



MASTER IN BUSINESS ADMINISTRATION (MBA)

THESIS



RESEARCH ON THE EFFECTIVENESS OF FORECASTING
MODELS ON EXCHANGE PRICES IN THE SPX INDEX



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ABSTRACT

With the advancement of technology, investment in the global markets has become easier than ever before. Various strategies exist for investors to try and “beat” the market, but in general most strategies fall under two main school of thoughts, fundamental and technical analysis. Fundamental analysis is based on statistics and data while technical analysis is mostly based in reading the way price auctions by using various chart patterns. Because technical analysis relies on intuition it can be very subjective and is considered the “black sheep” between the two.

Nevertheless, this paper focuses on technical analysis making an attempt to shine some light to the mystery that is price auction reading. Technical analysis has been used throughout history and throughout the world, it has evolved from the Babylonians simply inscribing the prices of materials on stone tablets to the modern price charts with complex indicators. Some of the most famous of these indicators, such as the moving average (SMA-EMA), the MACD, the RSI and the Bollinger bands, will be presented in this paper accompanied by various researches results on their effectiveness. However, the main focus of this thesis is the testing of a different strategy, one that does not rely on any indicators and instead is an attempt to read raw price auction using the combination of some specific price patterns. The testing has been done using the python language and the backtesting.py library, while the data was collected from the tradingview.com website. It is important to note that the use of the written algorithm to test the below trading strategy has in some cases negatively impacted its results which is to be expected when strict rules are imposed on a strategy that relies partially on intuition and the human factor.

That being said, since there is no way of measuring intuition, using modern tools to dissect technical analysis patterns seems like an efficient way to bridge the gap between fundamental and technical analysts by presenting the former with the much-needed data on the later.

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1. Introduction

The prosperity of any developing economy, nation, or society in the twenty-first century is primarily dependent on the performance of their market economies and stock prices, with the financial market serving as the central and crucial factor. Therefore, it is crucial and essential to thoroughly study and gain knowledge about the financial market. Because of various uncertainties, including general economic conditions, social factors, and political events on both domestic and international scales, predicting financial markets becomes challenging. (Nti et al., 2020) This paper is an attempt to use a specific technical analysis strategy to predict the movement of price in the S&P 500 index (SPX).

The S&P 500 index is a stock market index that measures the performance of 500 leading publicly traded companies in the United States. SPX is a numerical value that represents the level of the S&P 500 index and is calculated using the stock price and the market capitalization of these companies. In other words, it is a weighted average of the stock prices of these 500 companies with the weights determined by each company's market capitalization. It is therefore logical for SPX to be one of the most followed stock market indices in the world and often be used as a benchmark by investors, financial analysts and professionals. (<https://www.etf.com/>)

As far as technical analysis goes, there are various definitions. The one that, in the author's opinion, encapsulates all is "The forecasting of prices based on patterns in past market data". Technical analysis is a method used since ancient times, from ancient Babylonia to feudal Japan, and despite the distance in both geography and time the similarities are astonishing. Such similarities reveal how deeply ingrained it is in human psychology to reason in technical terms in order to follow the trends, making technical analysis a truly universal phenomenon. Technical analysis is considered an empirical method; hence it comes as no surprise that, in many cases, the historical evidence is indirect and many ideas were not fully developed by their originators. Its intuitive nature which lacks statistical legitimacy makes it an easy target of today's data backed scientific community. (Lo and Hasanhodzic, 2010)

The aim of this paper is to backtest, meaning test the accuracy of a strategy on historical data, a specific technical analysis strategy using strict rules and enough data, effectively bridging the gap between the intuitiveness of technical analysis and the data backed quantitative strategies made possible by today's computer age.

2. Literature review

2.1 History of technical analysis

Contrary to what many think today, technical analysis is not a toolbox of indicators, like MACD, RSI, moon phases etc, but rather the use of past prices to try and forecast future ones. There is evidence of this in Babylonian price records, Greek market sentiment assessments, Roman seasonality patterns and throughout world history in general. It seems like people at the time weren't just following market prices but made attempts to measure supply/demand imbalances and react to them for their profit, often combining their insights with "data" from fundamental nature or astrology. The ancient Babylonians used a systematic approach to meticulously document the prices of different commodities, frequently updating them throughout the day. Interestingly enough, they would also associate these commodities with astrological signs such as Pisces and Taurus, depending on whether they held a positive (bullish) or negative (bearish) outlook.

This combination of technical analysis and astrology has led most of the modern scientific community to disregard technical analysis practices. That been said, at the time, astrology was a way of life, applied to a wide variety of human endeavors including warfare and medicine. If viewed as a random number generator of the pre-computer era, it becomes more understandable why it was the prevailing method. Just as computer-generated random numbers are part of today's statistical forecasting models, astrology may be thought as a random input in ancient forecasting models.

Despite the above, technical analysis is still viewed as something of a black sheep in modern economics. In today's era of extensive data analysis, it is easy to disregard models that are mostly based on intuition instead of hard data as speculative, akin to gambling. Unfortunately, besides being stigmatized by its intuitive nature, technical analysis has also been associated with speculators, bear raiders and market cornerers of previous eras, making its reputation even more questionable. To get a feeling of the situation, in the 1930s, during the

Great Depression, technicians were nearly identified as low-level criminals due to the manipulative market operations that had identified the '20s.

All things considered, the fact remains that technical analysis is an ancient practice used throughout the world, which evolved through time according to the available means. From the Babylonian stone tablets to the current price charts, technical analysis should be considered a legitimate discipline stigmatized by deceptive associations and deserving further academic study. (Lo and Hasanhodzic, 2010)

2.1.1 Technical analysis in the modern age

An interesting definition for technical analysis is found in the Brazilian review of finance; “Technical analysis, or charting, aims on visually identifying geometrical patterns in price charts in order to anticipate price trends”, trends meaning direction. (Lorenzoni et al., 2007) This however is but one of the techniques that are encompassed in the technical analysis spectrum, the most controversial at that. The reason this technique is controversial is that it relies heavily on the smoothing filter of the human eye, meaning it is highly subjective. However, in their quest to quantify technical analysis, academics have turned to this particular technique of identifying geometric patterns in price. (Lo and Hasanhodzic, 2010) That being said, there is a theory that views chart formations as graphic representations of unchanging human behavior in a complex variety of situations. (Edwards et al., 2007)

An argument can be made that the term “technical”, in its application to the stock market has come to have a very special meaning, quite different from its ordinary. It could be argued that technical analysis is the science of recording, usually in graphic form, the actual history of trading (price changes, volume of transactions, etc.) in a certain stock and then deducing from that pictured history the probable future trend. Meaning that, in the modern age, technical analysis refers to the study of the action of the market itself as opposed to the study of the goods in which the market deals. A technical analyst basically argues that the real value of a share is determined at any given time solely by the supply and demand mechanics of the market. Even if a fundamentalist, who leans on statistics, might see eye to eye on this, the technical analyst goes one

step further and argues that the market price doesn't only reflect the opinions of orthodox security appraisers, but also the hopes and fears and all kinds of emotions of thousands of potential buyers and sellers, which defy analysis and no statistics are obtainable, but are nevertheless all expressed in a single chart figure over which a buyer and seller get together and make a deal. (Edwards et al., 2007)

Furthermore, a technician also claims that the market is forward looking, attempting to take into account future developments, weighing and balancing all the estimates and guesses of thousands of investors who try to look into the future, each one from their own point of view. In other words, the technician claims that the going price, as established by the market itself, has already taken into account all the fundamental information that a statistical analyst could hope to get, oftentimes even more than that (due to insider trading), and many other factors of equal or maybe greater importance. All of this would be of little significance if it wasn't for the well-known fact that markets move in trends and trends tend to continue until there is a change in the supply-demand balance. Such changes can oftentimes be detected in the price action of the market itself. Certain patterns or levels tend to appear in the chart which can be used to predict the probable future trend development. Of course, they are not infallible but, as experience has amply proved, the odds are definitely in their favor. (Edwards et al., 2007)

2.2 Testing of technical analysis strategies in literature

There are plenty of examples in literature where different trading strategies based on technical analysis are being tested. The indicators and oscillators explored below are, simple/exponential moving averages (SMA / EMA), moving average convergence/divergence (MACD), relative strength index (RSI) and Bollinger Bands (BB).

2.2.1 Simple moving averages strategies

Possibly the most celebrated of all technical analysis indicators, the simple moving average and its variations, e.g. exponential moving average, can be found throughout literature, either as a standalone indicator or as part of a bigger system. The moving averages are basically the averages of past prices, usually closing prices, and have a length of n , with n being the lookback period. (Teixeira and Oliveira, 2010) The general rule is to buy when the fast (or small) moving average crosses the slow (or big) moving average and vice-versa. Each

of the strategies analyzed below uses a different combination of moving averages, in different market conditions and different markets.

The first research tests the profitability of the SMA5 (5 days Simple Moving Average), SMA10, SMA15, WMA5 (5 days Weighted Moving Average), WMA10, and WMA15, using a combination of short and long strategies. It is conducted on a country level instead of company level, using prices from the years 2010 and 2011. A buy (long) signal is generated when the stock price crosses up the SMA line and a sell (short) signal when it crosses down the SMA line. The returns of each SMA / WMA strategy are then compared to the returns of a buy and hold strategy. The findings suggest that during declining market conditions (bearish) the use of any of these strategies outperform the buy and hold strategy, with the WMA5 and SMA5 short strategies being the clear outperformers. On the other hand, during up-trending (bullish) market conditions, the buy and hold strategy seems to outperform all the rest. These findings suggest that the use of moving averages alone, whether it is for selling or buying, outperforms in down-trending market conditions the buy and hold strategy, while it underperforms, heavily in most of the sell strategies, in up-trending market conditions. Finally, during up-trending market conditions, the sell strategy using the above moving averages produces negative results (losses), and likewise, during down-trending market conditions, the buy strategy also produces negative results. (Hartono et al., 2015)

A second research tests moving averages of variable lengths, specifically the following pairs: SMA1-50, SMA1-150, SMA5-150, SMA1-200, SMA2-200. In this case the 1,2 and 5 SMAs represent the short moving average and the 50, 150 and 200 represent the long moving average. The strategy is a simple SMA strategy where a buy signal is indicated when the short moving average exceeds, crosses upwards, the long moving average and a sell signal vice versa. In this case a sell strategy indicates the closing of an existing long position and not a short opening signal. These strategies were tested in ten emerging equity markets in Latin America and Asia from January 1982 through April 1995. The average return was afterwards compared to a buy and hold strategy return during the same period. One of the findings of this research is that the length of the used moving average pairs does not seem to influence the significance of the models. Regarding the profitability of this strategy, the paper found that in one-fifth (21%) of the occasions, mostly concentrated in Mexico, Taiwan, Thailand and the Philippines, the strategy demonstrates statistical significance and the model appears to be profitable after trading costs. Furthermore, it appears that in 82% of the occasions the indicators provide the correct indication of the index return change in emerging markets, if statistical significance is disregarded. Concluding, the paper argues this indicates that regardless of the classical statistical significance, the results may have important economic implications and advocates for further research as to

why most statistically significant and profitable trading strategies are concentrated in a handful of countries. (Ratner and Leal, 1999)

Another research conducted on the London Stock Exchange FT30 index for the period 1935-1994, using various lengths of moving averages and comparing them to a simple buy and hold strategy, found that the MA strategies consistently show profit even through the many years in which the market was driftless (not trending). In fact, the research shows that even when the market starts growing modestly, the MA strategy has very similar returns to a buy and hold strategy. It was only when the market started growing exponentially that the buy and hold strategy heavily outperformed the MA strategies. The strategies followed were simple MA crossovers using the MA1-50, MA1-150, MA5-150 and MA2-200, buy when the fast MA crosses the slow MA upwards and sell or short when the fast MA crosses the slow MA downwards. An important modification to these rules was also tested and compared to the traditional rules, in order for a buy or sell crossover to be considered as legitimate, price had to move at least 1% (band-width) above or below the crossover accordingly. It seems however, that only in the case of the SMA1-50, especially in the case of a 1% band-width, are the buy-sell signal statistics significant and that is why in the end only that particular strategy is being compared to the buy and hold strategy. (Mills, 1998)

To continue, a different type of study was done on the capital markets, NYSE (New York Stock Exchange), ASE (Athens Stock Exchange) and the VSE (Vienna Stock Exchange), for a period of 12 years (1993-2005). In this study, instead of using a specific pair of moving averages, the authors took into account the variability of the performance of the MA trading rule due to the length of the longer MA. This was achieved by jointly considering the rule's cumulative returns using long moving averages of varying lengths. Returns were compared to a buy and hold strategy, with and without taking into account the transaction costs. Without taking into account the transaction costs, the cumulative returns for the ASE and the VSE were, on some occasions, significantly higher than the corresponding buy and hold strategy return. On the contrary, the cumulative returns when it came to the NYSE were found to be significantly lower than the buy and hold strategy. When taking into account the transaction costs, results vary even more. On the ASE it was found that cumulative returns were still, in some occasions, significantly higher than the return of a buy and hold strategy while on other occasions they did not differ significantly. Moreover, on the VSE the cumulative returns did not differ significantly from the buy and hold returns. Lastly, it seems that the cumulative returns were negative on the NYSE, meaning loss of funds, even though the buy and hold strategy return was positive. This study provides evidence that the MA trading rule does not possess any predictive power whatsoever on the

NYSE and the VSE, with the NYSE providing particularly striking counterevidence, and only some in the ASE. (Milionis and Papanagiotou, 2011)

Furthermore, the results of a study conducted in 198 stocks traded in the Brazilian stock market in the period 2000-2014, conclude that the application of technical analysis tools, such as moving averages, leads to a high probability of obtaining a return that exceeds the investment value. However, when trading fees are taken into account, there is a substantial impact on the returns of the strategies and therefore it is improbable that the applied trading system can overcome a simple buy and hold strategy. In regards to the MA strategy used in this study, a variety of pairs (short and long moving averages) were used with the short being anywhere between 5 and 55 periods and the long between 60 and 220. Another thing that differentiates this study from the rest, is the fact that the use of a stop loss has been tested, albeit a fixed one, the exponential moving average of 9 periods. The study concludes that the use of the stop loss should be considered with other samples and with other parameters since, in the case of this study, the results were mixed. (Da Costa et al., 2015)

Finally, in one paper an attempt was made to combine the traditional MA50-MA200 crossover strategy with 2 more indicators, the relative strength graph (relative strength compared to the S&P) and the cumulative volume graph, to provide entries and exits. The data sample was from 1976 to 1985 and a total of 204 stocks were studied. Three criteria had to be met in order for a position to be opened. First, the 50-day price moving average graph must intersect the 200-day price moving average graph from below when the slope of the latter graph is greater than or equal to zero. Second, the relative strength graph, from beginning to ending point over the previous four weeks, must have a slope greater than or equal to zero. Third, the cumulative volume graph from beginning to ending point over the previous four weeks must have a slope greater than zero. When these criteria are satisfied, a buy position is opened if price reaches the 110% of the level established by the crossover of the 50 and 200 moving averages. This level is used in order to avoid getting caught in fake trend initiations. The position is closed in profit if price reaches the 120% level established again by the crossover or in a loss if the price of the stock declines below the 200-day moving average. The results of this study provide evidence to support the predictive ability of technical analysis since, in the studied sample, the trading system outperformed the buy and hold return strategy even after adjusting for timing, risk and transaction cost. A total of 204 trades were taken during the duration of the study. (Pruitt and White, 1988)

2.2.2 Moving Average Convergence Divergence (MACD)

The MACD is an oscillator made up of two lines, the MACD line and the signal line. The MACD line is formed by subtracting the 26-exponential moving average from the 12-exponential moving average, using the closing prices. The signal line is drawn as the 9-period exponential moving average of the MACD

line. A “buy” signal is generated when the MACD line crosses the Signal line from below, while a “sell” signal is generated when the MACD line crosses the Signal line from above. (Hejase et al., 2017)

In a study mentioned in the previous chapter, where 198 Brazilian stocks were tested, other than simple moving averages, the authors also tested the profitability of the MACD indicator. The conclusion was of a similar nature, meaning that the use of the MACD has a high probability of growing the initial investment value but, with the introduction of trading fees, the trading strategy starts to underperform against the buy and hold strategy. It is noteworthy to mention that the use of a stop loss, namely the EMA9, did not lead to greater protection from risk, on the contrary it affected negatively the predictive power of the MACD. (Da Costa et al., 2015)

Another study, this time on the efficiency of the MACD indicator in the Lebanese stock market during the period 2004-2014, concluded that the indicator does not outperform the buy and hold approach. The study goes on to argue that this might be happening because of the inactive nature of the Lebanese stock market. It is common to think that technical analysis has the desirable effect in more active markets, where the bid and ask spread is lower, there is less market manipulation and more liquidity in general. That being said, more research is suggested to support the above claims, e.g. a combination of the MACD and other indicators. (Hejase et al., 2017)

Contrary to the above, a study conducted on forex pairs of 22 currencies quoted in US dollars during the period of 1996-2015, seems to reach a different conclusion. Two sub-samples were studied, those of 1997-2005 and of 2006-2015. After accounting for interest rate differential and data snooping, the results appear to be supporting the profitability of the MACD strategy. Through the period of 1997-2005, the mean excess returns of the MACD strategy were 9.36% and in the 2006-2015 period the mean reached 11.48%. On the other hand, the MACD (zero) strategy, where a bullish signal is considered even if the signal line crosses the zero line, had a mean of 5% in the 1997-2005 period and of 7.06% in the 2006-2015 period. Finally, it is encouraged, for future researches to consider a combination of technical trading rules. (Coakley et al., 2016)

2.2.3 Relative strength index (RSI) and Bollinger Bands (BB)

The RSI is one of the most popular momentum oscillators. It compares the magnitude of the recent gains to the magnitude of the recent losses and generates a number that ranges from 0 to 100. The technicians say that generally when the RSI rises above 30 it is considered a bullish signal; a signal that prices tend to rise. Conversely, when it falls below 70 it is considered a bearish signal; a signal that prices are likely to fall.

$$RSI = 100 - \frac{100}{1 + RS}, \text{ where } RS = \frac{avgGain}{avgLoss}$$

$$avgGain = \frac{\text{total of gains during past } n \text{ periods}}{n}$$

$$avgLoss = \frac{\text{total of losses during past } n \text{ periods}}{n}$$

The Bollinger bands were designed to compare the volatility and relative price levels over a period time. It consists of three bands that encompass the majority of the price action. The bands are: (i) a central Simple Moving Average (SMA), (ii) an upper band derived from the SMA plus a specified number of standard deviations, and (iii) a lower band derived from the SMA minus a specified number of standard deviations. Beyond simply recognizing relative price levels and volatility, Bollinger Bands can be employed in conjunction with price action to produce signals and anticipate substantial market shifts. (Teixeira and Oliveira, 2010)

A study conducted in forex, which was also mentioned in the previous chapter, tests the profitability of both the RSI and BB. In this study, regarding the Bollinger bands, a buy signal is generated when the exchange rate crosses the lower band from above by b% (then prices are considered to be low) and a sell signal when the exchange rate cuts the upper band from below by b%. Regarding the RSI, the level 60 was set as the high level and 40 as the low level. When the RSI was b% above the high or below the low a buy or sell signal was generated accordingly. The results of this study provided strong evidence that, in the tested sample of 22 currencies and in the specific period of 1997-2015, the Bollinger band and RSI strategies outperformed the rest of the strategies, even the MACD index, after accounting for rate differentials and data snooping. (Coakley et al., 2016)

To conclude with, another study, this time on the Indonesian stock market (LQ45 stock index), during February 2021 – July 2021 aimed to compare the results from the RSI, BB and SMA. The results found that all 3 of these indicators were accurate, with the relative strength index having more optimal performance than the rest. Specifically, the RSI had an optimal return of 8.31%, the BB of 5.36% and the SMA of 1.20%. (Daniswara et al., 2022)

3. Trading Strategy

3.1 Data

In order to test the trading strategy below, a large sample of data (Open, High, Low, Close) regarding the SPX was collected starting from the 3rd of January, 2000 and ending in the 20th of December, 2023. The timeframe used, for the most part, in the candlesticks chart is the daily timeframe except for the last part where the strategy was tested in a high frequency scenario, using the 15 minutes candlesticks chart. Continuing, the daily data was split in 4 periods of time, early 2000 to early 2007, early 2007 to early 2011, early 2011 to early 2019 and early 2019 to late 2023. The choice of these periods of time was not done at random, during the early 2000s the dot com bubble burst, during the 2007-2011 period the great recession took place, during the 2011-2019 period the U.S. economy was in a considerable uptrend and during the 2019-2023 period the Covid outbreak hit the global economy. Finally, the data was collected using the tradingview.com website and processed in the python language.

3.2 Description of the Trading Strategy

Contrary to most trading strategies, this strategy does not rely on any particular indicator or information outside the stock's, or in this case index's, chart. It is an attempt to read the way price is auctioned and depicted in a candlesticks chart. For this to happen, a strict set of rules was created and written in the python language, as an attempt to watch price in a more mechanic way. To test the performance of this strategy the backtesting.py library was used in conjunction with the written code. Both the code written and the library used have their own limitations in applying the strategy in its true form, e.g. the library can only have orders be executed during the open/close of a candle which in some cases greatly affects the tested strategy.

3.2.1 Candlesticks Chart

The candlesticks chart was developed in the seventeenth-century Japan by trader Munehisa Homma. It is a way to visualize the open, high, low and close of market prices over a specific period of time. (Lo and Hasanhodzic, 2010) The candlesticks chart is popular to this day and it is the tool over which the strategy developed in this paper stands on. Based on the way a candle opens and closes the candle takes a different color, e.g. green for up-close candles and red for down-close candles. Regarding the timeframe of the candles, a candle could be depicting the OHLC prices of the month, week, day etc. In this study the candles represent 1 trading day, except for the high frequency part of the study where the candles represent 15 minutes of a trading day.

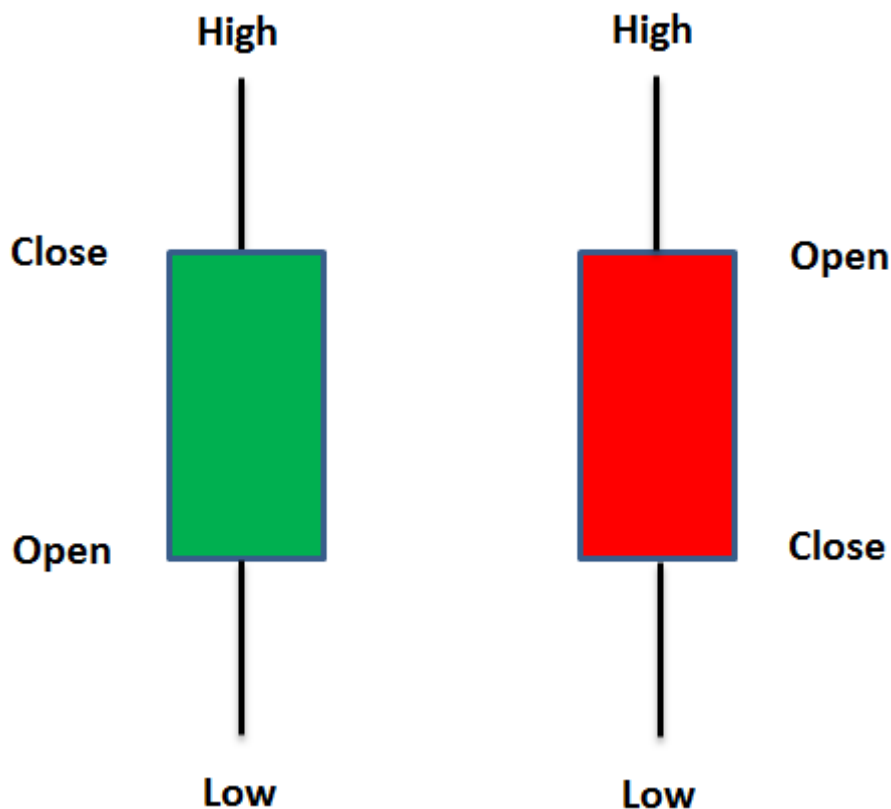


Figure 1: Up-close candle (left) and down-close candle (right)

3.2.2 Value Gaps

Value gaps in price are identified as a triple candle formation pattern and they are usually formed when a one-sided move has occurred, either to the upside or the downside. The formation consists of 3 consecutive candles and the gap always lies in the middle one. For a downside value gap to form, the low of the first candle (candle on the left) should be higher than the high of the 3rd candle (candle on the right). Accordingly, for an upside value gap to form, the high of the first candle should be lower than the low of the third candle. The reasoning behind the use of this gaps is that price did not have the time to be auctioned efficiently at those levels. This is considered to mean that buyers and sellers did not have the time to agree to a fair price for the index due to a large one-sided move. This move can occur for a variety of reasons, e.g. a news driven event which leads investors to buy/sell and by no means does it mean that price has to auction back in it to establish a fair price. However, for the purpose of this strategy, value gaps are considered when searching for an entry, in combination with some more price auction formations. Both upside and downside value gap formations are depicted below:

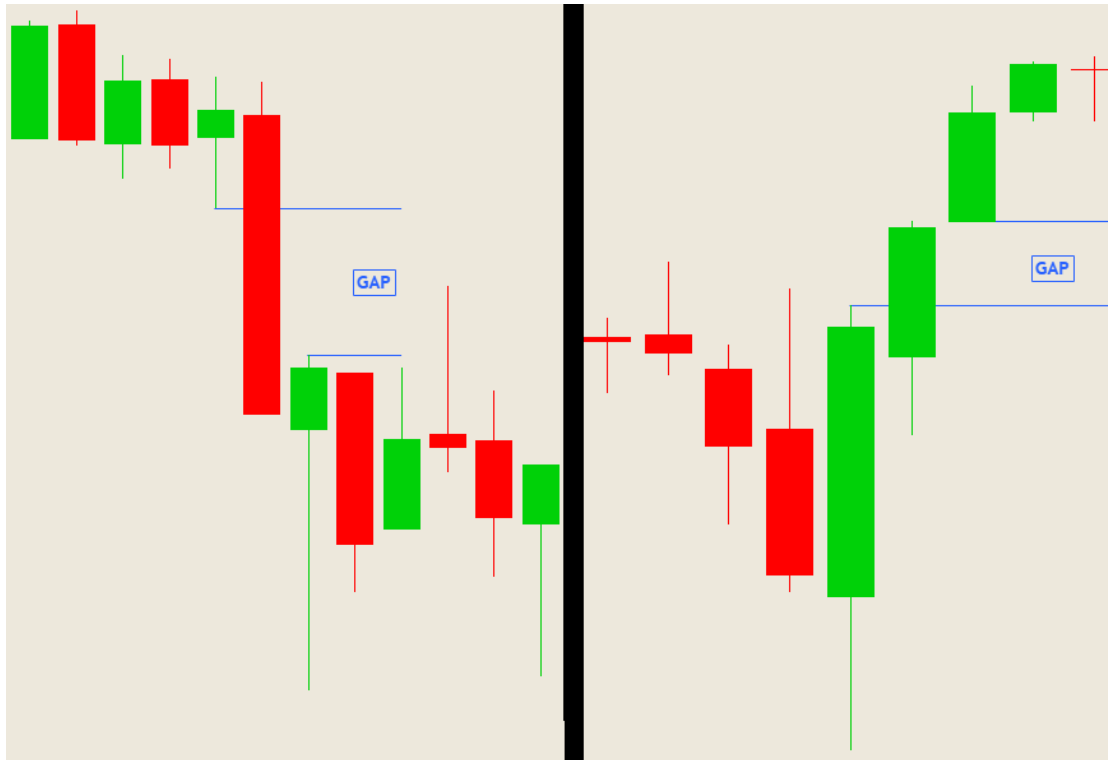


Figure 2: Downside value gap (left) and upside value gap(right)

3.2.3 Defining the trend

For the purpose of this strategy, the trend is either considered bearish (downtrend) or bullish (uptrend), never is the market considered as “ranging”. Two prices are taken into account to define the trend as bullish or bearish, the “high price” and the “low price”. The high price starts by being the highest price traded up to that moment in time and the low price starts as the lowest price up to that moment in time. When the price trades above the high price, a new high price is created and the trend is considered bullish. In the same way, when price trades below the low price, a new low price is created and the trend is considered bearish. As price is unfolding, depending on whether the trend is bullish or bearish, candles are assigned different meanings. Starting with a bullish trend, any down candle in a bullish trend is suspect of forming a new “low price”. When a down candle forms in a bullish trend it is immediately taken into account and as price unfolds the strategy looks for candles that auction above the high of the down candle (or candles). If the high of one of the candles formed after the down candle is higher than the down candle’s high then the algorithm looks for the lowest low in that area (which usually is the down candle’s low) and assigns it to the “low price” variable. This effectively means that if price auctions below this new low price the trend changes from bullish to bearish. Conversely, when an upside candle forms in a bearish trend the strategy looks for candles that auction below the low of the up candle (or candles). If the low of one of the candles formed after the up candle is lower

than the up candle's low then the algorithm looks for the highest high in that area (which usually is the up candle's high) and assigns it to the "high price" variable. Again, this practically means that if price auctions above this new high price the trend changes from bearish to bullish.

This way of defining the trend serves in a couple of things. Firstly, it is a way of identifying early trend reversion and making the best of it. Secondly, it serves as a trend following strategy, since as long as the trend remains the same the strategy keeps its position open, effectively following the trend. Lastly, it serves as a way of defining a trailing stop loss order, which is considered at the same time a take profit order since this strategy does not have any specific target for taking profits and closing the position. The reasoning behind this way of defining the trend is similar to the reasoning behind the value gaps, as it is an attempt to read how price was auctioned in particular levels and use the conclusions to predict how it will unfold in the future. In an uptrend, two things are bound to happen, either price will go up in a straight line, in which case value gaps are formed, or it will consolidate and/or pullback before its next move up. During these consolidation periods a lot of transactions are expected to take place. This effectively means that in those levels, a lot of investors/traders have bought and/or sold the index, creating a lot of interest for the index in those prices and trapping a lot of them in unprofitable positions which they will look to exit at the best possible price. This is the reason why this strategy considers the aforementioned consolidation zones as important support levels and especially the zones where most selling has happened (down candles), in the case of a bullish trend. Conversely, in a down trend the green candles in a consolidation are usually where most buying has happened, effectively creating a resistance zone which "defends" the down trend. This theory is also in line with the higher highs – higher lows (bullish trend) and lower highs – lower lows (bearish trend) logic and it is the reason why if a low (high) is breached the trend changes from bullish (bearish) to bearish (bullish).

3.2.4 Creating the strategy

The studied strategy is a combination of the value gaps and the way of defining the trend analyzed in the previous subchapter. In order to open a position, either long or short, the strategy first waits for a trend change to happen, as explained above. When a trend change happens, the strategy looks for the closest value gap possible and waits for price to auction back to that value gap. If price auctions back inside the gap a buy or sell order is issued depending on the trend change, bearish-bullish or bullish-bearish accordingly. If price does not auction back to the value gap, according to this strategy no auction is taken and the trader/investor should wait for the next opportunity. The strategy exits the position only when a new trend shift takes place as to avoid any unnecessary loss of capital or secure the profit made. Two examples are being presented below, one of a bullish and one of a bearish trend swift.

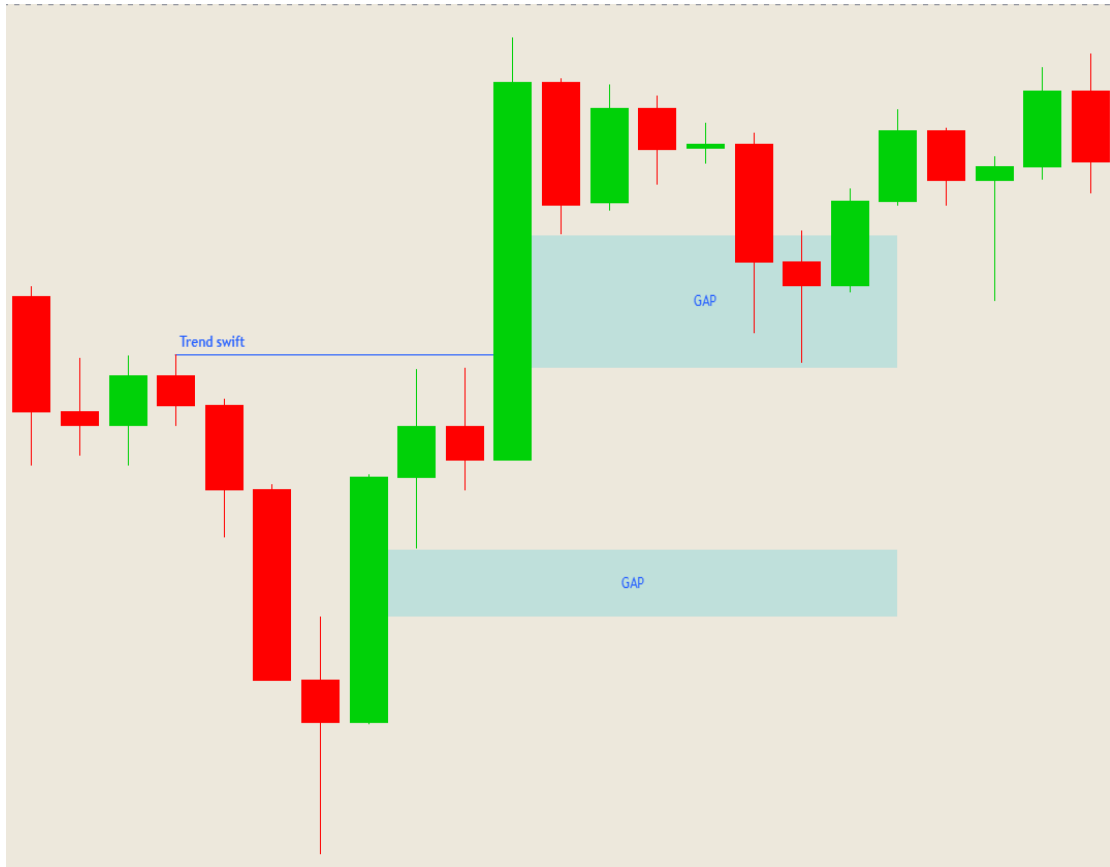


Figure 3: Bullish trend shift



Figure 4: Bearish trend shift

3.3 Results

As mentioned before, the testing was done in four distinct periods of time during which the market was unfolding under different trends and circumstances. Below a table is listed regarding the statistics of the studied strategy, without taking into account any exchange commissions.

Results without exchange commissions				
A/A	2000-2007	2007-2011	2011-2019	2019-2023
Period duration (Days)	1760	1008	2012	1251
Exposure duration	35%	21.9%	39.22%	31.03%
Peak return	27%	3%	9%	5%
Strategy's return	12.65%	0.67%	-6,77%	1.11%
Buy and Hold return	-2.65%	-10.22%	97,35%	87.18%
# Trades	51	20	51	29
Win rate	39.22%	35%	39.22%	31.03%

Table 1: Results without taking into account exchange commissions

From the above table, it immediately becomes clear that in the first two periods, 2000-2007 and 2007-2011, the strategy's return surpasses the return of a buy and hold strategy. However, in the last two periods, 2011-2019 and 2019-2023, the buy and hold strategy returns greatly surpass those of the studied strategy. There is a very clear reason as to why the returns are split the way they are. During the first two periods, the markets were in a period of great turbulence and were trying to recover, as shown by the charts below. First it was the dotcom bubble, then it was the great recession. During times like these, it's expected for the buy and hold strategy to underperform since the market is either going down or sideways, just like it is expected to outperform when the market is growing non-stop, as is the case for the 3rd and 4th studied periods. On the other hand, the tested strategy uses both long and short orders and was expected to perform equally well whether the market was bearish or bullish. This doesn't seem to be the case as per the results, while it outperforms the buy and hold strategy in both bearish periods for more than 10%, it heavily underperforms during the bullish periods, even ending up at a loss in the 3rd one.

However, a benefit of using a trading strategy, as opposed to a simple buy and hold strategy, that is often overlooked is the exposure time. Exposure time is basically the amount of time the investor/trader is exposed to risk and has his capital locked up. While in the buy and hold strategy the exposure time is of course 100%, using this strategy exposure is reduced to an average of 35%. Finally, the win rate average is about 36% which means that around 1 out of 3 trades are winners. For someone trading the strategy this means that only

signals that have a risk to reward ratio of at least 1:3 should be taken into consideration. This ratio means that, in every trade, for every dollar in risk of losing there should be a potential profit of at least 3 dollars. This would of course require a fixed target when opening a trade which is not included in this strategy.



Figure 5: 1st trading period (2000-2007)



Figure 6: 2nd trading period (2007-2011)



Figure 7: 3rd trading period (2011-2019)



Figure 8: 4th trading period (2019-2023)

To continue with, the same strategy was tested using exchange commissions of 0.1% per trade, meaning 0.1% was charged to enter and 0.1% to exit a trade. The results are shown in the following table:

Results with exchange commissions				
A/A	2000-2007	2007-2011	2011-2019	2019-2023
Strategy's return	5%	0%	-11,00%	-1%
Buy and Hold return	-2.65%	-10.22%	97,35%	87.18%

Table 2: Results after taking into account exchange commissions

As expected, it is clear that the strategy's performance has fallen after introducing exchange fees. It also makes sense for the 2 periods with the most trades, 1st and 2nd, to have taken the biggest hits, the 1st is down about 7% and the 3rd is down about 5%. Conversely the 2nd and 4th period were impacted much less, with the 2nd being down less than 1% and the 4th about 2%.

3.3.1 Compared to RSI strategy

Withing the scope of this thesis it was thought necessary to juxtapose the previously developed strategy to one more traditional such as the RSI indicator strategy. As previously mentioned, the RSI is an oscillator which takes numbers from 0 to 100. A widespread strategy using the RSI is to execute buy orders when the RSI crosses the 30 level from below and sell orders when it crosses the 70 level from above. The existing long positions are closed when the RSI crosses the 70 level from above, while the existing short positions are closed when the RSI crosses the 30 level from below. The number of periods (n) taken into account to calculate total gains and total losses and form the RSI chart is 14. Finally, this strategy is tested during the same 4 periods that the previous strategy was. The results are listed below:

RSI results without exchange commissions				
A/A	2000-2007	2007-2011	2011-2019	2019-2023
Period duration (Days)	1760	1008	2012	1251
Exposure duration	96.76%	96.23%	98.56%	98.64%
Peak return	32%	24%	26.07%	4.87%
Strategy's return	18.44%	-18.70%	56%	24%
Buy and Hold return	-2.65%	-10.22%	97,35%	87.18%
# Trades	11	6	16	13
Win rate	45.5%	50%	75%	61.53%

Table 3: RSI strategy results without taking into account commissions

Except for the period of 2007-2011, the RSI strategy seems to bring considerably greater returns than the previously tested strategy, while it struggles to outperform the buy and hold strategy. Exposure time is close to 100%, very similar to the buy and hold exposure time. There seems to be a considerable difference between the peak return and the final return in every period, making the strategy quite volatile. The number of trades is considered small for the number of days studied and since it is smaller than the previous strategy's trades there will not be further research with commissions taken into account. The win rate fluctuates from one period to another with an average of 58%, considerably better than the previous 36%. All in all, the RSI strategy seems to outperform the previous strategy in the studied periods of time while they both underperform the buy and hold strategy returns. The RSI charts from the studied periods of time are depicted below:

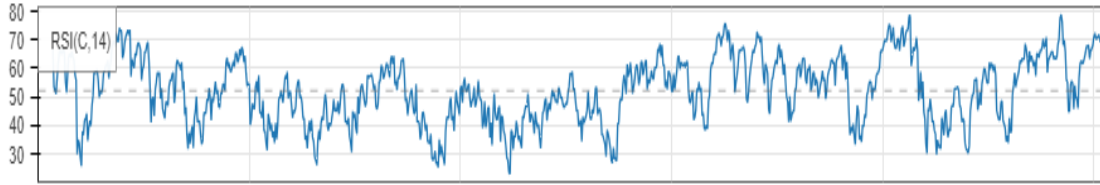


Figure 9: RSI chart, 2000-2007

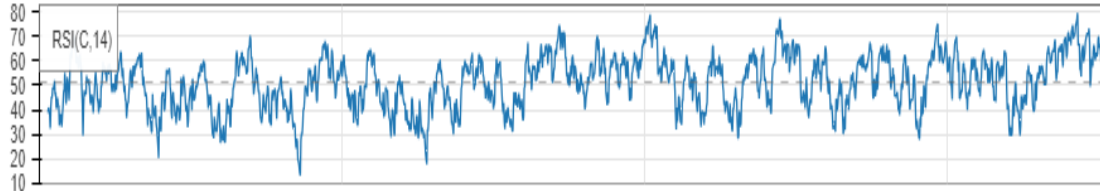


Figure 10: RSI chart, 2007-2011

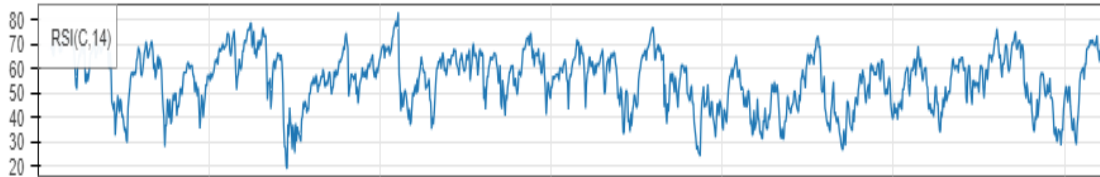


Figure 11: RSI chart, 2011-2019

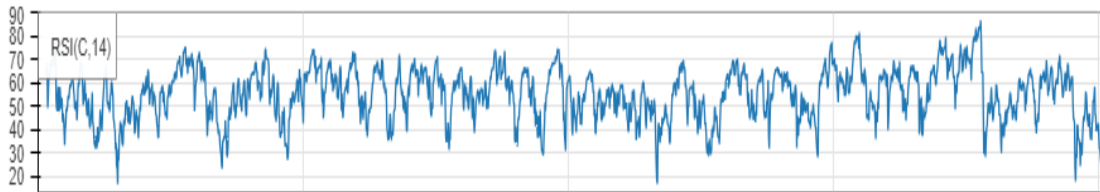


Figure 12: RSI chart, 2019-2023

3.3.2 Trading the 15 minutes chart

The 15 minutes chart starts from the 2nd November of 2020, 2:30 pm GMT and ends on the 22nd of December 2023, 8:45 pm GMT. This is done in order to test the strategy in a high-frequency scenario, where price is more susceptible to “noise”. The results of the test are shown on the following table:

High frequency test	
Period duration (15min)	20174
Exposure duration	31.75%
Peak return	6%
Strategy's return	-18.93%
Buy and hold return	26.64%
# Trades	417
Win rate	38.85%

Table 4: Results of high frequency testing

It is interesting to note that a total of 417 trades have been taken during this high frequency study, considerably more than the total of trades taken in all the periods of the high time frame testing depicted above. This makes sense, since the total candles studied in this high timeframe strategy are also considerably more, 20174 candles. Continuing, it is clear that the strategy did not perform well during this high frequency period, featuring a loss of 18.93% while the buy and hold strategy had a total return of 26.64%. It is also worrisome that price seems to be ranging, instead of trending, during the studied period of time which is the type of movement where this strategy was thought to perform better. Finally, it is considered noteworthy that the win rate and the exposure duration are both around the same levels as they were in the four high timeframe periods depicted above. This fact supports the idea proposed in the previous sub-chapter, that the tested strategy in combination with clear risk to reward ratios could have its performance boosted. A visual representation of the price chart of the tested data is shown below:



Figure 13: High frequency trading price chart

One more high frequency test was conducted in the current sample, again without taking into account exchange commissions, this time using the RSI strategy analyzed in the previous sub-chapter. The results are presented in the table below:

High frequency test	
Period duration (15min)	20174
Exposure duration	99.90%
Peak return	18%
Strategy's return	-17.41%
Buy and hold return	26.64%
# Trades	180
Win rate	57.22%

Table 5: Results of high frequency testing, RSI strategy

Starting from the strategy's return, it is more or less the same as the return from the previous strategy, heavily underperforming the buy and hold return. The exposure time is extremely high, nearly 100%, and the volatility of the returns is also considerably high, around 36% difference between peak and final returns, just like it was when previously testing the strategy in high timeframe

circumstances. Moreover, the number of trades to period duration ratio and the win rate appear to be about the same as the averages of the previous high timeframe tests, leading to the conclusion that they remain stable despite the studied timeframe which could be used in future studies. Finally, with a win rate of 57.22% and a final return of -17.41%, it is safe to assume that the average losses per trade were considerably higher than the average profits per trade.

A/A	2000-2007	2007-2011	2011-2019	2019-2023	15min	Average
N.Trades/N.Candles	160	168	125.75	96.23	112.08	132.41
Win Rate	45.5%	50,00%	75,00%	61.53%	57.22%	57.85%

Table 6: Number of trades to period duration ratio and win rate for the RSI strategy throughout the tested periods of time

4. Conclusions

To sum up all the above, this study has presented a non-traditional technical analysis strategy, tested it during 4 different periods of time where important economic events transpired and in a high frequency scenario and compared the results against the buy and hold and the traditional RSI strategy.

The results suggest that both technical analysis strategies (non-traditional and RSI) may have some merit in the higher time frames (daily candles chart), specifically during periods of time when price is ranging and/or trending to the downside, but they seem to lose their edge, compared to the buy and hold strategy, when price is heavily trending to the upside. The tested strategies also seem to be highly inefficient, at least in the current data sample, when testing them in high frequency scenarios, 15 minutes candle chart, since they result in considerable losses during a period when a simple buy and hold strategy results in 26% profits.

Despite the above, there are some changes that could be worth implementing to improve the results of both the tested strategies. The non-traditional strategy has an average win rate of 36% while the RSI strategy has an average win rate of 57%. This basically means that in order for the strategies to be in profit, in the long term, the executed trades should have a risk to reward ratio of at least 1:3 (non-traditional) and 1:2 (RSI), meaning that for every unit of currency risked there should be a 3 (2) units reward at least. That being said, for this to happen there should be clear price levels in which to take profit, this way the trader is able to measure the risk to reward ratio. When testing these strategies, no particular profit targets were set, instead the open positions were closed when a signal to open an opposite trade appeared or was suspected to appear. These take profit levels could be defined by the use of a different technical analysis strategy in combination with the studied ones, such as the moving averages or the Bollinger bands.

To continue with, deriving from the conclusion that the tested strategies brought better results in the higher timeframe testing, one more change that seems worth testing is a multi-timeframe approach. A multi-timeframe approach would be to use the weekly candlesticks chart for signals and the daily for entries. When it comes to the non-traditional strategy this could be viewed as a “follow the trend depicted by the weekly chart and look for entries (value gaps) in the daily chart” approach. This new multi-timeframe approach is expected to result in higher win rate and less trades taken in a specific period of time; thus, further research is noted as worthwhile.

All things considered, technical analysis seems to have some merit to it in specific occasions but seems to lag behind when the market is growing in a fast pace. A combination of different strategies could bring about better results.

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