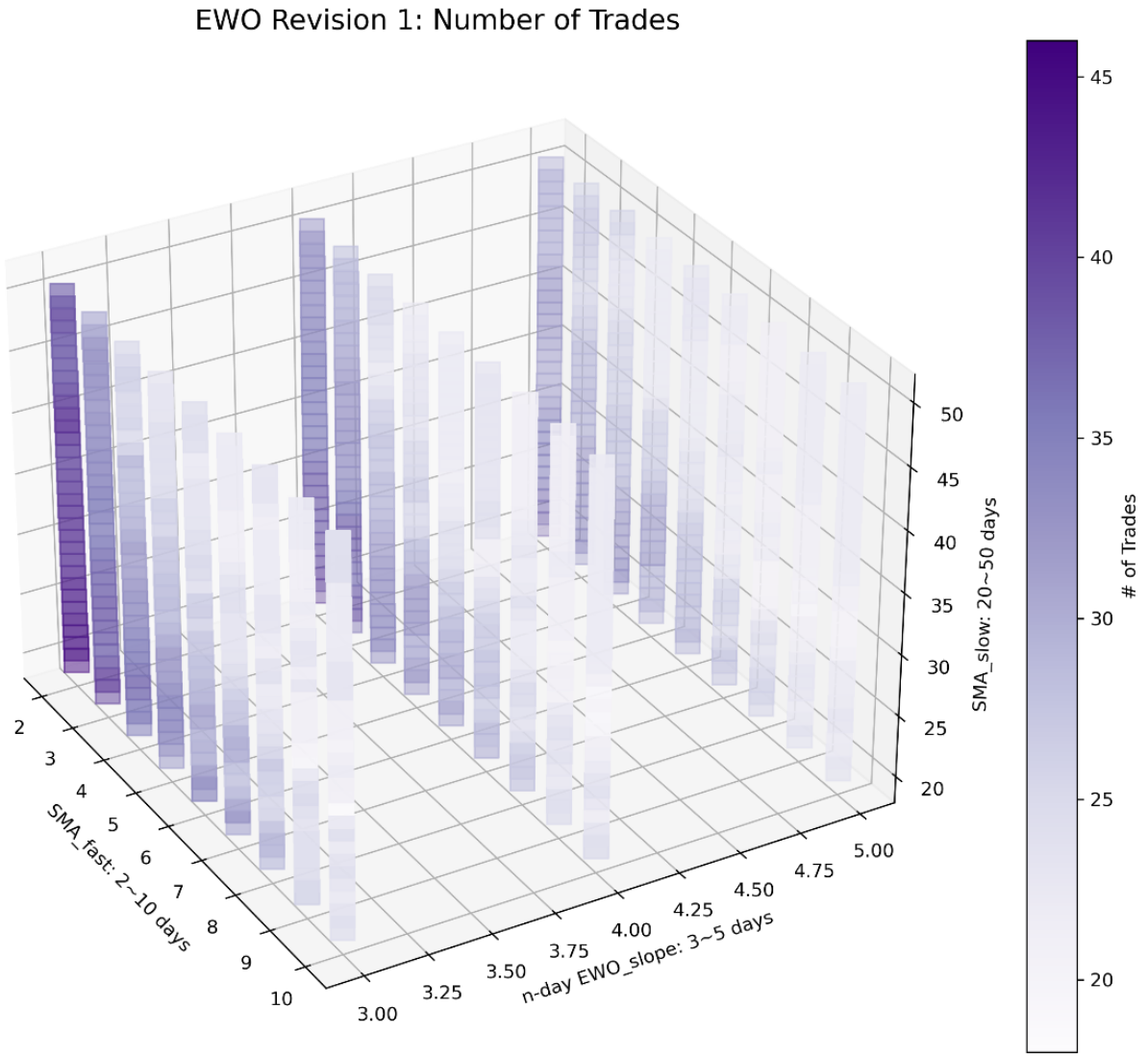

Figure 8. *EWO Revision 1 3D heatmap showing the number of trades of different combinations of three parameters*

While the heatmap for the final cash shows a relatively discrete pattern of colors, meaning the strategy does not work at all in some combinations of three parameters, the heatmap for the number of trades shows a relatively continuous pattern of colors, with combinations of parameters of shorter time periods having more trade opportunities.

3.3 EWO Revision 2

As mentioned in 3.1, EWO Revision 2 is tested with all combinations of the two remaining parameters. Although it is important to understand that there is a spectrum of combinations, not one specific combination, of three previous parameters that can be used for Revision 2, based on the result of EWO Revision 1, SMA_2, SMA_{45}, and 5-day EWO_{slope} are used for parameters SMA_{fast}, SMA_{slow}, and n-day EWO_{slope}, respectively. A total of 6561 combinations are backtested, and the combination with the most final cash is analyzed as follows:

Table 10. *Two parameters and their combination with the highest profit*

Parameters	Combination with the Highest Profit
$SMA_{longer-term}$	SMA_{50}
n-day $Closing\ Price_{slope}$	125-day $Closing\ Price_{slope}$

Table 11. *EWO Revision 2 and Buy and Hold strategies comparison*

Strategies	Initial Cash	Final Cash	CAGR	Number of Trades	Percentage Increase
EWO Revision 2	100,000 USD	243,944 USD	10.42%	27	+143.9%
Buy and Hold	100,000 USD	265,073 USD	11.44%	1	+165.1%

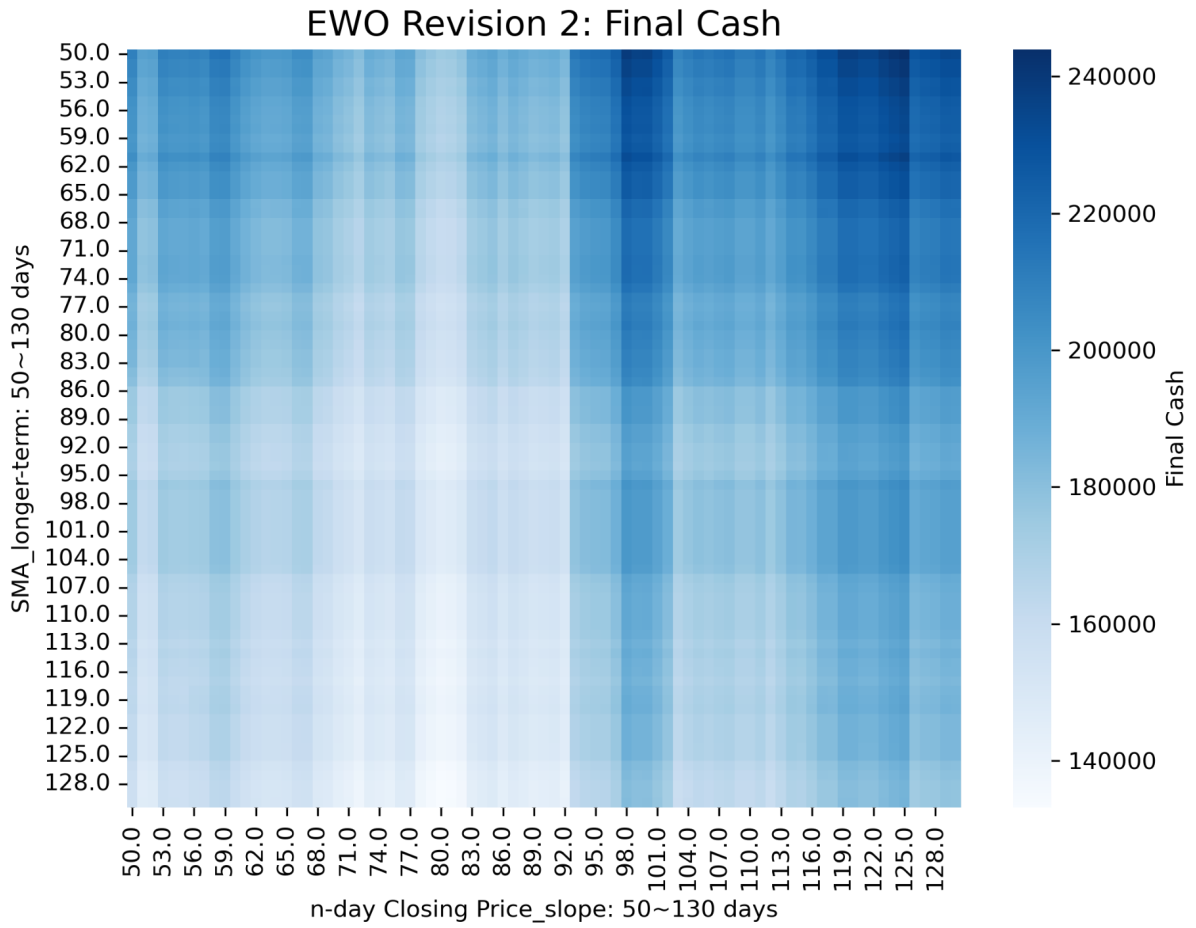

Figure 9. *EWO Revision 2 2D heatmap showing final cash of different combinations of three parameters*

Specifically for the EWO Revision 2, the figure above demonstrates the general trend of increasing final cash with an increasing period of n-day $Closing\ Price_{slope}$ and a decreasing period of $SMA_{longer-term}$.

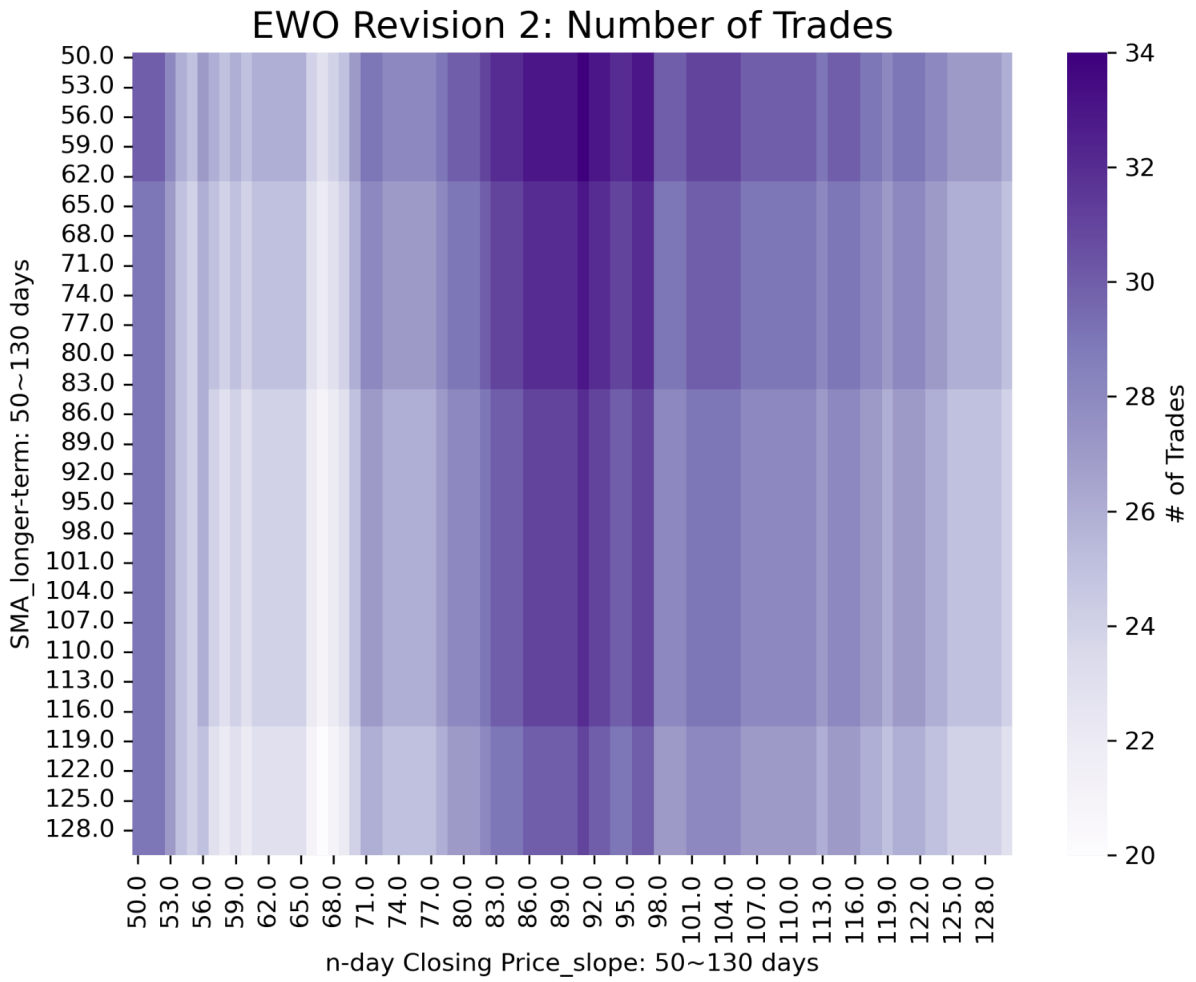

Figure 10. *EWO Revision 2 2D heatmap showing the number of trades of different combinations of three parameters*

It is demonstrated that EWO Revision 2 is comparable to the buy and hold strategy and is more effective than EWO Revision 1 in terms of the profit generated. However, Revision 2 also shows that it generates less efficient buy signals in certain circumstances. For instance, when the position is cleared with a sell signal and the EWO value and price of the security drop notably, the EWO value starts to increase from its local minimum; when this happens, the next buy signal reacts slowly to the uptrend as the figure below shows.

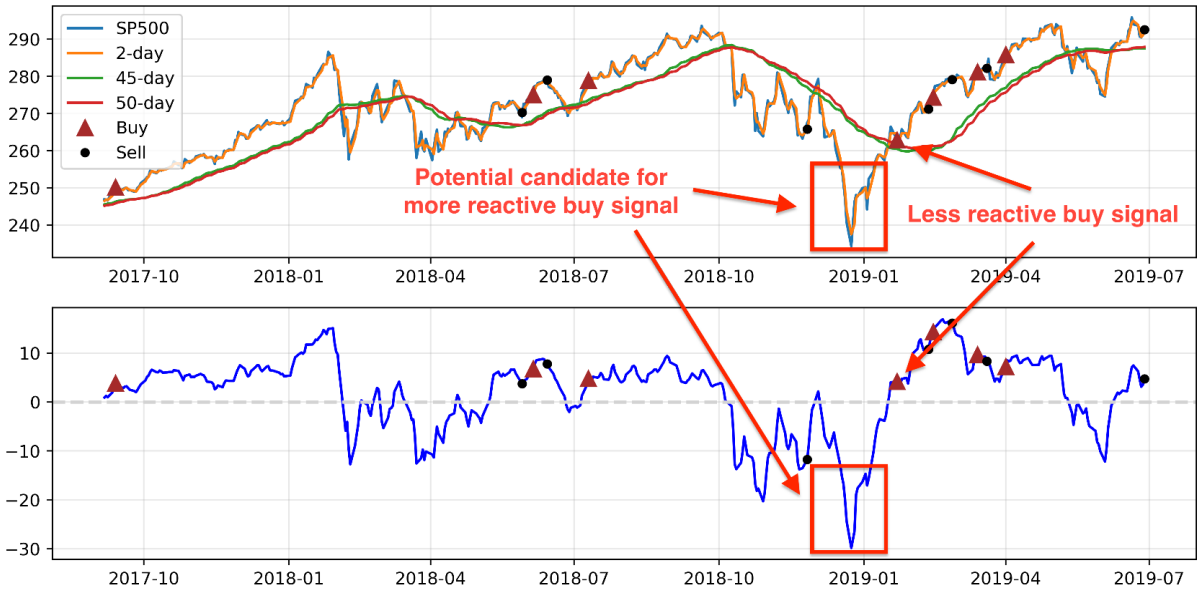

Figure 11. *Example of EWO Revision 2's less reactive buy signal and candidate for more reactive buy signal when there was a notable drop in the stock market*

3.4 EWO Revision 3

Therefore, for EWO Revision 3, another independent filter is introduced to help buy signals react faster when there was a notable drop in the market:

$$\textit{Filter 4: EWO} < \textit{-10\% of } SMA_2$$

Filter 4 refers to the place where there was a significant drop in the EWO value (-10% of SMA_5 is arbitrarily used for the purpose of this report) and is only considered when the current position is already cleared with a sell signal. In other words, the buy signal is generated when filter 4 is satisfied while filters 1, 2, and 3 are not.

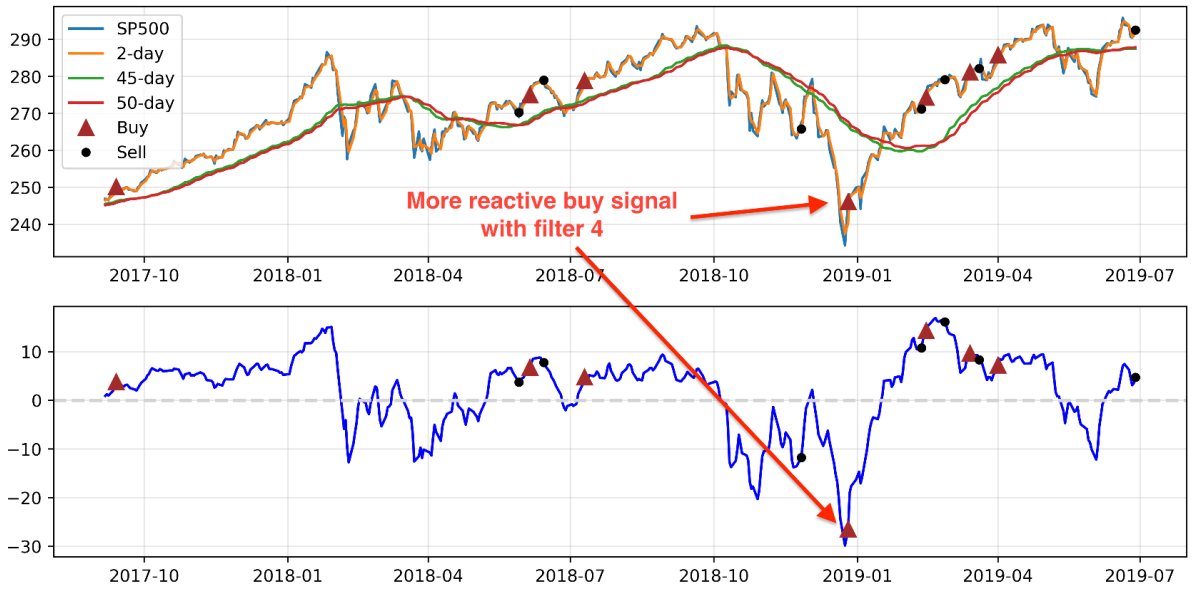

Figure 12. *Example of EWO Revision 3's more reactive buy signal when there was a notable drop in the stock market*

The introduction of filter 4 helps Revision 3 have a faster and more efficient buy signal after a notable drop in the EWO value. Same as previous backtestings, when there are consecutive buy signals without a sell signal, only the first buy signal is considered, and the strategy is backtested on SPY from 2010-09-07 to 2019-06-28 and compared with the buy and hold strategy.

Table 12. *EWO Revision 3 and Buy and Hold strategies comparison*

Strategies	Initial Cash	Final Cash	CAGR	Number of Trades	Percentage Increase
EWO Revision 3	100,000 USD	303,500 USD	13.13%	27	+203.5%
Buy and Hold	100,000 USD	265,073 USD	11.44%	1	+165.1%

As demonstrated in the table, the EWO Revision 3 with the introduction of filter 4 outperformed the buy and hold strategy for a period of 9 years in terms of the profit generated.

Regarding the condition of filter 4, since an arbitrary figure of -10% is used, backtesting results across a 9-year period may not be generalized to longer time frames. This is also true for the condition of filter 1, which uses a figure of 1% arbitrarily. Therefore, other backtestings are conducted on SPY for another time frame from 1990-09-07 to 2022-06-28 using all four strategies (EWO Revision 1, 2, and 3 and Buy and Hold). Below are the backtesting summaries of four strategies for two different time frames:

Table 13. *Four trading strategies comparison (2010-09-07~2019-06-28)*

Strategies	Initial Cash	Final Cash	CAGR	Number of Trades	Percentage Increase
EWO Revision 1	100,000 USD	209,861 USD	8.585%	30	+109.9%
EWO Revision 2	100,000 USD	243,944 USD	10.42%	27	+143.9%
EWO Revision 3	100,000 USD	303,500 USD	13.13%	27	+203.5%
Buy and Hold	100,000 USD	265,073 USD	11.44%	1	+165.1%

Table 14. *Four trading strategies comparison (1990-09-07~2022-06-28)*

Strategies	Initial Cash	Final Cash	CAGR	Number of Trades	Percentage Increase
EWO Revision 1	100,000 USD	414,707 USD	4.545%	107	+314.7%
EWO Revision 2	100,000 USD	653,870 USD	6.044%	111	+553.9%
EWO Revision 3	100,000 USD	1,134,585 USD	7.886%	113	+1,035%
Buy and Hold	100,000 USD	872,563 USD	7.004%	1	+772.6%

For a period of 32 years, the EWO Revision 3, which utilizes filter 4, demonstrates the highest profit and the greatest number of trades among the four strategies investigated in the report.

4. Conclusion

After several revisions of parameters of time periods and a filter generating a buy signal, it is demonstrated that the EWO Revision 3 with optimized parameters and four filters is more effective than the buy and hold strategy in terms of the trading profit generated, and introducing filter 4 helps the strategy make a profit right after the price of a security has rapidly fallen. From 1990 to 2022, EWO Revision 3 strategy demonstrates a higher CAGR of 7.886% than a CAGR of 7.004% of the buy and hold strategy. Also, it is shown that, on top of the value of the EWO itself, other criteria, such as the slope of the EWO and a longer-term SMA, should also be utilized in order to use the EWO for a profitable trading strategy.