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TRADING & QUANTITATIVE RESEARCH REPORT

Momentum Strategy - Events

Extending research on intraday momentum effects
surrounding interest rate announcements by FOMC

In collaboration with:

LYNX

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Introduction & Theory

Introduction

This project's purpose is to extend already conducted research and further analyse the short-term momentum effects using technical indicators on intraday data surrounding specific macroeconomic events. The chosen macroeconomic events are the Federal Reserve (FED) announcements regarding the Federal Open Market Committee (FOMC) meetings' interest rate decisions, which occur eight times per year. These events have shown to have a substantial impact on the excess return of the stock market. In fact, according to a previous research on stock market returns prior to FOMC announcements, it was shown that the market rises by more than 20 times what it does on all other trading days (Lucca and Moench, 2015). Since this report is an extension of the previous one, theory and method sections will be mainly covering the newly introduced changes.

Theory

As mentioned in the last report, the research aims at investigating if there are oddities embedded in the market surrounding "event days", and in what way, if any, these oddities affect investments. A trading day would be classified as an event day if it occurred on;

- One business day prior to the day of the announcement, or;
- Day of the announcement, or;
- One business day post the announcement.

To limit the sources of error in this research, in the first report the investment algorithm implemented to carry out the trading was designed by combining two relatively simple technical indicators: Moving Average Convergence Divergence (MACD) and Relative Strength Index (RSI). However, in this report it, there are a few changes introduced to the original strategy. Firstly, the signal generation for entering a position is solely based on MACD indicator, excluding the RSI, simply because the inclusion of the previous RSI condition seemed to decrease the algorithm's performance. It was also decided to apply ATR differently. Instead of using it to generate fixed bounds for each entered position to be neutralised, ATR is used as part of trailing stop loss technique called Chandelier Exit (CE). The decision to implement CE was made due to the general holding period being way too short in the previous report. Thus, trailing stop loss tool such as CE allows the positions to run as long as the trend is observed until the reversal occurs.

The MACD indicator consists of the MACD line and Signal line, which are shown in *Figure. 1* The MACD line, displaying the relationship between two moving averages, is calculated by subtracting a longer-period exponential moving average (EMA) of the security's price from a shorter-period EMA:

$$MACD_{cp} = EMA_{12}(cp) - EMA_{26}(cp).$$

Whereas, the signal line, functioning as a trigger for buy and sell signals, is calculated as an EMA of the MACD line:

$$S_{MACD} = EMA_9(MACD).$$

The standardized or default version of settings for the MACD indicator are 12, 26, and 9, meaning that the MACD derived

by subtracting a 26-period EMA (if the price resolution is 30-minute bars, then a 26-period EMA would include 26 such bars, for example) from a 12-period EMA, and the signal line derived by taking a 9-period EMA of the MACD line. However, as it is later demonstrated in this report, these settings are subject to adjustment depending on the preferences of the investor, asset class, price resolution, etc.

The MACD indicator can be used to generate a variety of trading strategies. Although, one of the most common ways of using MACD is to look for bullish and bearish "signal line crossovers". A bullish crossover occurs as the MACD line crosses the signal line in an upwards direction, thus, generating a buy signal. Alternatively, a bearish crossover occurs as the MACD line crosses the signal line in a downwards direction, therefore, creating a sell signal [1]. Also, in order to enter a position, a last condition ensured the portfolio to be in a neutral state, disabling a short position entry as a long position was held, and vice versa.

Chandelier Exit, which was developed by Chuck Le Beau is a volatility-based indicator that identifies stop loss exit points for long and short trading positions [2]. It is designed to keep traders in the trend until a defined trend reversal happens. Particularly, the CE is used by traders to maximize their returns in a trade and make stop loss exit decisions. It is based on the principle that a trend reversal is highly probable when the price of an asset moves against an existing trend up to three times the average volatility. It uses the high and low prices over a defined period of time to compute the CE values.

The way CE works is fairly simple. Chandelier Exits show two lines: the Chandelier Exit Long(CEL) and the Chandelier Exit Short (CES). The exit long is used to close long positions whereas the exit short is used to close short positions. Therefore, the rule of the indicator is to close long positions when the price goes below the CEL and to close short positions when the price goes above CES. Then, using the recommended setting of 22 periods, the Chandelier exit will calculate the highest high or the lowest low for the same period used to calculate ATR. Lastly, the multiple ATR is subtracted from the figure obtained for the highest high, and added to the value obtained for the lowest low.

Data & Method

CEL and CES are calculated according to the following formulas:

- **Chandelier Exit Long: n-day Highest High – ATR (n) x Multiplier**
- **Chandelier Exit Short: n-day Lowest Low + ATR (n) x Multiplier**

Hypothesis

Our hypothesis assumes that there are differences observed when performing the designed strategy on the historical data of the selected time period. More specifically, it is hypothesized that trades falling under the "event days" category, will show evidence of the positive relationship between the intraday momentum strategy and macroeconomic events, leading to portfolios performing better during days surrounding the events compared to other days.

Data

The research is conducted in collaboration with LYNX Asset Management. This study bases its research on data of The Standard and Poor's 500 (S&P500) index. It is important to state that it was decided to proceed with using Contracts for Difference (CFD) closing price data of the S&P500 index, due to restricted access to intraday data provided by other sources. CFD is not the underlying asset, but a tradable contract made to follow the price of the underlying asset, in this case, the S&P500 index. However, the data is considered to be fit for this research as it still provides valuable insights into short-term trading. The time period being analysed ranges from 1/1/2012 to 31/12/2020, while the data used is accessed through Dukascopy and consists of 15-minute intra-daily resolution prices.

Method

When it comes to the method, apart from signals to enter positions now being generated solely by MACD indicator, there are a few changes from the previous report. Firstly, as stated previously, it was decided to incorporate the Chandelier Exit into the strategy as the trailing stop loss. This is particularly important as the reason why this technique was especially relevant for this report is due to the holding periods stated in the last report being too short, neutralising lucrative positions too early. Thus, such tool allows to hold the positions longer and to neutralize them when the reversal in the trend is observed. Secondly, instead of basing indicators on closing prices, in this report they were calculated using rolling returns. The rolling returns are able to highlight the frequency and magnitude of an investment's stronger and poorer periods of performance [3]. In particular, the rolling returns can offer better insight into strategy's more comprehensive return history, which is not skewed by the most recent data points.

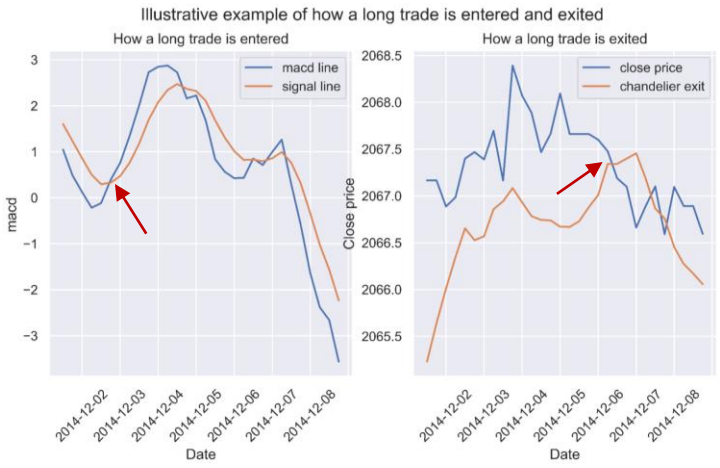

Figure 2: *Illustration of long position entry & exit*

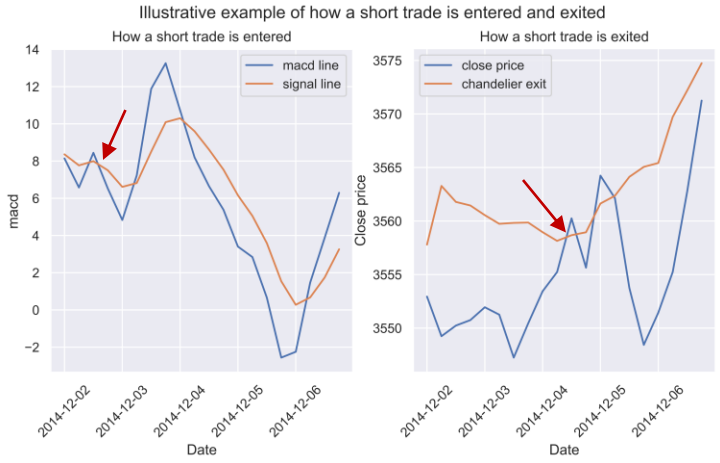

Figure 3: *Illustration of short position entry & exit*

The strategy can be easily visualised using the figures provided above. The *Figure 2* shows how long position is entered when there is a bullish crossover that occurs when the MACD line crosses the signal line in an upwards direction, thus, generating a buy signal. While the position is exited when the the Chandelier Exit Long line crosses the closing price line upwards, in other words, when the price becomes lower than CEL, generating signal to sell. The opposite applies to short positions. The trade is entered when there is a bearish crossover, which occurs as the MACD line crosses the signal line in a downwards direction, therefore, creating a sell signal. The short position is then exited when the Chandelier Exit Short line crosses the closing price line downwards, evidencing that the closing price is higher than CES. The short position entry and exit is similarly depicted in *Figure 3*.

Method

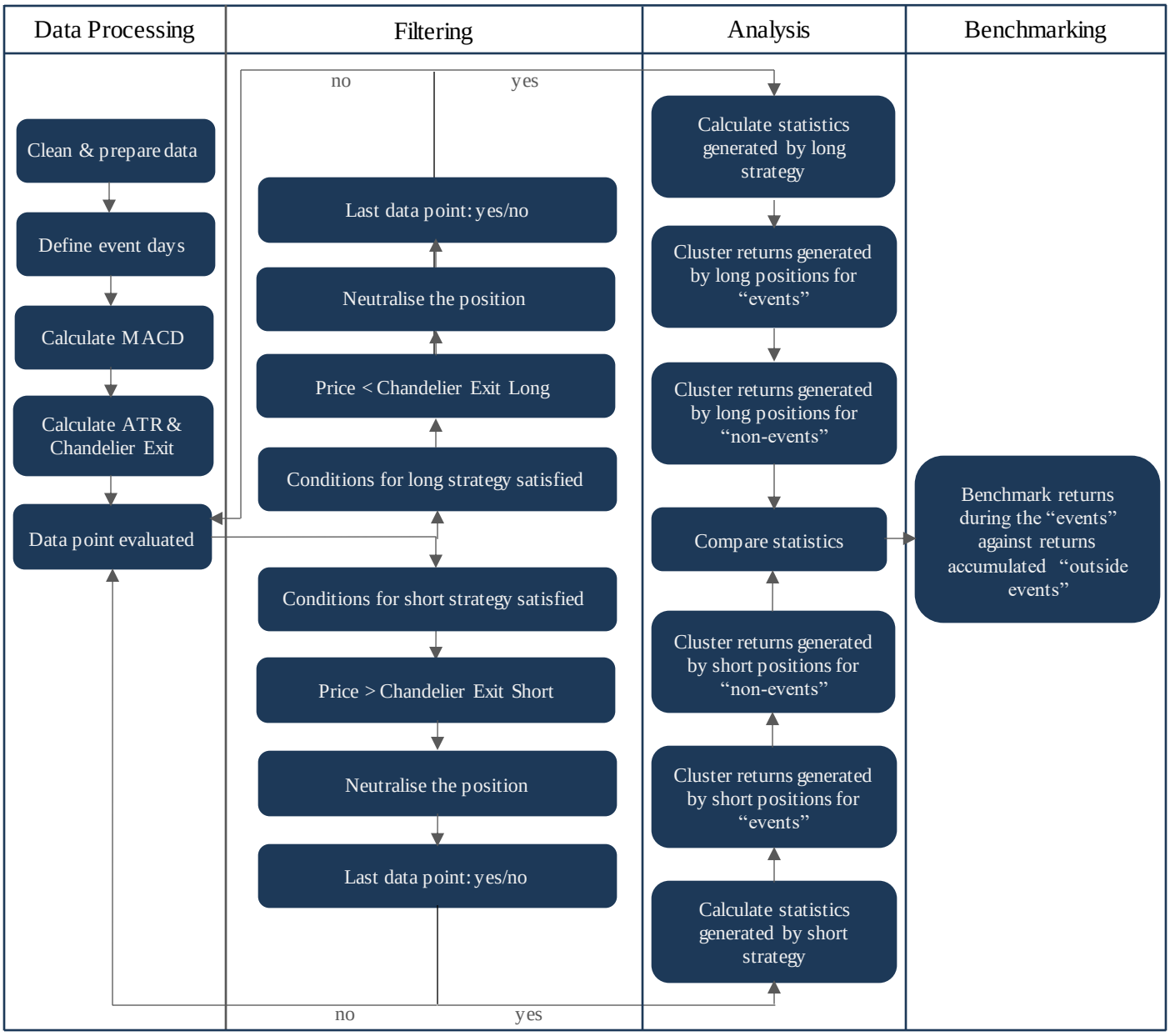

Figure 4: *Flowchart describing the trading algorithm*

The *Figure 4* displays how the trading algorithm applied in this research actually works. Firstly, the data was cleaned and structured in the desired format for further use. Then the MACD, ATR, and Chandelier Exit were calculated for each data point. Whenever a condition for either the short or the long position was satisfied, including that position was neutral at the moment, the trade was entered. Analogously, when the Chandelier Exit crossed the signal line, depending on the direction, the position would be exited. After all the trades were accounted for, the general statistics were calculated. As the purpose of this paper is to investigate the intraday effects inside and outside of FED related events, the computations were further divided into two groups "events" and "outside events". In the end, the results of these groups were benchmarked against each other.

As the trading algorithm used in this research works with 15-minute intraday resolution data points of the S&P 500 index CFD, unforeseen problems occurred, stemming from the phenomenon of overnight returns. Previous studies have been conducted on this topic of overnight returns, and the findings argue that investors actually earn their entire excess return while the market is closed (Cooper, 2007). Below the reader finds an extension of such research. By only using intraday trading, the overnight returns are disregarded. In this report a short investigation has shown the advantages with takin the overnight returns in consideration and also how an increased volatility overnight gives reason to have a 24 hours rolling return in the MACD-strategy.

Results & Analysis

Pros & Cons of overnight returns

Focusing only on intraday trading has shown advantage in the short period by giving the opportunity to avoid fluctuations during the night when the stock market is closed, thus, avoiding unimpressionable losses. However, in the long run, avoiding overnight returns statistically lead to generally lower return. The *Figure 5* shows that during the period 2010-01-01 to 2022-03-06, the S&P 500 index had an average positive return amounting to 0.019% per night. In other words, an annual average return of 4.90%, or, if taking the whole period, a total return of 78.95%.

Predicting the upcoming overnight return

The relationship between the daily return and the upcoming overnight return has also shown that during the same period that after a positive daily return, the upcoming overnight return was positive in 50.60% of the nights. While after a negative daily return the upcoming overnight return was positive in 56.31% of the nights as shown in *Figure 6*.

Predicting the upcoming daily return

Furthermore, the reverse relationship, in this case what the current overnight return says about the upcoming daily return, has shown that after a positive overnight return the upcoming daily return was positive in 63.49% of the days, which can be seen in *Figure 7*. Meanwhile, in case of negative overnight return, the upcoming daily return was negative in 56.63% of the days. Lastly, after no overnight return, the daily return was positive in 50.94% of the days.

Basing the MACD-strategy on overnight returns

Clearly, by looking at Figure 5 and 6, it is apparent that there is a considerable part of the index's returns occurring when the market is closed in this example too, accounting for the high overnight volatility. However, there seems also to be significant evidence in favour of the impact overnight returns have on the stock market the following day, as depicted in Figure 7.

As the signals generated by the trading algorithm in this research are based on the MACD indicator, which in turn depends on moving averages of the stock price, the overnight effect was assumed to have a strong impact on the generation of signals and was therefore needed to be accounted for. Hence, the MACD indicator was instead based on 24hr rolling returns; however, due to an error in the code, 14hr returns were implemented instead.

S&P 500	Return	Total nights	Percent of all nights	Average return	Total average return	Standard deviation
Overnight returns	No return	159	5.19%	0%	+0.019%	0.0397%
	Negative return	1275	41.63%	-0.211%		
	Positive return	1629	53.18%	+0,202%		

Figure 5: Distribution of positive, negative and zero overnight return

Upcoming nightly return	If positive daily return	If negative daily return
Positive	844 (50.60%)	785 (56.31%)
Negative	728 (43.65%)	545 (39.10%)
None	96 (5.75%)	64 (4.59%)

Figure 6: Expected overnight return based on daily return

Upcoming daily return	If positive nightly return	If negative nightly return	If none nightly return
Positive	1033 (63.49%)	533 (43.37%)	81 (50.94%)
Negative	594 (36.51%)	722 (56.63%)	78 (49.06%)

Figure 7: Expected daily return based on overnight return

Results & Analysis

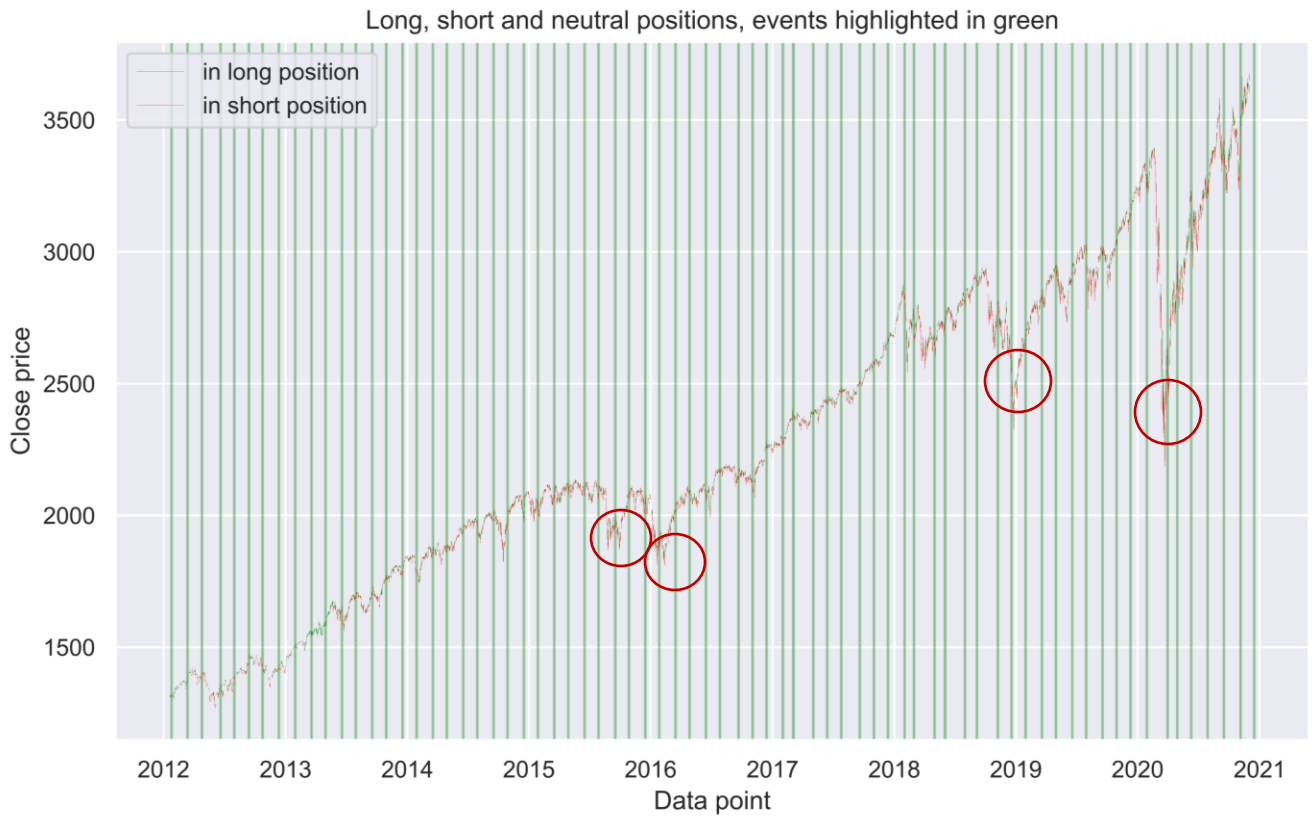

Figure 8: Market price between 2012-2021, displaying when Long & Short positions were entered and exited (events highlighted with green)

Looking at *Figure 8* we can observe a generally strong upward trend in the closing price of S&P500 CFD. From 2012 up till 2020 the price has increased from 1313.63 USD till 3659.45 USD. Thus, if a long position was entered at the start of the period and neutralized at the end, the investment would have yielded a return of 178.58%. Additionally, there are four significant price drops marked with red circles on the *Figure 8*. The first one happened in August of 2015, and was what some call "flash crash". On 24th August the markets opened with S&P 500 at 1965.15, which within matter of minutes dropped to 1867, amounting to 5% decline. Such outcome was argued to be result of several factors including strong selling prior to event, Chinese Shanghai Composite Index fall of 8.5%, which only exacerbated the sale and pushing down the price, as well as lack of liquidity in the markets and herd mentality [4]. The second decline happened during January of 2016 with S&P500 index dropping 6%. Similar phenomena was observed across the global markets sparked by renewed concerns over the Chinese economy, dropping oil prices, and increased geopolitical tension. Worried over potentially continuous decline, investors flocked away from risky equities and commodities towards "safe-haven" assets such as gold and government bonds [5]. The third dip occurred in the end of 2018, when S&P500 was down by 11% in December due to concerns over trade war with China, rising interest rates, partial government shutdown, and week borrowing positions [6]. Lastly, in 2020, the global pandemic had substantial adverse effects on economic growth, sending the equity indices such as S&P 500 into a tailspin. By March 23, 2020, the index had plummeted from 3,386.15 to 2,237.40, recording more than a nearly 34% decrease over just one month. [7]. Later in the paper, a closer look is taken at how exactly the implemented strategy performed during these pronounced declines.

In terms of positions, a total of 6423 signals are generated over the entire period. The long trades amount to 3214 with 305 being performed during the "events", while the number of short ones are equal to 3209, which include 296 trades happening during the "events". Moreover, the Federal Reserve announcements regarding its interest rate decisions take place 8 times per year and are highlighted with thin green columns on the *Figure 8*. Given that the 9 year period being analysed, all events sum up to 72 days falling under "events" category. Additionally, the long-short ratio during the "events" is equal to 0.51, while "outside events" ratio is 0.50, meaning that the amount of long and short positions entered, for both categories, were close to equal.

Results & Analysis

Figure 9: Cumulative returns during "events", outside "events", & overall for the market (not for long and short position as the title suggests) calculated based on 15-min ticks

Figure 9 depicts the development of cumulative returns of the S&P 500 CFD over the period 2012-2021, at first glance indicating that the market price in general was positively impacted by events. However, a closer inspection reveals that this was actually not the case. Considering that the FOMC announcements only occur eight times per year (i.e. 3*8 "event days" per year), data points falling outside of events with volume not being zero (137,216) constituted 89.67% of total tradable data points. Therefore, had the cumulative market return outside of events been normalized (by dividing returns with the relative size measured in tradable data points of each category) for a comparison with cumulative market returns during events, market returns outside of events would have been 27.4% greater than market returns during events. Considering findings of previous research looking at the market effect of macroeconomic announcements, this relationship was expected to be reversed, meaning that normalized returns during event days were expected to exceed normalized returns outside of events. A possible explanation for this could be the way in which days surrounding the announcements are categorized. As previously mentioned, it has been claimed that the stock market return follows a bi-weekly cyclical pattern around FOMC meetings. Perhaps, the larger part of the excessive return stemming from the market impact of the announcement could be attributed to another cycle of days than what this project has classified as event days.

	Outside Events		During Events	
	Long p.	**Short p.**	**Long p.**	**Short p.**
Average Return	0.0138%	-0.0014%	0.0326%	-0.0135%
Total Cumulative Return	34.4%	-0.46%	9.93%	-3.99%
Win Rate	40.0%	34.81%	39.3%	36.08%
Total Trades	2909	2913	305	296
Av. Hold Period (15 min bars)	39.5	29.4	28.2	23.5
St.D	0.5010%	0.499%	0.5276%	0.6054%
25th Percentile Return	-0.1483%	-0.1519%	-0.1924	-0.2064%
50th Percentile Return	-0.0320%	-0.0406%	-0.0382	-0.0529%
75 Percentile Return	0.0789%	0.0441%	0.0950	0.0366%
Long Trades/ Total Trades	49.97%		50.84%	

Figure 10: Statistics

Figure 10: *Cumulative returns with circles highlighting significant S&P 500 CFD price drops*

As is depicted in *Figure 10*, the long positions generated by the strategy are clearly outperforming short positions. However, considering the long-term market trend, short positions showed to perform surprisingly well, having a relatively flat profit-and-loss curve which eventually yielded a cumulative return of -4.46%. Opposed to what was concluded in the previous version of this report, but in line with what was hypothesized for this version, long positions appear to be positively impacted should they occur during an event day. A review of the statistics of average returns for long positions during events and long positions outside of events, respectively, show that the former is observed to be three times the size of the latter. By normalizing the categories in the same manner as before, returns generated during events would have yielded a cumulative return of 150.5% the size of the cumulative return generated outside of events. This serves as a strong indication that the market is more susceptible to "momentum trading" at times during events than outside of events. However, we observe that the reverse relationship could be argued to hold for short positions as the returns generated during the events accrued to a lesser value than returns accrued outside of events.

Although, it should be noted that the average return of long positions during events is greater than the corresponding short position returns, implying that the total effect on the portfolio based on the momentum strategy utilized in this project is still positively impacted by the FOMC announcements.

As is illustrated in Figure 10, cumulative returns for long positions spike rapidly in the early period of 2013. After backtracking any potential errors, it was found that the error should be attributed to the data set itself - over a period of three months, total traded volume in the market was recorded to be zero. However, despite the volume being zero for three consecutive months, the market price was moving, disabling any trades to be aborted as a condition for entering and exiting trades was the market to be open.

The first significant price drop observed, as previously denoted as the "flash crash", in August of 2015, put the strategy's short portfolio up to test. As can be deduced from observing the foremost circle, its performance was evidently satisfactory, sending cumulative returns of the short portfolio soaring by 10% in a matter of days. The second price drop in 2016 was responded to in a similar manner, increasing the total portfolio value despite the returns from long positions experiencing a negative trend. Clearly, these observations highlight the importance of including the ability to short positions as a tool of risk mitigation in turbulent times. Contrary to the short portfolio's performance throughout the first three severe price drops, the short strategy did not manage to take advantage of the plummeting of the S&P 500 index during the onset of the pandemic. Analysis of the backtesting data provided better insights into portfolio's unexpected performance. As to why the short strategy did not rocket as prices dropped could be explained by primarily two factors. Firstly, MACD's signals to enter a short position were not sensitive enough to capture the severe drops in the market until it was already too late. Additionally, long positions were at times undesirably entered, thus blocking any potential short ones since to enter any short position a neutral portfolio was required.

Results & Analysis

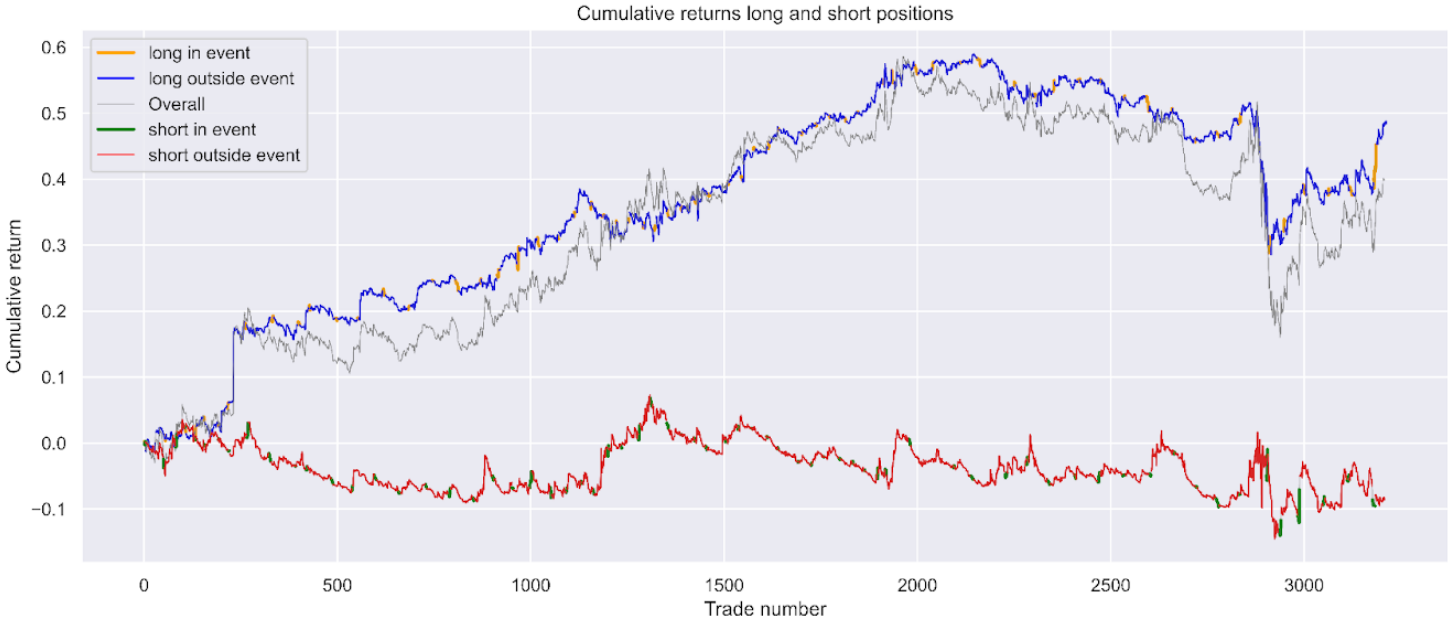

Figure 11: Cumulative returns of long , short & overall positions with events highlighted.

As mentioned previously, the issue in the algorithm of the previous report stemming from the rather short holding periods, was remedied by implementing the chandelier exits as opposed to keeping bearish (bullish) MACD signal line crossovers for a long (short) position to be exited. Evidently, this alteration had a substantial impact on the holding period (which the increased returns could be attributed to) of both long and short positions. Average holding period for long positions overall, measured in the amount of 15-min bars, was 34.78, whereas short positions holding period averaged 28.85 15-min bars. The relatively lower holding period of positions during events, 28.22 15-min bars, as compared to position outside of events, 39.57 15-min bars, pleads in favour of the notion that the market experiences a greater volatility close to macroeconomic announcements. Due to the very long run-time while deploying the algorithm on historical data, more statistics on holding periods for long positions failed to be extracted. However, by looking at the descriptive statistics for the short positions holding periods, it can be ascertained that the objective of creating a wider distribution of the holding periods (in the sense that profitable positions would be able to run longer than they previously were before being exited) was achieved. This could be considered the main reason for why the algorithm was able to take better advantage of the peculiar market conditions surrounding the FOMC announcements as compared to the previous report. Highly profitable trades were held onto for a much longer period than before, generating a larger portion of abnormal returns this time around. The histograms of returns for long and short positions (where returns for both categories are independently normalized for the sake of comparison), visible in Appendix *Figure 12*, clearly visualizes this results, where the outliers on the positive side of the returns are far greater than the outliers from the previous research.

The strategy utilized in this project showed signs of robustness as a variety of parameter settings were tested and different sample sizes were examined. Results stayed fairly consistent. A higher degree of robustness provides better chances for the results to hold out-of-sample, which is clearly desirable. However, in order to be able to claim that returns generated by long positions during events and outside of events are significantly different, a statistical t-test had to be performed. The observed p-value was not low enough in order to reject the null hypothesis, thus it was not possible to claim that returns during events were significantly different from returns outside of events. However, it should be noted that the sample size of long returns accrued during events was relatively small, which could be explanatory for the unsuccessful attempt to claim statistical significance.

Conclusion

In conclusion, the adoption of chandelier exits in place of the previous bearish (bullish) MACD signal line crossovers for a long (short) position to be exited proved to have a substantial, positive impact on the returns generated by the trading algorithm. Profitable trades were held onto for a longer time period, and loss-making trades were aborted more quickly than in the previous research. This alteration, in combination with the implementation of rolling returns to calculate MACD signal line crossovers for entering positions, paved the way for more reliable signals, thus increasing returns. Long positions were positively affected by the peculiar market conditions surrounding the FOMC announcements, whereas short positions showed the reverse relationship. In the long-run, however, considering the overall market trend, the short strategy of the algorithm showed to be relatively successful, displaying a rather flat profit-and-loss curve throughout the period.

In contrast to the previously conducted report, where it was found that returns generated by the algorithm for both long and short positions were actually negatively affected by the market conditions surrounding FOMC interest rate announcements, this report was able to provide a good reason to believe that momentum investing is highly applicable during event days. While the (long) returns of the algorithm overall are massively outperformed by the market outside of events, the difference between long returns generated by the algorithm during events and market returns during events are close to indistinguishable. Even though tradable data points during events are merely a tenth of tradable data points outside of events, the results yielded by normalizing the returns generated during events for both the market and long positions still provide good evidence in favour of the previous statement. However, one should be a bit careful before claiming that the hypothesis of the report has been proven to hold true. For one, the sample size is too small to conclude that the mean returns during events and outside of events are statistically significant. Also, the trades executed are considered to fall under events should they be entered during one of the three days surrounding a specific event, but there is no requirement for the position to be closed before the event days have passed. Still, the results were in line with what was desired.

As stated in the previous report, it is also important to emphasize the neglecting of transaction costs in this project. Although, the amount of positions entered during events (305 long trades spread out on 72 event days) is not too grand.

An extension of this project could be to conduct further analysis on the bi-weekly cyclical pattern that is claimed to exist surrounding the FOMC announcements. Should it be possible to classify days as event days to a higher precision, i.e. classifying any days surrounding the announcements that have a substantial impact on the overall excess return in the market as event day, it might also yield even greater returns should a momentum strategy be deployed. Lastly, a more technical detail regarding the construction of the Python code should be addressed as issues arose in relation to the computation time as the strategy was backtested. Perhaps, vectorizing parts of the code that in the current version utilized nested for loops could decrease the computation time, thus streamlining the backtesting process and providing better opportunities to allocate resources to other aspects of the research.

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Include extra plots or results, e.g. individual trade returns, less successful strategies which you tried previously, etc.

Label every appendix item with roman numerals: "Appendix I, Appendix II" and add a short description, e.g. *Appendix I – Results, strategy X*

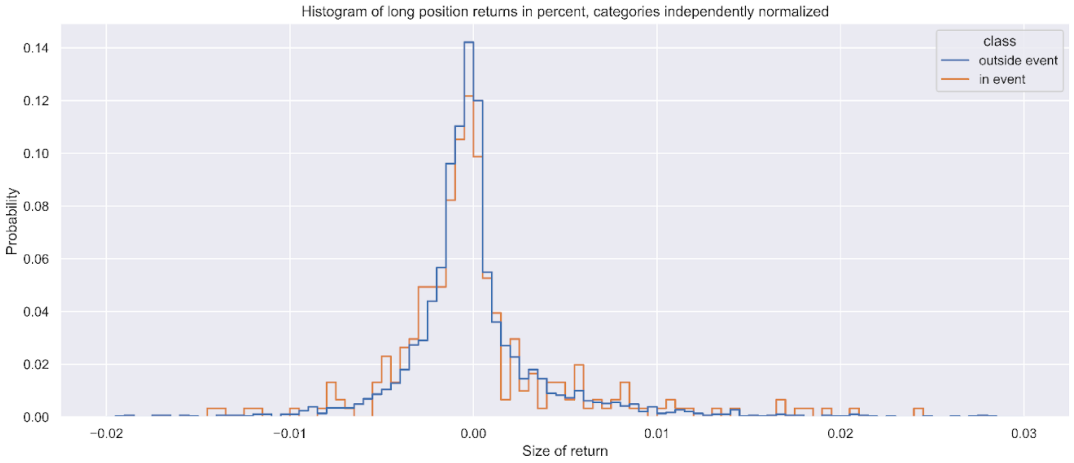

Figure 12: Histogram displaying returns for long positions

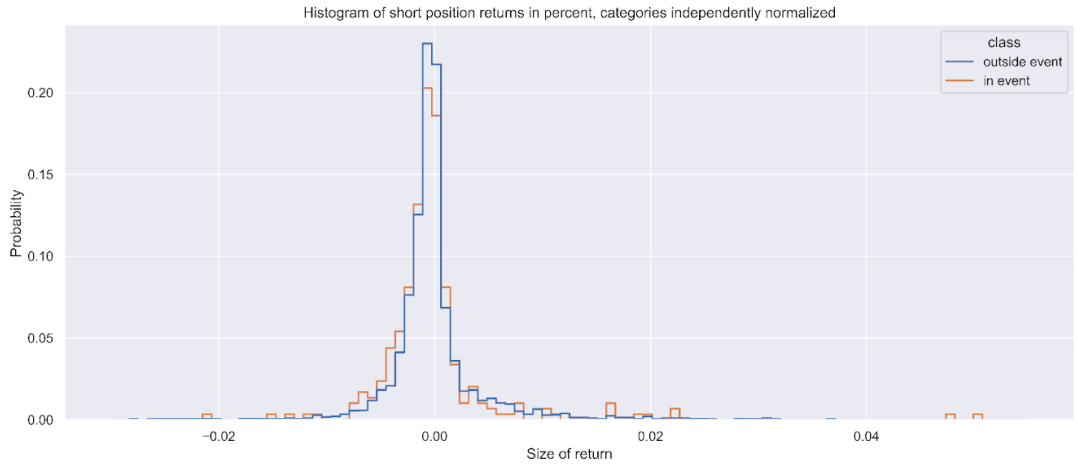

Figure 13: Histogram displaying returns for short positions

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