University of Essex
Department of Mathematical Sciences

MA981: DISSERTATION

A Systematic Study of Algorithmic Trading and Various Strategies

Arjun Gopal Cheroor Gokuladasan
2101406

Supervisor: Andrew Harrison

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Acknowledgement

"Thank you Universe!"

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CHAPTER 1

Introduction

The process by which an automated system takes trades following a set of instructions is known as algorithmic trading. Or in simple words, Algorithmic Trading uses computer code to automate, fast, and accurately execute trades on shares based on a trading strategy. Due to the speed and accuracy of algorithmic trading or automated systems, 80 percent of the world's trades are currently executed by such systems. Algorithms are used to determine parameters for buying and selling positions in these systems. Algorithmic trading is of many types, and the major difference is their speed of execution. Even though Python (the programming language) is slow, it is the most preferred programming language to do algorithmic trading. The process of algorithmic trading is done in a systematic way, first the data is collected then a strategy is developed. Back testing the strategy is very important and then it is implemented. To develop a strategy, different technical indicators are used. Some of the major technical indicators are Moving Average Convergence Divergence (MACD), Bollinger Bands (BB), Relative Strength Index (RSI), Average Directional Index (ADX), and On Balance Volume (OBV). High frequency trading is not suitable for these single trading strategies, since they perform poorly in turbulent and highly volatile markets. The aim of this dissertation is to propose and develop an automated algorithmic trading bot that uses multiple technical indicators with better profitability and speed as compared to a single-strategic system. An early study conducted by Brownlees et al. [1] On the basis focused on intra-daily volume modeling, the dynamic model captured time series dependence, intra-daily periodicity, and volume asymmetry of the series. It indicates the use of an economic

model based on conventional facts. To accommodate other asset classes, the research could have explored other aspects that could have benefited the model. An overview of Market Microstructure was presented by Frank et al.[2] that outlined how algorithms work using standard trading strategies such as Arrival price, time-weighted average price (TWAP), Volume-Weighted Average Price (VWAP), and Total Volume (TVOL). In order to achieve minimum transaction costs, the execution strategies were explained according to the market environment. There is no discussion of how automated trading affects the market, however. When taking trading decisions, it can be more profitable to use multiple technical strategies rather than one strategy using computational intelligence. Spyros K. Chandrinos et al.[3] developed trading strategies based on the Donchian Channel approach to generate stable profits. An MRB chart-based channel breakout trading strategy is developed and optimized in this article. In order to improve the performance of the system, each trading signal should be evaluated for quality and those likely to end in a loss should be identified. Based on data obtained from computer-based trading algorithms on turbulent days, Zhou et al.[4] examined the impact of algorithmic trading in turbulent markets. According to the analysis, algorithmic trading minimizes transient pricing errors and minimizes price pressures. High frequency trading was excluded from the study, however. It was this primary motivation that led me to learn more about different strategies, to try out merging different strategies and to develop a system based on multiple strategies that could handle markets while guaranteeing consistent profits. A free demo FXCM account is used to test the trading strategy.

CHAPTER 2

Literature Review

To explain changes in stock prices, there are many theories. In contrast, the Orthodox Theory suggests that stock price movement is caused by anticipation of changes in corporate earnings. In contrast, the Confidence Theory holds that stock price movement is based on fluctuations in investor confidence in future earnings, dividends, and stock prices. In organized markets, such as stock markets, trading prices of assets reflect all available information, with only news that has not yet been announced affecting prices. While EMH is weak, current asset prices at least reflect their own history. It is not possible to make profits solely by studying price history if the market is inefficient. However, there are studies that support technical strategies. Market information inefficiency is demonstrated by the effectiveness of making profits with technical trading rules 1997.A key advantage of Bollinger Bands is that they account for price volatility. Instead of moving average levels, Bollinger Bands are determined by the fluctuation of prices around the mean. The Bollinger Bands expand when volatility increases, while the Moving Average Envelopes do not, when the moving average remains unchanged. Bollinger Bands with two standard deviations will catch roughly 95% of stock price changes in a normal distribution.[5]

Capital gains can be made by investing in the stock market. Investors today face the challenge of choosing the right securities for their investments because choosing inappropriate securities can lead to substantial losses. There are many tools available to investors that can help them reduce the risk of losses and maximize return, among which RSI is an effective analytical tool. This will enable the investor to construct their portfolio in such a way that

risk is reduced, and return is increased. RSI was developed by J. Welles Wilder, an oscillator to measure price change and speed. RSI is a momentum indicator. Many articles, interviews, and books have been written about the RSI momentum indicator. Zero and 100 are the ranges of the RSI. Overbought and oversold are traditionally considered by Wilder to be when RSI is greater than 70 and less than 30, respectively. A divergence, failure swing, and centerline crossover can also be used to generate signals. A general trend can also be identified using RSI. The purpose of Technical Analysis, according to Reena Baral and Abhishek Kumar Chintu (2013)[6], is to direct investment decision-makers to a direction that is likely to produce the desired results and meet the investors' expectations. Investing in and exiting the stock market can be timed by technical indicators. A reliable indicator to use is the Relative Strength Index (RSI). The RSI value decreases whenever the share price decreases, indicating that shareholders should buy at that time. Researchers have found that MACD and RSI oscillators do a respectable job predicting prices on most exchanges throughout the world in a study by Tai-Leung Chong, Wing-Kam Ng, and Venus Khim-Sen Liew (2014)[7]. Many developed and developing markets generate significant abnormal returns using the MACD and RSI rules. By utilizing these tools, investors can make significant gains on their investments.

Evaluation of Super Trend indicator's parameters for major FOREX pairs over 12 years When a rate change appears that exceeds an upper or lower border, the Super Trend indicator provides a signal. In this case, the boundaries are formed by taking the average of the true rate over a given period multiplied by a multiplier parameter defined in the simulation. The Super Trend indicator is frequently used in chart analysis, such as in FOREX trading, but extensive studies of its influence were not yet available. The Super Trend indicator algorithm published by Robinson & Associates (2008, p. 42)[8] was used to detect up or down trends in historical daily rates data. An analysis of "window size" and "multiplier" parameters of the indicator was conducted between [1 to 50] step size 1 and [0.1 to 20] step size 0.1, respectively. There is little value in shorter windows than five. Therefore, 46*200 = 9,200 parameter pairs were tested for each currency pair. Whenever the indicator indicated a trend change, trades were entered and closed accordingly. As an example, a long order is initiated and closed when the trend is signalled to change to a downtrend by the Super Trend indicator. In the case of a closed order with a loss of more than 10% of its open price, the performance of the parameter pair is marked with -1. Simulated outcomes with a 30% or more drawback (relative to the order open price) are denoted with a 1. Parameter pairs that are labelled with

-1 are referred to as 'failed' parameter pairs.[9]

A Renko chart also disregards time and volume, just as the Point and Figure chart does. In the same way, Kagi & Line-Break charts work. Price action that is significant is plotted on these time-independent charts. To capture price changes on a chart, the user must decide how significant a move is. Thus, these charts are easy to read because noise is eliminated. A major advantage of these charts is their simplicity and objectivity. The typical bar or candlestick chart has two dimensions, price, and time. An x-axis plots time and a Y-axis plots price. No matter what the price trend is, charts move over time. Prices that are "significant" are captured by Renko charts and not time and volume. By filtering out insignificant price moves and noise, it concentrates on what is going on with the price. A brick chart is also known as a Renko chart. Renko charts provide us with the deepest insight into the trend. The most challenging aspect of trading is riding a profitable position. For significant returns in trading, we must be able to ride trends.[10]

The study by Ikhlaas Gurrib(2018)[11] examines whether major foreign currencies can indeed be used to trade successfully under a trend-based system, in the same manner as regulatory institutions such as the Bank of International Settlements, which is committed to promoting monetary and financial stability internationally. An average directional index model coupled with a parabolic stop and reverse indicator is used for testing the most actively traded USD currency pairs. There were more trades and steeper maximum drawdowns with the weekly-based system than with the monthly-based system, as expected. Swiss Francs, however, experienced the best and least productive performance under the monthly and weekly models, respectively. It is also important to note that relative performance depends on the frequency of the model. Total return and downside risk are typically higher with a weekly-based model. Even though the number of trades was lower, the maximum drawdown was higher, and Sharpe and Sortino values were positive, but they were low, the whole period analysis model showed a close performance after defragmentation over the pre and post crises periods. Due to the sparse number of trades, the monthly dataset is more effective over a longer period. As a future research avenue, Sortino values indicate the need for higher frequency data models to benefit from volatile foreign exchange markets. By improving their understanding of the risks and returns associated with the most actively traded foreign currency pairs, banks, which are the biggest players in the foreign currency markets, could enhance their banking systems.

Various technical indicators in Forex can be used to generate buy and sell rules for an automated trading system. Indicators are computed from their original formulas and interpretations using Virtual Historical Trading Software (VHTS); assumptions are applied; buy and sell signals are generated according to the MACD indicator. In the Forex market, the price of a currency is determined by supply and demand. Fundamental analysis (FA) is the most accurate method for determining asset valuation. Price and volume are included in technical analysis (TA) by utilizing historical data. Quantitative analysis uses indicators like MACD and P-SAR whereas qualitative analysis relies on the level of support, resistance, and double bottom shapes to clarify the shape of geometric patterns. Using a specific formula and currency information (opening, low, high, closing) with mathematical calculations. This trend indicator shows the relationship between prices and moving averages by displaying MACD (Moving Average Convergence Divergence). Gerald Appel invented the MACD in 1970. It is calculated by comparing 26 and 12 exponential rolling averages. To indicate long/short opportunities, another exponential average for 9 days is plotted on top of the MACD, referred to as "trigger" or "signal".[12] The MACD has the advantage of combining trend and momentum in one indicator. Indicators that follow trends are unlikely to be wrong too long. The indicator follows the underlying security after applying moving averages. The use of Exponential Moving Averages (EMAs) can eliminate some lags. MACD predicts moves in an underlying security based on its momentum. Forecasting a trend change relies on MACD divergences. There is a possibility of a Negative Divergence signal in which bullish momentum waned. It warns violent traders against taking advantage of long positions when setting off a short position. MACD is also useful on daily, weekly, and monthly charts. With the MACD, we can see the divergence and convergence of two trending averages. A combination of moving averages can be used, although the standard setting is 12 and 26 period EMA. Each security can also have its own set of movable averages applied in MACD. Weekly charts may benefit from faster changing averages. Slower moving averages, on the other hand, may help smooth volatile data. With the MACD, traders can adjust it to their trading style, risk tolerance, and objectives.[13]

According to the study by Yazdi et al.[13], the following findings were obtained: Trading EUR/USD with MACD produced better results. According to the assumptions of this study, MACD-EUR/USD is the most effective combination of MACD-Currency in terms of generating profit. At the end of the ten-year period of trading, the MACD created $8,068.53

cash for EUR/USD. In addition, all four traders lost 1,672 pips due to buy signals, while sell signals lost 7,360 pips, which is a considerable difference. There is more profitability in buy signals generated by MACD than in sell signals. VHTS generated notable results, including calculating market-based commissions for each trader. Despite winning or losing traders, brokers made profit.

An effective way to construct a portfolio is to use RSI. Long-term as well as short-term investments can be made with it. A buy or sell signal can be accurately predicted for various stocks using this software. Stocks' future trends can often be predicted with RSI. RSI has been studied on a number of stock markets throughout the world. However, RSI has not been studied extensively on India's stock market. Based on the results of our research, we found that RSI could also be successfully applied to Indian stock markets for short-term investments. Furthermore, P/E ratios are more accurate indicators of profitability than EPS, according to the study. Investing in the twenty stocks over the short and long term will also provide the following signals. As a result of their analysis[6], it is obvious that RSI is one of the most effective technical analysis tools. It can also serve as a useful tool to design a portfolio. As in other markets around the world, it performs the same in Indian stock markets. Compared to earnings per share, the P/E ratio better reflects an organization's performance. Even though RSI is an excellent analytical tool on its own, it is best used in conjunction with fundamental analysis and other technical analytical tools.

Leung et al.[3] study recommends short-term investments using Moving Average Envelopes and long-term investments using Bollinger Bands. In practice, however, Moving Average Envelopes would be better than Bollinger Bands because technical trading rules are typically designed for short-term investment purposes. Due to this, Bollinger Bands do not outperform Moving Average Envelopes in terms of profitability despite their ability to capture sudden price fluctuations.

The study demonstrated [9], with the appropriate parameter values, the Super Trend indication may be a potent indicator. This is the first time that we have provided the optimal parameters for 12 major FOREX currency pairs in a large-scale and systematic manner. It may be possible to extend this study by looking at different timescales, randomized start/end points, and asset classes. The parameter space performance was significantly different in the back test simulations (on daily rate data) that covered more than 12.5 years. Parameter robustness can be estimated by the percentage of parameter combinations that produce unac-

ceptable results. A parameter robustness concept may also be applied to the general problem of indicators that are dependent on their parameters. In regard to parameter choice, our results may help replace gut feeling with rationality. Further, we provide a recommendation for the appropriate parameters and visualize the effects of the parameter selection.

CHAPTER 3

Methodology

3.1 ALGORITHMIC TRADING OVERVIEW

3.1.1 Use programming to extract financial data from any of the following:

- Forex, commodities, and equity markets
- Web scraping and APIs
- Data sources that are free (Pandas data reader, Yahoo Finance, Alpha vantage, FXCM)
- Fundamental data and OHLCV data

3.1.2 Perform technical indicators coding & fundamental analysis using Python

- There are moving averages, MACD, RSI, ADX, OBVs, etc.
- Signals, slops, and crossovers
- Programming to analyze stocks' fundamentals.

3.1.3 Build trading strategies and then Back test it

- Code the trading strategies

- The performance of strategy is back tested by using historical data
- The KPI's of the strategy (Sharpe, Sortino, win ratio, etc.) must be calculated.

3.1.4 An automated trading setup can be built using these RESTful API's

- Integrating our strategy with live data and implementing it.
- Trading demo account with FXCM or any other broker that provides API.

3.2 DATA EXTRACTION

As discussed in the earlier section, there are different methods for data extraction and I will be using API's to extract the data.

3.2.1 API (Application Programming Interface)

Many websites/ web applications provide API which lets developers access data efficiently. Usually paid/ subscription based but can be available for free as well with restrictions. API's allows the developers to use a software created by someone using their own code, subjective API is provided by the software developer.

3.2.2 WEB SCRAPING

Web scraping is nothing but accessing data on a web page by passing the page's back end code. It is not as efficient as API. Legality is a grey area with conflicting opinions. However, use for non commercial purposes is generally allowed. Companies actively discourage users from using web scraping to access their data and therefore it is getting interestingly difficult to use scrape websites.

3.3 TECHNICAL INDICATORS

An important part of technical analysis is the use of technical indicators. In technical analysis, you analyze trends of stocks by studying chart patterns and things like that. I think it's pertinent to point out that most technical indicators are lagging indicators. The main purpose

of technical indicators is to confirm trends. It is also common to use them in conjunction with other technical indicators. It will not be enough to use one technical indicator and be done with it. In most cases, you will use a number of technical indicators. This will ensure that the signal generated on the first day is reinforced by the signal generated on the second day. It is a common practice among traders to do that. In support of technical indicator proponents, there is something called efficient market hypothesis. The efficient market hypothesis states that markets are efficient, fully efficient, and if updated information is announced to the market rate, it is immediately incorporated into asset prices. Some of the popular technical indicators are:

- MACD: Moving Average Convergence Divergence
- Bollinger Bands
- RSI: Relative Strength Index
- ADX: Average Directional Index
- OBV: On-Balance Volume
- Renko Charts

3.3.1 MACD (Moving Average Convergence Divergence)

It is a trend following momentum indicator which is calculated by the difference of moving averages of an asset price (typically 12 period MA & 26 period MA). A signal line is also calculated which is again a moving average (typically a period) of the MACD line calculated as per the above step. The MACD line cutting the signal line from below signals a bullish period and the former cutting the letter from above signals a bearish period. This is called the Crossover strategy. Many false positives -especially denying sideways market. Suggested that this indicator be used in conjunction with other indicators. Lagging indicator - Trails behind the actual price action.

3.3.2 Bollinger Bands and ATR (Average True Range)

Both Bollinger bands and ATR are volatility-based indicators.Bollinger band comprises two lines plotted n (n is typically 2) Standard deviations from an m period simple moving average

line (m is typically 20). The bands widen during periods of increased volatility and shrink during periods of reduced volatility. ATR focuses on total price movement & conveys hence widely the market is swinging as it moves. It takes into account the price movement in each period by considering the following ranges.

- Difference between high and low of each period
- Difference between high and previous period's close
- Difference between low and previous period's close

Traders typically use them in conjunction as they approach volatility differently and are complimentary.

Calculation- BB

There are three bands when using Bollinger Bands:

1. Middle Band: $20\ Day\ Simple\ Moving\ Average$
2. Upper Band: $20\ Day\ Simple\ Moving\ Average + (Standard\ Deviation * 2)$
3. Lower Band: $20\ Day\ Simple\ Moving\ Average - (Standard\ Deviation * 2)$

3.3.3 RSI (Relative Strength Index)

RSI is a momentum oscillator which measures the speed and change of the price movement.RSI value oscillates between 0 & 100 with values above 70 indicating that the asset has now reached oversold territory. Assets can remain in overbought and oversold territories for long duration's. Calculations follow a two-step method whereas the second step is a smoothening technique(similar to calculating exponential MA).

Calculation- RSI

$$RSI = 100 - 100/(1 + RS)$$

$$RS = Average\ Gain\ of\ n\ days\ UP\ /Average\ Loss\ of\ n\ days\ DOWN$$

$$change = change(close)$$

$$gain = change >= 0\ ?\ change : 0.0$$

$$loss = change < 0 \ ? \ (-1) * change : 0.0$$

$$avgGain = rma(gain, 14)$$

$$avgLoss = rma(loss, 14)$$

$$rs = avgGain/avgLoss$$

$$rsi = 100 - (100/(1 + rs))$$

3.3.4 ADX (Average Directional Index)

ADX is a way of measuring the strength of a trend. Value ranges from 0 to 100 & qualifies the strength of a trend as per below:

- 0-25: Absent or weak trend
- 25- 50: Strong trend
- 50-75: Very strong trend
- 75-100: Extremely strong trend

It is imperative to note that ADX is a non-directional indicator, which means it does not indicate the strength of the trend. By comparing successive highs and successive lows, a smoothed average is calculated by calculating the difference between positive and negative directional movement.

Calculation- DMI and ADX

Before calculating ADX, we have to determine the Directional Movement Indexes(DMI's), +DI and -DI, and then compute ADX. +DM and -DM are Directional Movements. +DM and -DM are computed using the High, Low and Close for each period. You can then calculate the following:

$$Current\ High - Previous\ High = UpMove$$

$$Previous\ Low - Current\ Low = DownMove$$

If $UpMove > DownMove \, and \, UpMove > 0$, then$+DM = UpMove$, else $+DM = 0$

If $DownMove > Upmove\ and\ Downmove > 0$, then$-DM = DownMove$, else $-DM = 0$

Once you have the current +DM and -DM calculated, the +DM and -DM lines can be calculated and plotted based on the number of user defined periods.

$$+DI = 100\ times\ Exponential\ Moving\ Average\ of\ (+DM/Average\ True\ Range)$$
$$-DI = 100\ times\ Exponential\ Moving\ Average\ of\ (-DM/Average\ True\ Range)$$

Now that +DX and -DX have been calculated, the last step is calculating the ADX.

$ADX = 100\ times\ the\ Exponential\ Moving\ Average\ of\ the\ Absolute\ Value\ of(+DI - -DI)/(+DI + -DI)$

3.3.5 OBV (On-Balance Volume)

Calculation- OBV

Based on changes in trading volume, OBV indicators are used to predict future asset price movements. The OBV formula is based on the theory that volume precedes price movement. Generally speaking, when OBV rises, price increases may be expected, whereas when it falls, price declines may be expected. Indicators such as this are considered leading indicators for the market, however they are prone to false signals. This indicator is usually used in conjunction with a lagging indicator such as MACD. Calculating OBV is as simple as adding up the volume traded and adjusting it for the direction in which the price has moved.

1. If Current Closing Price is greater than the Prior Closing Price, then:

$$PreviousOBV + CurrentVolume = CurrentOBV$$

2. If Current Closing Price is less than the Prior Closing Price, then:

$$PreviousOBV - CurrentVolume = CurrentOBV$$

3. If Current Closing Price is equal to the Prior Closing Price, then:

$$PreviousOBV = CurrentOBV$$

3.3.6 Renko Chart

Renko chart is built using price movement, and not price against standardised time intervals - this filters out the noise and lets you visualise the true trend. Price movements (fixed) are represented as bricks stacked at 45 degrees to each other. A new brick is added to the chart only when the price moves by a pre-determined amount in either direction. Renko charts have a time axis, but the time scale is not fixed, some bricks may take longer to form than others, depending on how long it takes the price to move the required box size. Renko charts typically use only the closing price based on the chart time frame chosen.

3.4 STRATEGIES

3.4.1 STRATEGY 1 - MONTHLY PORTFOLIO RE-BALANCING

Pick any universe of stocks (large caps, mid caps, small caps, industry-specific, factor-specific, etc) and use this group of stocks as your portfolio source for the entire duration of back-testing. Build a fixed-size long portfolio by selecting 'm' number of stocks based on monthly returns (or any other suitable criteria). Monthly re balance the portfolio by removing the worse 'x' stocks and replacing them with the top 'x' stocks.

3.4.2 STRATEGY 2 - IN TRADING RESISTANCE BREAKOUT

In traditional trading terminology, resistance breakouts refer to a stock's price breaching a presumed resistance level (based on the price chart). When you use this strategy, you should choose stocks with a high volume and high activity (pre-market movers, historically high volume stocks, etc.). I will apply the breakout rule of price breaching 20 periods rolling maximum/minimum price in conjunction with volume breaching maximum volume in order to decide whether I want to buy / sell the stocks. The stop loss price will be determined based on the previous price plus or minus 20-period ATR used as the exit/stop loss signal. Calculate cumulative returns for each stock in the portfolio in order to back-test the strategy.

3.4.3 STRATEGY 3 - RENKO & OBV

In this strategy, the OBV indicator is combined with Renko charts. Invest in high volume, high activity stocks (pre-market movers, historical high volume stocks) for this strategy.
Buy signal:

- Renko bar greater than or equal to 2
- 5-day Renko slope greater than 30 degrees
- Exit if Renko bar is less than 2

Sell signal:

- Renko bar less than or equal to -2
- 5-day OBV slope less than -30 degrees
- Exit if Renko bar is greater than -2

3.4.4 STRATEGY 4 - RENKO & MACD

In this strategy, we combine the Renko chart and MACD indicator. It is recommended that you use this strategy with stocks that have a high volume, high activity (pre-market movers, historically high volumes, etc.)
Buy signal:

- Renko bar greater than or equal to 2
- MACD line is above the signal line
- MACD line's slope (over the last 5 periods) is greater than the signal line's slope over the last 5 periods)
- Exit when the MACD line goes below the signal line and the MACD line's slope is lower than the signal line's slope.

Sell signal:

- Renko bar less than or equal to -2

- MACD line is below the signal line
- MACD line's slope (over the last 5 periods) is less than the signal line's slope (over the last 5 periods)
- Exit, when the MACD line goes above the signal line MACD line's slope is greater than the signal line's slope.

3.5 Performance Measurement

Any trading strategy must be back tested before implementing it. Back testing is imperative to measure the expected performance of any trading strategy by testing it on historical data and attempting to mimic actual trading conditions. So if you have a trading strategy, which has a bunch of rules and methods by which it generates a trading a trading signal to execute a trade, we look back in time and try to see at what points of time, our trading strategy would have generated a signal. And as a result, a trade will be executed. The performance of each trade and the overall strategy are analyzed. Pretty much all investment firms and professional traders use some kind of back-testing.Back-testing relies on KPI's. Each back-test aims to measure performance, which is primarily based on the risk profile and return profile of the strategy. There are number of KPI's that traders use, some of the important KPI's are:

- Cumulative Annual Growth Rate (CAGR)
- Annualized Volatility
- Sharpe Ratio/ Sortino Ratio
- Maximum drawdown
- Calmar Ratio

3.5.1 Cumulative Annual Growth Rate (CAGR)

A compound annual growth rate is a measure of the rate of return an asset or portfolio has achieved from its initial value to the value it has attained today. In the calculation of CAGR, profits are assumed to be continuously reinvested. Make it easier to compare different trading

strategies. As it does not reflect investment risk, it should always be used in conjunction with volatility measures.

$$CAGR = \left(\frac{End\,Value}{Beginning\,Value}\right)^{\frac{1}{years}} - 1$$

3.5.2 Sharpe ratio/ Sortino ratio

Sharpe ratio indicates that the average return earned over the risk-free rate is higher than the risk-free rate, per unit of volatility. One of the most widely used measures of performance is risk-adjusted return. This is a metric that can be useful when comparing funds based on their performance. In general, it is considered effective when the Sharpe ratio exceeds 1, very good when it exceeds 2, and excellent when it exceeds 3.

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

$\mathrm{R}_p = Expected\,Return$

$\mathrm{R}_f = Risk\,Free\,Rate\,Of\,Return$

$\sigma_p = Standard\,Deviation\,Of\,Asset\,Returns$

As a variation of the Sharpe ratio, the Sortino ratio uses only negative returns for standard deviation. Based on this distinction, Sortino only considers harmful volatility. In contrast to Sharpe ratios, Sortino makes a distinction between fluctuations on the upside and those on the downside.

$$Sortino\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

$\mathrm{R}_p = Expected\,Return$

$\mathrm{R}_f = Risk\,Free\,Rate\,Of\,Return$

$\sigma_p = Standard\,Deviation\,Of\,Negative\,Asset\,Returns$

3.5.3 Volatility

The standard deviation of a strategy's returns represents its volatility. It is an important tool for measuring risk. The square root of the annualization factor is multiplied by volatility to obtain annualization.

3.5.4 Maximum Drawdown and Calmar Ratio

Maximum drawdown is the largest drop in an asset price over a specified period of time. It is important to note that the drop should happen after the peak value, only then we can measure the maximum dropdown.

Calmar Ratio is obtained by dividing CAGR with maximum drawdown.

$$Calmar\ Ratio = \frac{CAGR}{MaximumDrawdown}$$

CHAPTER 4

Results

4.1 Back-testing strategies

It is really important to back test any strategy before deploying it in the real time data. in simple words back testing is nothing but applying your strategy on historical data and analysing the performance. Here the strategies that we discussed earlier are back tested and the results are as follows:

4.1.1 Strategy 1

The first strategy is monthly portfolio re-balancing. Here I have calculated the return when we buy hold a stocks against the monthly portfolio re-balancing (removing worse stocks based on the monthly returns). Table 4.1 shows the performance indicators measured when we buy and hold the stocks over a period of time and table 4.2 shows the performance indicators measured when the strategy is applied. DJI is nothing but Dow Jones Industrial Average, that is the 30 best companies listed on the stock exchanges in the United States of America. Even though the KPI's in buy and hold are having better values, the final outcome is better for the strategy return, see figure 4.1. The term Max-dd is maximum draw down. If someone invested 1 dollar 10 years ago, it would have been 3 dollars now and by buy and hold it would have been around 2.5 dollars.

Label	Value
CAGR	0.11284
Sharpe	0.60803
Max-dd	0.24031

Table 4.1: Strategy 1.1: KPI's

Label	Value
CAGR(DJI)	0.09045
Sharpe(DJI)	0.473063
Max-dd(DJI)	0.23201

Table 4.2: Strategy 1.2: KPI's

Figure 4.1: Strategy 1: Index return vs Strategy return

4.1.2 Strategy 2

The second strategy is Intraday resistance breakout, have selected the highly active stocks to try this strategy. When we take a look at the KPIś, the sharpe ratio is very high, usually such higher values are very rarely obtained, and this strategy needs more analysis because of the very high sharpe ratio. This is not suggested to be used for automation. The graph 4.2 also shows that this strategy is highly volatile.

Label	Value
CAGR	0.39050
Sharpe	8.48140
Max-dd	0.00425

Table 4.3: Strategy 2: KPI's

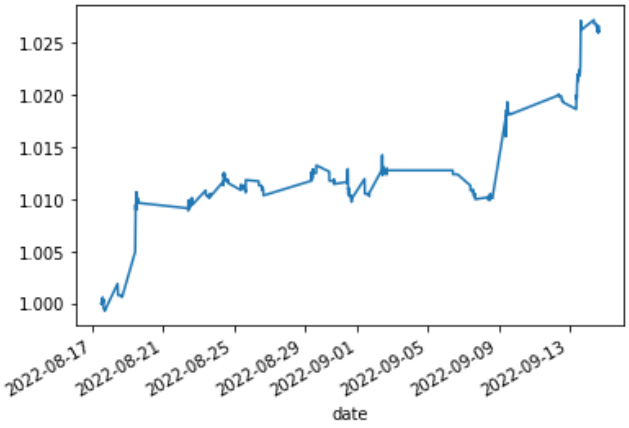


Figure 4.2: Strategy 2: Strategy return

4.1.3 Strategy 3

The third strategy is Intraday Renko and OBV. Similar to strategy 2, we have to use high activity stocks to test this strategy. Here also the sharpe ratio is very high, which is subjected to more analysis and the strategy needs more testing. Even though the graph is volatile, it never had a significant drop down.

Label	Value
CAGR	1.28459
Sharpe	15.39582
Max-dd	0.020358

Table 4.4: Strategy 3: KPI's

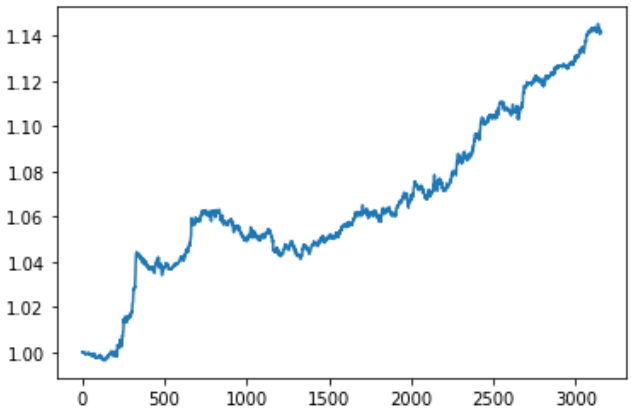


Figure 4.3: Strategy 3: Strategy return

4.1.4 Strategy 4

The last strategy is combination of MACD indicator and Renko Charts. The sharpe ratio is comparatively less than strategy 2 and 3. It has decent CAGR value as well. There is no significant rise in the stock price, but it is still profitable. This strategy is suitable for intraday trading and can be used to test out automated trading.

Label	Value
CAGR	0.52655
Sharpe	6.81133
Max-dd	0.023566

Table 4.5: Strategy 4: KPI's

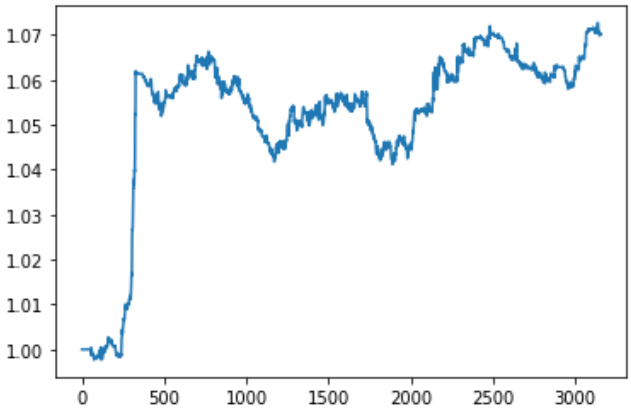
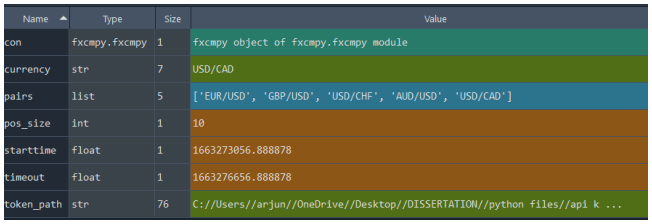


Figure 4.4: Strategy 4: Strategy return

4.2 Data

The data for the automated trading system is accessed using API of FXCM. Live data is used to process the strategy. Since the plan is to do forex trading, we have only very few currency pair options.



Name	Type	Size	Value
con	fxcmpy.fxcmpy	1	fxcmpy object of fxcmpy.fxcmpy module
currency	str	7	USD/CAD
pairs	list	5	['EUR/USD', 'GBP/USD', 'USD/CHF', 'AUD/USD', 'USD/CAD']
pos_size	int	1	10
starttime	float	1	1663273056.888878
timeout	float	1	1663276656.888878
token_path	str	76	C://Users//arjun//OneDrive//Desktop//DISSERTATION//python files//api k ...

Figure 4.5: Data Stored in Python

4.3 Structure

The intraday strategy with MACD and Renko is used to create the algorithmic trading bot. To test out the other strategies, more time is required and further changes to the code is necessary. The structure of automated strategy is as follows: The first thing I need to do is import the libraries and then establish the connection. I will then input bears or equity or whatever asset I am using for my strategy. I will give their aliases and I'll give their ticker information. After that, I define the size of every trade I want to make. So this section is the input section. Specifically, what asset am I planning to trade and what is the position. So if you want to have other risk management measures, for example, what is going to be the pip size or what is going to be the pip size for a stop loss, etc can also be included in this section. I then import the functions that I have already created. For this strategy, the functions that I am planning to use are for all the technical indicators I am intending to deploy. So obviously, MACD, ATR, slope, Renko, and Renko merge. The next part of the code is that I import these functions. So after I have all the functions of the technical indicators or any other indicators that I'm using, I then proceed to identifying the function that gives the trading signal. So for every pass through, script needs to analyze data. It will be processed and a trading signal will be generated. So this function is where I do most of my heavy lifting, most of the decision making, etc. There are other ways to write a script, but this really helps me create signals when I analyze data. And then return the signal from this function. Then I

have the main function, and the main function for every pass through, it extracts the data or extracts a candle for that particular interval. And then it attempts to interpret the signal. After that, either book straight or close straight. So the main function is how we interpret the signal that we have received from the trade signal function. And then we make trades, we make trading orders, etc. And so once the main function is defined, the penultimate section is where I use the time function to kind of incorporate the continuous execution rate. So if I want my script to run every five minutes, every 10 minutes, or every 15 minutes, I do it here. So this is where I calculated or programmed the continuous execution rate. And the last part of the script is where I close. It is very important to close the trade.

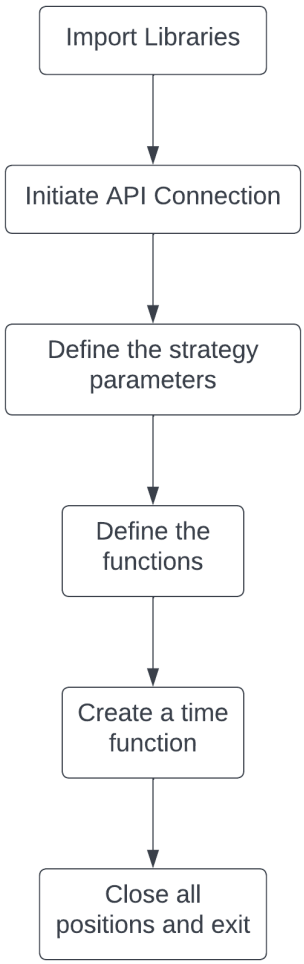


Figure 4.6: Flow chart of Automated System

4.4 Testing a strategy in FXCM

The Forex Capital Markets (FXCM) is a retail broker for trading on the foreign exchange market. The reason for choosing FXCM is that they have provided a free API, which can be used to create a demo account in their platform. We have to create a demo account to get the API token. Then login to FXCM portal as shown in figure 4.6.

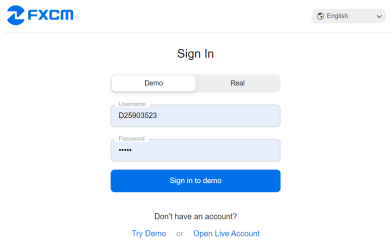


Figure 4.7: FXCM Login

Once we login to the portal, we can access their demo dashboard as shown in 4.8. They give 50000 points to try out the trading in their demo account, which is quite useful for someone who wants to learn trading. Since our objective is to create an automated trading strategy, we use python script to connect with the FXCM server using their API. The documentation of FXCMś API is really good and it helps the traders who want to try out their API.

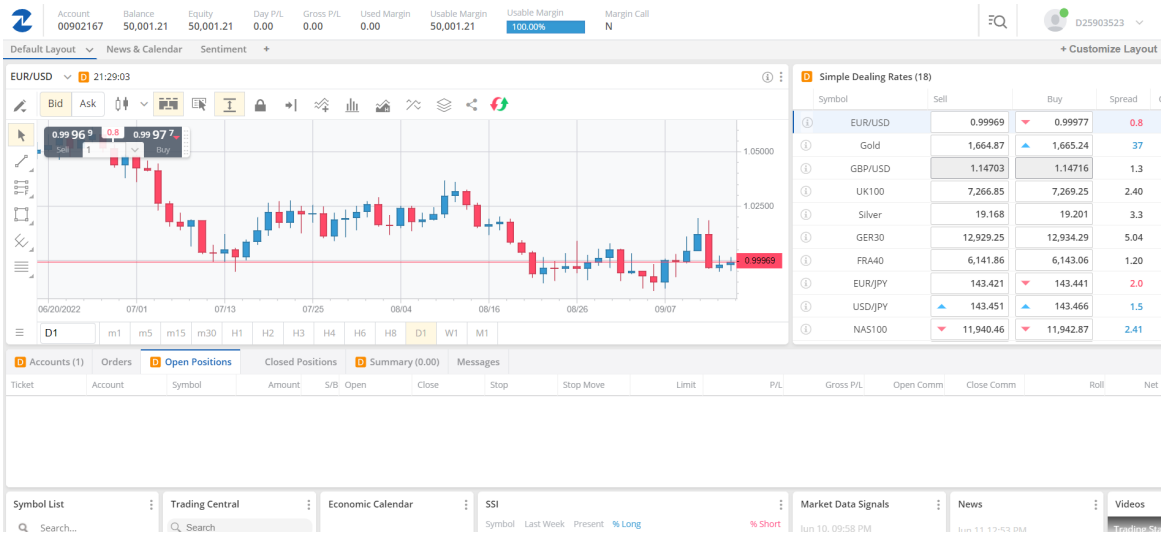


Figure 4.8: FXCM Dashboard

I experienced some connection issues when I tried to connect with their server. But could successfully execute a trade using automated strategy as shown in 4.9. I test ran the code for

60 minutes and got profit of approximately 2 points in the demo account. There are other broker websites which allow us to get API's, they are ProRealTime, MetaTrader4, OANDA, etc.

CLOSED TRADE LIST

Ticket #	Symbol	Volume	Date	Sold	Bought	Gross P/L	Comm	Dividends	Rollover	Adj	Net P/L	Condition	Created By
123037161	EUR/USD	10,000	9/13/22 8:36 PM 9/14/22 9:02 PM	0.99797	0.99762	3.03	0.00	0.00	-0.57	0.00	2.46	Mkt Mkt	d25903523 d25903523

Figure 4.9: FXCM automated trade result

CHAPTER 5

Discussion and Future scope

5.1 Is Python a viable choice for algorithmic trading?

Five of the most prominent programming languages accessible to traders are Python, C++, Java, C#, and R. However, Python stands out due to its excellent features.

- Code in Python is easily readable and understandable. A robust library reduces the amount of coding compared to other languages. The result is less coding and more trading.
- Debugging is constructed by executing the code statements through the interpreted language. In addition, the execution of a single error speeds up the construction process.
- The Python programming language is extremely powerful and offers scalability and a multitude of applications. Besides this, Python is more straightforward to work with when it comes to creating new modules and expanding them.
- Several programming language tasks are included within its extensive library in a simple manner.[14]

5.2 Applying Quantitative Approach to value Investing

A whole new field of quantitative finance has emerged in which fundamental analysis is performed. In the fundamental analysis, the stock is analyzed based on its balance sheet,

income statement, and cash flow statement. Other factors may also be considered in some fundamental analyses. Consider the management stand (what are the types of decisions or projects these companies undertake or what other industries they are involved in). Therefore, it is a completely different area of finance. The value investment area of fundamental analysis falls under this category. The value investment philosophy selects undervalued stocks despite their very solid financial and operational metrics. Companies or stocks that are valued at a discount to their intrinsic values are selected by value investors based on a rigorous analysis of their fundamentals. To summarize:

- Undervalued stocks are selected based on sound financial operational metrics despite their undervalued market value. By analyzing fundamentals rigorously, value investors buy stocks at a discount to their intrinsic value.
- Investing in value involves paying less than the value of a security. Price reverts to its true value when profit is realized.
- Investors who consider value separate from price are value investors. According to Warren Buffet, "price is what you pay, value is what you get".
- Utilizing computational power, investors can analyze a vast number of stocks using the quantitative approach.
- Value investing can be done quantitatively in several ways.

5.2.1 Joel Greenblatt's Magic Formula

The small book that beats the market: Investment Philosophy. "Wonderful stocks" at "bargain prices" were the focus of the investment approach. Return On Invested Capital (ROIC) is used to determine "wonderful stock" by measuring how much money is returned for the amount invested in the stock. The focus is only on assets that generate the return for the business, excluding excess cash and interest-bearing assets. The value of a "bargain price" is measured by earning yield which equals Earnings Before Interest and Taxes (EBIT) divided by enterprise value (same as P/E, but independent of capital structure). Over a 12-month period, accumulate 2-3 positions per month in the top 20-30 companies (excluding finance

and insurance companies). The portfolio should be re balanced once a year.

$$Earnings\ Yield = \frac{EBIT}{Enterprise\ Value}$$

$$ROIC = \frac{EBIT}{Net\ Fixed\ Assets + Net\ Working\ Capital}$$

$$Magic\ Formula = Rank(Rank(Earnings\ Yield) + (Rank(ROIC))$$

5.3 Challenges faced and How to improve the strategies

Algorithmic trading was a completely new topic for me. My learning process was in a systematic way, I started from the basics of extracting data from yahoo finance, alpha vantage and process it to see how the stock data is generated. I could look into basic statistics, python basics, and study about the technical indicators. Since it is a field of study with tremendous growth, it was challenging and very informative project. My approach to improve the strategies would be to experiment more with code. Because, I did get errors in the code at times and maybe more improvement is necessary to develop a smooth strategy. Experience in trading and coding will help to improve the strategies.

5.4 Future scope

The advancements in the field of machine learning is making changes in every sector. The results obtained from this study was satisfactory because we can do further developments in the project by introducing sentiment analysis. Sentiment analysis comes under natural language processing. So, if we can create an algorithm to detect various news and suggestions by people in social media to convert it in a way that the machine could understand, basically training the machine to process those data, it will be helpful in getting data about various stocks that are going upwards or downwards. It is not an easy task, but it is possible to execute if we could label large volume of news data.The equities can't have a general classifier, industry specific classifiers are required. It will be also easier to build commodity trading by using sentiment analysis. Similarly now I have used a local computer to run my algorithm, this can also be executed in cloud computer. The cloud computers are more faster, we don't

need to worry about power failures or internet issues(if the algorithm is running in cloud). The users need to pay only as per their usage. We have many cloud options like amazon web services, google cloud, microsoft azure, etc. Considering the advantages of the algorithmic trading, if someone has an effective strategy, then it is suggested to execute that in cloud. Further research is required to develop more effective trading strategy.

CHAPTER 6

Conclusions

To conclude, the main aim of this study was to develop an algorithmic trading bot to successfully execute trading using live data. The trading bot used MACD Renko Intraday strategy and could execute trading in the FXCM platform. By reading various research paper's, it was evident that the technical indicator's should be used in conjunction with another technical indicator to improve the outcome and to create new strategies. From my study, the individual technical indicator's were outperformed by when the TI's were used in conjuction with another TI. The best way to extract data is by using API's of the various broker's. The following strategies were back tested Monthly portfolio re balancing, Intraday resistance break out, Intraday Renko OBV, and Intraday Renko MACD. Every strategy used was showing profit, but the values while measuring the KPI's were not satisfactory, because some were very high, this can be because of one or two particular stock's that are performing well in the market. When I tested individual KPI's of strategy 2,3, and 4, it was seen that some of the stocks were performing better. See figures 6.1, 6.2, and 6.3. I did experience connection issues while connecting with the FXCM website, since there are more broker's who provide demo account's, that needs to be explored. Among the benefits of an algorithmic trading bot are security, cost, and speed, as well as its revolutionary potential for the future of the financial markets and economy. Both novice and experienced traders benefit from Algorithmic Trading Bots since it minimizes their effort, time, and loss. Future trading will require the integration of Financial Knowledge and Machine Learning, resulting in improved performance and revenue.[14]

	Return	Sharpe Ratio	Max Drawdown
MSFT	0.750307	7.671321	0.008627
AAPL	0.305194	4.274336	0.007151
META	1.056648	7.087443	0.037226
AMZN	0.080967	0.617659	0.011637
INTC	0.368323	3.658426	0.019677
CSCO	0.195113	2.574825	0.007442
VZ	0.233580	2.032071	0.013696
IBM	0.031792	0.191228	0.008454
TSLA	0.554168	4.772625	0.026657
AMD	0.587866	5.734685	0.022030

Figure 6.1: Strategy 2: Individual KPI's of stocks

	Return	Sharpe Ratio	Max Drawdown
MSFT	0.743035	4.350804	0.059304
AAPL	0.830892	5.499729	0.050120
META	1.187713	5.219862	0.063495
AMZN	0.419361	1.749186	0.054095
INTC	0.595156	3.042667	0.088860
CSCO	0.948920	4.227823	0.045593
VZ	0.373335	2.483709	0.061363
IBM	0.034535	0.056456	0.037597
QCOM	1.901264	6.871555	0.043846
LYFT	9.483940	19.562052	0.113518

Figure 6.2: Strategy 3: Individual KPI's of stocks

	Return	Sharpe Ratio	Max Drawdown
MSFT	0.579037	4.154158	0.035173
AAPL	0.461782	4.031911	0.038484
META	1.706932	9.139269	0.032880
AMZN	0.242159	1.135329	0.063557
INTC	0.024913	-0.000641	0.088071

Figure 6.3: Strategy 3: Individual KPI's of stocks

APPENDIX A

Websites Referred

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- https://www.investopedia.com/terms/d/drawdown.asp
- https://www.investopedia.com/terms/m/macd.asp
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