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**DESIGN AND BACKTESTING OF A TRADING ALGORITHM WITH  
SCALPING DAY STRATEGY FOR XAU/USD FX MARKET FOR  
INDIVIDUAL TRADERS**

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Tez Başlığı: DESIGN AND BACKTESTING OF A TRADING ALGORITHM WITH SCALPING DAY TRADING STRATEGY FOR XAU/USD FX MARKET FOR INDIVIDUAL TRADERS.

Yukarıda başlığı belirtilen Yüksek Lisans/Doktora tez çalışmamın; Giriş, Ana Bölümler ve Sonuç Bölümünden oluşan, toplam 72 sayfalık kısmına ilişkin, 08/07/2021 tarihinde şahsım/tez danışmanım tarafından Turnitin adlı intihal tespit programından aşağıda belirtilen filtrelemeler uygulanarak alınmış olan orijinallik raporuna göre, tezimin benzerlik oranı % 3'dür. Uygulanan filtrelemeler:

1. Kaynakça hariç
2. Alıntılar hariç
3. Beş (5) kelimedenden daha az örtüşme içeren metin kısımları hariç

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## ABSTRACT

The thesis study was carried out to test the possibility of an individual investor to evaluate his savings by trading instead of classical methods such as savings accounts, both in terms of success rate and profitability. The tested algorithm makes decisions by simultaneously measuring the trend, momentum, and volatility of the market, which requires the coordinated operation of three different technical indicators.

Within the scope of the thesis study, tens of technical indicators have been examined, and a total of ten technical indicators that will only be included in backtesting are explained in Chapter II. The suitability selections of the indicators were carried out according to the suitability of the embedded functions and general tendencies in the markets with high unit price, stable high volume, and low volatility in a 5-minute time interval.

XAU/USD, chosen as the market, is an extremely high volume and generally stable market. Spot gold price changes are low in percentage. In markets where price fluctuations are high, a study beyond the limits of this study is required to ensure that the signal rate and profitability are at levels where it can be considered a reasonable investment.

With backtesting, the algorithm designed for the study was run on 379176 five-minute candlestick data in a sixty-four-month period, according to the results from the system includes a trend indicator, momentum indicator, and volatility indicator. There are fifteen combinations in total.

Backtesting results are listed by keeping the focus on return rates and profit percentages. Comparing the algorithmic trading results with the spot gold buy&hold strategy, USD savings account, and TRY savings account returns. After all comparisons, it is questioned whether the indicator system is a financially logical choice. The results of the study are shared in the appendix as tables and interpreted in Chapter IV.

**Keywords:** Algorithm modelling, Basic indicators, Gold market, Forex market.

## ÖZET

Tez çalışması, bireysel bir yatırımcının birikimlerini vadeli birikim hesapları gibi klasik yöntemler yerine trading ile değerlendirmesinin mümkünlüğünün hem başarı oranı hem de kârlılık olarak test edilmesi amacıyla gerçekleştirilmiştir. Test edilen algoritma, üç farklı teknik indikatörünün koordine şekilde çalıştırılmasını gerektiren, aynı anda piyasanın trendini, momentumunu ve volatilitisini ölçerek karar vermektedir.

Tez çalışması kapsamında onlarca teknik indikatör incelenmiş olup, yalnızca backtesting’de yer alacak olan toplam on adet teknik indikatör Bölüm II’de anlatılmıştır. İndikatörlerin uygunluk seçimleri, gömülü fonksiyonlarının ve genel yatkınlıklarının 5 dk’lık zaman aralığında, birim fiyatı yüksek, hacmi stabil yüksek, dalgalanmanın düşük olduğu piyasalara uygunluğuna göre gerçekleştirilmiştir.

Piyasa olarak seçilmiş olan XAU/USD, son derece yüksek hacimli ve genel olarak stabil bir piyasadır. Spot altın fiyat değişiklikleri yüzdesel olarak düşüktür. Fiyat değişiminin yüksek olduğu piyasalarda, sinyal oranının ve kârlılığın makul bir yatırım olarak görülebileceği seviyelerde olması için bu çalışmanın limitlerinin ötesinde bir çalışma gerçekleştirilmesi gerekmektedir.

Backtesting ile altmış dört aylık periyotta beşer dakikalık 379176 adet mum grafiği verisi üzerinde, çalışma için tasarlanmış algoritma, birer trend indikatörü, momentum indikatörü ve volatilité indikatöründen oluşan sistemden gelen sonuçlara göre çalıştırılmıştır. Toplamda onbeş adet kombinasyon vardır.

Backtesting sonuçları, getiri oranları ve kâr etme yüzdeleri odakta tutularak sıralanmıştır. Algortmik trading sonuçları ile spot altın buy&hold stratejisi, vadeli USD hesabı ve TRY vadeli hesabı getirileri ile kıyaslanarak indikatör sisteminin finansal olarak mantıklı bir seçim olup olmadığı sorgulanmıştır. Çalışma sonuçları tablolar olarak ekte paylaşılmış olup, Bölüm IV’te yorumlanmıştır.

**Anahtar Kelimeler: / Keywords:** Algoritma modelleme = Algorithm modelling, Temel göstergeler = Basic indicators, Altınpiyasası = Gold market, Foreks piyasası = Forex market.

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## **SYMBOLS & ABBREVIATIONS**

ATR	Average True Range
CEO	Chief Executive Officer
DEMA	Double Exponential Moving Average
DOT	Designated Order Turnaround
EMA	Exponential Moving Average
EP	Extremum Point
ER	Efficiency Ratio
FOREX	Foreign Exchange Market
GDP	Gross Domestic Product
HLC3	High-Low-Close
HMA	Hull Moving Average
NYSE	New York Stock Exchange
PSAR	Parabolic Stop and Reverse
ROR	Rate of Return
RSI	Relative Strength Index
S	Smoothing
SMA	Single Moving Average
SMMA	Smothered Moving Average
TEMA	Triple Exponential Moving Average
TRY	Turkish Lira
TSI	True Strength Index

USD	American Dollar
WMA	Weighted Moving Average
XAU/USD	USD price of Gold per ounce
$\alpha$	Acceleration Factor

## INTRODUCTION

Trading goes back to the start of the modern civilization of the human race. The early practice of trading was over consumer goods and precious metals by either swapping or first convert into cash then buy the desired item. Trading in the modern era has become more complex than exchanging real items in their ratio over their values. Over centuries, trading has evolved into an activity that is carried out by buying and selling stocks, futures, precious metals, commodities, and many other investment instruments. The trader aims to profit as a result of the transactions.

There are many markets to seek trading opportunities. From local exchanges to gigantic dynamic global markets that are open 24/7. FOREX is the biggest trading market in which its daily trading volume is higher than 8 trillion USD. 80% of the trading volume is executed by software that specialized in the task (Bigotti & Navarra, 2018). High volume and volatility create opportunities for traders. Deals can be completed in milliseconds with little to no commission depends on the brokerage services. Traders have the opportunity to pursue low-profit each trade in a small amount of time and with increasing trade amount significant overall profit can be gained.

The trading market is a unique combination of mathematic and human behavior. Most manual traders, even the trader is experienced and skilled, cannot decide as rationally as trading bots. The human brain, by its nature, tends to make mistakes under stress. Emotions and bias toward an asset affect decision-making (Fenton-O’Creevy, Soane, Nicholson & Willman, 2011). A manual trader’s decision-making process and reaction time might be sluggish against the market movement. The slow process ends up in a missed opportunity to profit in case of high-speed trading or sharp increases and decreases in asset price. Trading bots became more superior in stated topics and gives the trader edge on the market.

Many professional solo traders and institutions upgraded their arsenal from manual trading to extremely complicated, state-of-the-art software in time. The software provides much-needed help to the trader as assistance by clearing noise and complete needed calculations accurately and faster so the trader can gain upper hand against other traders. Customized software is called algorithmic trading bots. Trader - programmer creates algorithms based on their trading strategy and takes as many parameters. These parameters can be selected from technical indicators, the trader’s desired profit rate, and risk management selections.

Trader-programmer must select suitable, and if possible, the best parameters as inputs needed by trade bot to operate successfully. Parameter selection is crucial for the trading bot's performance. Parameters can be technical indicators, announcements, political and military action news, or market behavior itself. To create a well-performing bot, all major sources of effects should place on account as inputs for signal generation. Simultaneous processing of all these data is extremely difficult to analyze and correctly simplify into basic signals.

Indicators are a crucial part of trading. Each indicator follows the input data required, processing them with their embedded functions, and producing results. Almost all traders use more than one indicator simultaneously with their own choices and preferences. Some traders use unique indicators to make the decisions that they have developed themselves. Indicator combination is a critical part of an algorithmic trading bot.

Study motivation is based on both technical and economic reasons. There are a vast number of studies on technical indicator combination efficiency and profit rates but the topic is yet to resolve. The technical reason is the obscurity of suitable indicator combinations for short-term trading. Basic technical indicator setups tend to generate signals with relatively low accuracy or late to trend and a missing window of opportunity. One of the main reasons for the poor performance of fast pace individual traders is the misuse of technical indicators.

The second motivation of the study is the economic development of developing countries with high inflation rates and decreasing purchase power each year. Decreasing purchase power forces individuals to search for better options than time deposit accounts since interest rates for deposit accounts are generally lower than inflation dramatically.

Turkey is a perfect example of such a situation. Between the years 2010 and 2019, the consumer price index of Turkey increased more than 134% meanwhile the real GDP growth is only around 62%. In the period between the years of 2017 and 2019, the GDP increase is only 3.73% meanwhile the consumer price index increased 33.98%. (World Bank, 2019)

Another critical issue affecting the Turkish economy is population growth does not follow by job opportunities causes constantly increasing unemployment rates especially in youth. The high number of unemployed also causes lower salaries due to excess demand for a job position. The total employment rate is for the end of 2019 is 44% of the overall population (World Bank, 2019). Higher living costs and decreasing employment numbers pushed individuals and firms to search for alternative incomes or higher profit investments in order to protect the purchasing power of savings and survive.



Banks and hedge funds are run by experts in investing departments. An individual can choose to select a higher risk of investing or saving account offered by related institutes investing managers. Famous investor and CEO of Berkshire Hathaway, Warren Buffett challenged the hedge fund industry, and the challenge was accepted by Protégé Partners LLC who selected five hedge funds for challenge. Challenge is the hedge fund could not create a portfolio performing better than the S&P 500 Index Fund in 10 year period. Challenge started on the 1<sup>st</sup> of January 2008 with 1.000.000 \$ for each side. End of 10 year period, the S&P 500 Index Fund resulted in 125.8% gained and crushed hedge funds average of 36%. (Wattles, 2018)

Some individuals are looking out for higher return rate investments at cost of higher risks. Trading stocks on the exchange market can offer a higher return rate with higher risk but the small capital of a trader lack to generate enough even the trader is successful. The futures and options market and forex market offer leverage ratios for traders. The trader can execute trades with a budget equal to multiplying the capital with the leverage ratio. Profits and losses are reflected in the trader's accounts at the same rate (Almeida, Neves, & Horta, 2018).

Most of the individual traders suffer from a lack of experience, training/education, and budget to cover up bad decisions by regulating the average price of the asset. Many traders try to learn in practice without training and lose money in this process. Loss of money causes many to leave trading in a short period. 40% of the traders quit in one month and only 7% continue to trading in five years. Profit rates are showing another shocking truth about individual traders' trading performance. Only 1.6% of the day traders have a positive net record (Barber, Lee, Liu, & Odean, 2014). A portion of traders seeks out only excitement and handle trading as gambling. After the lottery was started by the Government of Taiwan, 25% of traders left the market. This group has the highest percentage of losses among all individual traders (Barber, Lee, Liu, & Odean, 2008). The related group is the worst-performing individual investors.

Individual traders also tend to hold losing assets in the hope of prices would come to their target. This is also caused by miss or none usage of stop-loss orders. Some traders also do not admit the loss and continue to keep seeking out better deals. Inexperienced and untrained traders have an unrealistic expectation that they will win in every trade or the majority of them executed. When this expectation faced the reality, have trouble accepting the truth. (Calvet, Campbell, & Sodini, 2009)

Due to these data, day trading is a high-risk low reward trading strategy for an average individual trader. The present study aiming to fill the gap in algorithmic trading researches of passive income generation of small capital like an individual trader. The goal of the study to find out efficient technical indicator combinations that are suitable for day trading strategy to profit on the XAU/USD FOREX market. Backtesting of the algorithmic trading technical indicators setups completed from the start of July 2015 to the end of the November 2020 period of the XAU/USD market.

The global gold market is affected by many factors like political developments, military actions, financial news, technological breakthroughs, market behavior, or pandemic situations. Even though these factors are extremely important for precious metals, the study focused on technical indicators only. In practice, it is obvious that ignoring these factors increases risk by causing blind trading and may cause losses.

The thesis is subdivided into four chapters. Chapter I contains algorithmic trading and strategies. In the second chapter, technical indicators that are suitable for selected trading strategies and algorithms were chosen for the study are explained with a literature survey in both academic and practical studies. The third chapter includes the algorithm design of the study, backtesting period selection, methodology, and techniques used for the backtesting results in the study to answer the hypotheses. The last subsection of the thesis contains the results of the study and the conclusion.

## **CHAPTER I: TRADING STRATEGIES & ALGORITHMIC TRADING**

Trading is unique in terms of approach to the market for each trader. The trading strategy is extremely rich due to its uniqueness for each individual in profit goals and risk management. Even if the strategies of the two traders are identical in principle, it is extremely unlikely that they will be matched one to one during live trading executions.

Classifying trading strategies is a difficult task. Groupings in terms of strategy classes are carried out according to similarities. In practice, strategies cannot be expected to be affected by just one type of strategy. Within the scope of academic studies, the aim is to seek out answers for questions to shed light on future studies rather than pure performance.

With the choice of strategy, the trader decides to hold the period of the asset, trading frequency, trading amount, and what kind of trend he/she seeks opportunities. Evaluating the aforementioned factors that should be taken into account in the strategy selection. Selecting the most suitable strategy requires a serious study on its own and exceeds this study's scope.

The algorithm is a conditional-to-do scheme that is carefully designed taking into account the conditions and the exceptions according to the requirements of the objective. Algorithms needed to be well defined. If any loophole is left open in the algorithm that may cause harm to the performance of the related operation. With the use of algorithms, an action plan is prepared against different scenarios foreseen. Algorithmic trading allows traders to plan for different market behaviors, different trends, and goal-oriented customized trade execution tactics.

By using an algorithm, the trader sets some rules for himself/herself as principles. Setting an algorithm before a trading session rather than classic manual trading, the amount of decisions that need to be made instantly reduced, and the trading result is more predictable. Although the designer of the algorithm is a human, it reduces human-induced errors by not being affected by factors such as human behavior tendencies and stress during the trading session. The strategy and algorithm must be compatible. If the strategy and algorithm do not suit each other, the targeted profit and risk management can only be achieved by luck.

### **1.1 Trading Strategies**

Trading strategies are generally classified and named according to the factor affecting the asset price or the parameter followed in the practice of the trading. The most common strategies are grouped as momentum strategies, average strategies, rebalancing strategies, mean

reversion strategies, arbitrage strategies, market-making strategies, and dark pool strategies. Dark pool strategies differ from other strategies due to the illegal approach to the market such as fraud and misleading trading such as spoofing and quote stuffing.

Some traders choose to follow correlated assets and balance their portfolios due to market changes named rebalancing strategy. Shifting the balance between assets and aim to increase the number of the same assets is the goal of the rebalancing strategy. Rebalancing generates profit for traders but also creates a vacuum in the fund itself with inaccurate balancing for passive investors which causes poor returns for the majority (Siedle, 2013). Following the news is a must for any trader. Turn a blind eye to news is a bad choice for any trader. Momentum's trading strategy is solely focused on news that affects the market. Momentum trading strategy does not rely on technical indicators (Bozdog, Wang, Khaldoun & Florescu, 2011).

The mean reversion strategy is based on the average price of an asset's true value. High and low prices are extremities. If asset price divergence from the true price, the trader opens position to the direction of the true asset price. Calculating the true price of an asset is complicated and a separate topic on its own. Many investment consultancy firms provide their clients' advice on which asset is overpriced or underpriced by using standard deviations on asset price within the scope of different time periods. Change in price affects assets like suspension and the market starts damping in throughout oscillation. The process focuses to calculate the oscillation period and settle value mathematically to gain foresight of related asset price.

Arbitrage is another major strategy in the FOREX market. The strategy is aiming to profit by executing a trade in different markets by selling one asset and buying another almost instantly. Arbitrage can be executed by more than two assets. Arbitrage strategies require a search for an imbalance between parities, stocks, and other assets so the trader can exploit and profit from it. Trading speed is also an important factor in the arbitrage strategy. If the trader does not close the deal as soon as possible, asset prices may change again and opportunity may fade or worse. The risk of taking a loss during trading itself is called "execution risk". Arbitrage traders seek high volatility and liquidity for the fast completion of trades.

Dark pool strategies are operating in grey zones in the financial market's rules. As morality, these strategies can be classified as illegal but cannot be punished due to laws. Three major dark pool strategies came forward. Sniffing is aiming to detect other trader's movements and takes countermeasures against them. This strategy is controversial, as it is based on gain

profit from targeted individuals or organizations rather than from the market itself. This causes losses to the other side of the situation.

Spoofing is another strategy prohibited that creates false signals for sale/buy intention from itself to other traders but not to complete the trade. This manipulation causes fake demand for assets and forces other traders to change prices to profit from it. Once the asset holder changes to price, the algorithm cancels the order before execution so this fake demand causes price change which harms other traders.

Quote-stuffing is a banned strategy audited by the authorities under legal requirements. The strategy aims to flood the market with a high quantity of trade orders. The order immediately gets canceled after placing but the system still shows us there is an ask/demand on the price that was flooded previously. This causes slower algorithms or classical traders with no direct access to market data to move their order to quote stuffing trader's desired price, so asset price is manipulated ("How To Build Robust Algorithmic Trading Strategies", n.d).

Average strategies are based on moving average technical indicators. The strategy aims to foresee the direction of the market by looking average price of previous bars. Selected moving average indicators can be customized based on the trader's needs. Long-term traders are generally using more safe and slow reaction moving averages which neglects short-lived trends that are also named as noise.

Single Moving Average (SMA) is the most popular technical indicator of average strategies. SMA gives the average of the closing asset price over a selected time period with the same weight to all values. SMA has a slow reaction to change but also a very stable trend indicator. SMA is widely used and popular among long-term traders. In SMA formulation, the  $n$  index is the selected time length.

$$SMA = \frac{Value_1 + Value_2 + \dots + Value_n}{n}$$

**Equation 1:** Formulation of SMA

Some traders choose to trade in shorter-term so requires more responsive technical indicators and settings. Responsive technical indicators and settings are prone to whipsaws and under influence of noise. Long-term traders generally avoid noise and whipsaw trades but in fast trading, they affect the average itself. A heavily affected moving average indicator may provide false signals to the trader. Reducing lag and neglecting whipsaw trades is essential in

fast pace moving average strategy. Specialized moving average indicators are varied and require attention to select suitable for the trader. Chapter II section 2.1 is dedicated mostly to moving average technical indicators.

Most of these stated strategies are not suitable for low computing power and small capital. The study focuses on individual traders with small capital as a starting budget. The created scenario of the study is suitable for the day trading strategy.

### **1.1.1 Day Trading Strategy**

Day trading strategy is at a relatively fast pace, with the need for liquidity and volatility to operate efficiently. Day trading strategy is based on opening a position in market hours and close it before the market closes and profit from the volatility of the market. In some circumstances, traders tend to hold their position if he/she is thinking that the trend continues in their favor. Positions are generally held for multiple hours maximum. Each trade goal is earning small profits each time, which ultimately reaches a significant amount. High liquidity offers the day trader to open and close positions faster which is important to react to the news that hit the market as soon as possible (Song, Chu, & Lai, 2018).

Individual traders with day trading strategy traders tend to close their positions with local markets close. The trader could not take action when the collaborator brokerage out of working hours. This may end up in losses in dynamic global markets like FOREX. Risk is increased in overnight open positions and more likely to result in a loss (Lin & Liu, 2017).

Day trading is not a newcomer to the trading strategy scene and common among individual traders. Day trading became much popular with a widespread internet connection, lowered brokerage fees, and a lowered margin span. A large span margin was not suitable to fast pace trading for a small profit rate. In 2001, the minimum transaction step decreased to \$ 0.01 from \$ 0.0625 (Hall, 2018). This interval change allows traders to gain an even cent per deal. Making it possible to profit a significant amount in a high number of trades. Day trading is one of the most advantages gained trading strategies that can improve the profit rate by this development.

Some day traders choose to follow a high-risk – high reward path with leverages. The leverage system is multiplying of net change of profits and losses with the leverage rate. Risk management became an important part of the strategy especially since the trader is using leverage. In this study, the XAU/USD Forex market backtesting runs set with a no-leverage

since risk management is out of the context of the study. Each trade uses 50% of the total capital per position.

Individual traders have to deal with thorns in their trading careers. Day trading requires focus and have a high workload. The workload is longer than in-session hours. To succeed as an individual trader, the trader needed to analyze previous events to get foresight of tomorrow's market. Working alone also creates a need for social interaction. The financial pressure of living costs from profit pushes traders to take more risks which ultimately may cause the demise of the trading budget (Bulkowski, 2013). Stress affects both mental and physical health negatively in long term. In this study, all these behavioral effects were neglected and focused on only the performance of the algorithmic trading setup.

Suffering losses is inevitable in trading. Disciplined and experienced traders hold losing trades shorter and move on to seek upcoming opportunities (Locke & Mann, 2005). In this study, the trading algorithm monitors the market continuously and closes positions when the market is unfavorable to the trader. This approach acts as a stop-loss mechanism.

Day trading also has its subtypes. Scalping and momentum trading are headliners of these subtypes. Scalping focuses on fast pace trading in selected price channels. Both day trading strategies depend on technical analysis rather than the value of assets or operating performance of the related company/country. Technical indicators, news, and other market changes are followed by the trader closely. Any change of trend can make or break the trader's account (Pitters & Oberlechner, 2014).

#### **1.1.1.1 Scalping Day Trading Strategy**

Scalping is a heavily technical, fast pace day trading strategy. Scalping, in theory, only takes technical indicators into account during trading activity. Scalpers are not aiming to hold the asset for a long time or become shareholders of the company. Scalping day trading strategy solely focused on price changes and profit from the difference. The scalper would close their position when the profit reaches a satisfactory amount/goal or when stop-loss is triggered. (Logue, 2019).

Scalper's goal is to earn profit consistently, even it is small. A scalper also has to manage risk carefully to not get into the trades that offer lower profit than the loss risk taken. Portfolio management is also crucial for scalping day trading strategy. No indicator setup can provide an absolute true signal, so the trader must be aware of the need for cost reduction/regulation of the previous trades in suitable situations.

Scalpers also named as market makers by some, creating minor oscillations during market time. Since there are hundreds even thousands of traders trading at the same time on the same asset, scalpers are the second most behind high-frequency traders in terms of the number of trades. Scalpers are also responsible for the major amount of noise on market. Noise increases the unpredictability of the market. The chaotic market creates opportunities for some meanwhile forcing many to make mistakes. In this study, the price changes caused by the trader is neglected due to the trading capital is insignificant.

Scalping day trading strategy has been chosen as the strategy of the study. Scalping is the ideal strategy for testing technical indicator combination setups since it is taking inputs only from technical indicators.

## **1.2 Algorithmic Trading**

Unlike the meaning it is used today, trading with the algorithm was done by manual calculations in pre-computer days. The use of Algorithmic Trading in market movements has been made possible both by the development of software languages and by making microprocessors' which is a blockbuster technology that opens the path to modern computers.

Algorithms are widely using in all aspects of life. Financial markets are no different from that. In the article, Markowitz (1991), succeeded in determining the most suitable portfolio, which he called modern portfolio theory, and focused on expected risk-return, by using the computer of the period. Markowitz later won the 1990 Nobel Prize in Economics for his work. In the 1960s, Michael Goodkin and Ed Thorp who runs a hedge fund with Markowitz introduced the first computer to perform arbitrage (Poundstone, 2006).

The first transaction on the major markets with computers was carried out in the 1970's New York Stock Exchange using the DOT (Designated Order Turnaround) system. DOT provides faster buy-sell orders complete by bypassing one or even more layers of brokers. Although it is a very primitive algorithm compared to today, it was strengthening the hand of



investors by enabling the transactions to be performed faster. In 1984, DOT was developed and replaced with SuperDOT (Wyss, 2000).

The computerized financial market faced a few crashes due to algorithm failure or any other reasons to this day. It is seen that better-constructed algorithms perform even better in unexpected situations (Roll, 1998). It was stated that the classic traders who do not use any type of algorithm and trades via the pre-computer era approach, had three to five times more losses as a result of comparing the losses of the group called portfolio insurers, which uses a separate signal for stop-loss (Miller, Hawke, Malkiel & Scholes, 1989).

Some of the algorithmic trading strategies aim to take advantage of the complicated market situation either by creating noise or abusing certain price movements by the superior computing power of their system. This strategy makes it difficult for competitors' similar software and classic traders to decide what their best next move for their interest. Competitors would not react as quickly as required to protect their positions. Legally, such approaches are intertwined with market manipulation - fraud. Therefore, different reasons arise from financial targets-parameters such as profit and risk, which should be considered in terms of strategy selection and implementation (Aldridge, 2013).

Algorithms are specifically designed for each task solely. Trading algorithms are mainly designed for four separate objectives. Each of the four objectives is also has a common goal to achieve which is to increase profit and decrease the risk of loss of the trading activity. The first of these objectives is selecting a suitable asset that provides an opportunity for the trader. The second objective is required for seeking an advantageous entry point and position for the selected asset. The third one is to find out moment change points to close the position with maximum profit. The trader should also create a stop-loss structure to decrease losses due to false signals generated from the trading algorithm or sudden market changes triggered by the news.

XAU/USD market is selected for this study. Due to that, the market-asset selection objective is not a concern in this scenario. The stop-loss algorithm is also complex and requires a study entirely focused on it. For this reason, no optimization has been completed for the stop-loss mechanism, and a static approach has followed. Assumptions have been made for the stop-loss of the study.

## CHAPTER II: TECHNICAL INDICATORS

Technical analysis is the most important element of scalping day trading strategy. The scalping day trader looking out for opportunities with small windows by relying on technical indicators. Technical indicators take the required parameters from the market and use them as inputs to embedded functions. Results produced by the indicators are crucial for the trader's decision. All technical indicators are different from each other due to input parameters, embedded functions, and provided the result's meaning.

Technical indicators can be grouped into four classes according to the input type taken from the market. These classes are trend indicators, momentum-oscillator indicators, volatility indicators, and volume indicators. Each technical indicator class aiming to provide useful and noise-free information to the trader. Many traders are using multiple technical indicators simultaneously. Using indicators as a combination is a double-edged sword. Higher the number of indicators working simultaneously, the harder the interpretation of the data provided. Using none or single indicators also dangerous since the setup may suffer from a lack of information providing to the trader.

This chapter is focused on the technical indicators that are widely used in the market by many traders and suitable for the scalping day trading strategy. It is important to keep in mind that most technical indicators are kept secret for a long time by their developers. Developers of these technical indicators are generally chosen to use them to gain profit generally before publishing them. Due to that, it is practically impossible to learn the state of art technical indicators and setups of the prime traders at any time.

There are hundreds of technical indicators published in the world. Financial technology and brokerage firms provide technical indicators to their customers as service. Some experienced traders created their unique technical indicators and do not publish them. In this study, common technical indicators that are suitable for scalping day trading strategy taken into consideration.

In this study, common and published indicators were taken into account for backtesting since it is an inaccurate approach to include premium technical indicators to low capital individual trader's arsenal. There are promising technical indicators that require further looking that require research budget since they are patented and sold from the developer directly like Jurik Moving Average and many others. Formulation of the technical indicator is essential to

understand its strengths and weaknesses to find out the best performing technical indicator setup.

## **2.1 Trend Indicators**

Trend indicators are widely popular among traders. These indicators are used to identify the market direction which is up, down, or sideways. Trend indicators perform better when the market is choppy and changing. When the market is sideways with little price changes, trend indicator signals, even they are correct, price change is too little to generate enough profit for the trader. The profit can be even smaller than commissions and brokerage fees so the net change of balance is negative of that trade.

Trend following traders do not set market trends into direction but can heavily affect price change once the trend is set. Following the trend, the strategy increases the demand for the asset. Increased demand causes a rise or fall of the asset price depending on the trend direction. Trend detection is maybe the most important step for the scalper. If the trader knows the market direction, the trader most likely profit if only brokerage fees are higher than the profit itself (Banga & Brorsen, 2019)

In low volatile markets, relatively low-budget trade can affect trends. FOREX XAU/USD market is highly volatile and does not create that type of scenario unless the order is extremely large. The study focuses on low-budget trading so the effect caused by trades are ignored since they are very insignificant.

Scalping day trading strategy is fast pace and requires indicators with rapid reactions to the market. There are many more trend indicators that are actively used around the globe but it is practically impossible to analyze and back-test all in the scope of the study. Five trend indicators are promising and suitable for the selected trading strategy.

Moving Average technical indicators are common among trend indicators. Moving Averages can be used as couples or triplets to identify trends when they crossover each other. When crossover happened, the trader takes a position based on a crossover direction. If the fast one crosses the slow indicator while decreasing it means the trend is bearish and the price is going down and works the other way around.

### 2.1.1 Exponential Moving Average

Exponential Moving Average (EMA) is extremely common among traders and other positive sciences that are required to calculate the next value of a variable. The exponential approach is significantly different from the SMA. SMA weights all previous values of the parameter equal meanwhile EMA weights of previous values are not the same.

The EMA includes the past values into the calculation by weighing more the closer they are to the present time bar. The closest bars have the highest influence. The decrease in weight is exponential. The trader can adjust the total number of bars. Due to the higher influence of the most recent value, EMA has superior reaction capability against SMA.

$$EMA_n = \left[ \text{Value}_n \times \left( \frac{S}{1+n} \right) \right] + EMA_{n-1} \times \left[ 1 - \left( \frac{S}{1+n} \right) \right]$$

**Equation 2:** Formulation of EMA (Hayes, 2020)

Smoothing (S), allows the trader to adjust the weight of the most recent value without changing the total timeframe. S parameter divided by selected time length (n) gives multiplier. Value is the asset price meanwhile n is the selected bar length.

Even though the EMA is less sophisticated compare to its modern counterparts, it is highly stable in exchange for lagging. Lagging trend indicators may cause miss opportunities. The trading bot opens and closes positions with a margin to ideal prices. This margin may be acceptable to the trader in order to achieve stable and dependable results.

### 2.1.2 Double and Triple Exponential Moving Averages

EMA is highly customizable based on need and can be used as double and even as triple sets. Double Exponential Moving Average (DEMA) and Triple Exponential Moving Average (TEMA) technical indicators are derived from EMA. DEMA is the EMA of an EMA and TEMA is the third derivative from the original EMA. The trader can eliminate lag by setting one with a lower time length or eliminate whipsaw by increasing time length. DEMA and TEMA were developed by Patrick Mulloy and published in 1994. (Mitchell, 2020)

$$DEMA = 2 \times EMA_n - (EMA_n \times EMA_N)$$

**Equation 3:** Formulation of DEMA (Trading Technologies, 2015)

$$TEMA = 3 \times EMA_n - 3 \times (EMA_n \times EMA_N) + (EMA_n \times EMA_N \times EMA_N)$$

**Equation 4:** Formulation of TEMA (Brown, 2013)

TEMA requires a minimum of three bars to operate since each EMA derives from the previous one. DEMA and especially TEMA perform significantly superior in terms of reaction time. Fast reaction time with very highly weighted asset prices from closest bars may generate false signals of trend changes if a sharp change on market occurs. The trader must adjust Exponential Moving Averages carefully to reduce false signals but also optimize reaction time to not miss opportunities.

### 2.1.3 Hull Moving Average

Developed by Alan Hull and published in 2005. Alan Hull pursues the goal of a fast, responsive moving average with high smoothness which is important to eliminate whipsaw trades. HMA is more modern and advanced than Exponential Moving Averages. HMA could be used as pair as one fast and one slow like other moving averages to execute a crossover strategy to generate a buy/sell signal or as the only indicator to determine the trend only. (Kaufman, 2020)

HMA is a modified version of the Weighted Moving Average (WMA) technical indicator. WMA takes previous data into the calculation by decreasing arithmetically. HMA is calculated by a few steps. First, WMA is calculated with half of the selected time length and the result multiplied by 2. The second step is the calculation of WMA with selected time length then subtract from WMA that is already calculated with  $\frac{n}{2}$  time length and doubled. As the final step of the HMA calculation, the square root of n rounded is the K variable. The first two-step is taken into temporal variable  $D_n$ .

$$WMA_M = \frac{np_M + (n-1)p_{M-1} + \dots + 2 \times p_{(M-n+2)} + p_{(M-n+1)}}{n + (n-1) + \dots + 2 + 1}$$

**Equation 5:** Formulation of the WMA (Devcic, 2020)

$$D_n = 2 \times WMA \left( \frac{n}{2} \right) - WMA(n)$$

**Equation 6:** Formulation of the HMA's temporal variable  $D_n$  (Kaufman, 2020)

$$HMA_n = \frac{[D(n - K + 1) + 2 \times D(n - K + 2) + 3 \times D(n - K + 3) + \dots + K \times D(n)]}{[K \times (K + 1) \times 0.5]}$$

**Equation 7:** Formulation of the HMA (Kaufman, 2020)

#### 2.1.4 Parabolic Stop and Reverse

PSAR is a lagging indicator created by J. Welles Wilder Jr. PSAR's aim to identify the trend and find potential trend-changing prices of the asset. PSAR is good to determine entry/exit positions and stop loss by percentage management. PSAR performs better in trending markets. Sideways market trends are generally very little to profit and hard to detect. Even the indicator able to detect such trends, the trader may end up with whipsaw trade and face losses. The PSAR is a strong trend detecting indicator but it is not suitable to operate alone. The creator of PSAR, J. Welles Wilder Jr. strongly advises it should cooperate with other indicators to measure trend strength. (Welles, 1978)

The indicator generates markers to display the results of the embedded function itself. If the markers are below the asset price means the trend is upward and vice versa. Markers are positioned by some margin based on the market volatility and momentum on current asset prices. PSAR takes the previous period's price range as a reference. If the current price maximum is higher than the previous time bar, marker placement will be further than the actual asset price. Higher the displacement between the marker and current price, the stronger the trend is. Markers are suitable to use as supports and resistances. If the current price touches the marker, PSAR changes direction which means the trend is changing. (Welles, 1978)

$$SAR_{n+1} = SAR_n + \alpha(EP - SAR_n)$$

**Equation 14:** Formulation of Parabolic Stop and Reverse (Welles, 1978)

Formulation of Parabolic Stop and Reverse is fairly simple.  $SAR_{n+1}$  is current's and  $SAR_n$  is the last completed bar's SAR values. Acceleration Factor ( $\alpha$ ) is the coefficient that allows the trader to do fine-tuning the indicator. The default value of  $\alpha$  is 0.02. The step size value is another parameter that can be adjusted by the trader. The default value of the step size is 0.02. Higher the step size, the faster the response of indicator to price changes.

Fast reaction is important in scalping day trading but increased step size also creates an inclination to miss detect whipsaw trades. Extremum Point (EP) is the maximum and minimum value of the asset in the n time bar. The maximum EP value is limited to 0.20 to prevent an

unrealistic deviation that generates aberrant results. Once the trend switches, EP and  $\alpha$  reset to initial values (Pistole, T.C. & Metghalchi, M, 2010).

## **2.2 Momentum – Oscillator Indicators**

Momentum - Oscillator indicators are another class of technical indicators that takes an asset's price change rate as input to calculate trend strengths. The momentum of a trend is extremely important to detect entry and exit points for the trader. If an asset has strong momentum in any direction, the trader would take the position due to that and gain profit. Momentum indicators are suitable to use as combinations and do not perform well if the trader does not have the foresight of an on-trend direction (Segal, 2020).

### **2.2.1 True Strength Index**

True Strength Index (TSI) was developed by William Blau and published in 1991. The indicator is one step forward from basic momentum indicators that only measure market momentum with double smoothing. Double smoothing calculation means EMA of the EMA. Double smoothing reduces noise and purifies the instant overshoots from data taken as input to calculate the momentum of the asset. The TSI not only measures the momentum of an asset and also the trend direction. (Blau, 1991)

Scalping day trading strategy is usually used with 5 to 15 minute time length and for fast pace trading, extreme zones would be starting after  $-5$  to  $+5$  which is too close in comparison to long-term trading scales. If the trader uses leverage, extreme zones would be even become closer to the zero lines since the leverage rate directly multiplies profits and losses.

Momentum measurement is scaled as a traditional system with  $-100$  to  $100$ . The overbought and oversold zone is relative that depends on previously closed bars and selected time bar. If a long-term trader looking for extreme movements, extreme zones would be higher depending on time length. Extreme bearish momentum is scaled between  $-100$  to  $-60$  and  $60$  to  $100$  for extreme bullish momentum. Each side of the zero lines to  $-60$  and  $60$  are considered as moderate strength momentums for both bearish and bullish momentums.

TSI embedded function has four variables taken as inputs or adjustable settings. Selected time bars last closing price shows as  $c_0$ . The momentum difference between the last closed time bar and the previous one is  $m$  variable. EMA smoothing takes  $m$  and  $n$  parameter inputs. The parameter  $n$  is the selected signal length adjustable by the trader. EMA smoothing periods are also can be changed by the trader choices. Default settings for  $r$ , the EMA smoothing period for the momentum is 25 and EMA smoothing period for  $r$  is 13.

$$EMA(m_0, n) = \frac{2}{n + 1} [m_0 - EMA(m_1, n)] + EMA(m_1, n)$$

**Equation 15:** Formulation of EMA smoothing function of TSI (Blau, 1995)

$$TSI(c_0, r, s) = 100 \times \frac{EMA[EMA(m, r), s]}{EMA[EMA(|m|, r), s]}$$

**Equation 16:** General Formulation of TSI embedded function (Blau, 1995)

### 2.2.2 Relative Strength Index

Relative Strength Index (RSI) was developed by J. Welles Wilder Jr. who is also a developer of the PSAR and published in 1978. After publication, RSI became widely popular among all types of traders. RSI measures the selected asset's price change magnitude in time length. Momentum magnitude scaled from 0 to 100. 50 value acts as zero lines for the momentum scale. As deviation increases from the zero line, the momentum became stronger. Extreme momentum zones are the edge of the scale-like 0-20 and 80-100. (Welles, 1978)

RSI's embedded functions to make calculations are very simple. The variable  $u$  is the net change of the price between the current and previous bar. The variable  $D$  is set defaults as zero. If  $U$  is equal to zero,  $D$  calculated as it is  $U$ . In the case of  $U$  and  $D$  are equal to zero together, the indicator recalculates  $U$  and  $D$  variables with the Smothered Moving Average (SMMA) technique.

$$SMMA(i) = \frac{\sum_{i=0}^n Close(i)}{n}$$

**Equation 17:** Smoothed Moving Average Formulation (MetaTrader 5, 2010)



$$SMMA(U, n) = \frac{[SMMA(U - 1) \times (n - 1) + Close(U)]}{n}$$

**Equation 18:** Smoothed Moving Average Formulation as used in RSI (MetaTrader 5, 2010)

$$RS = \frac{SMMA(U, n)}{SMMA(D, n)}$$

**Equation 19:** RS calculation from the RSI technical indicator (MetaTrader 5, 2010)

$$RSI = 100 - \frac{100}{1 + RS}$$

**Equation 20:** RSI formulation (MetaTrader 5, 2010)

Even the RSI is lack behind against its modern counterparts, simple settings and readability increase its popularity among beginner traders. The only adjustable setting of the RSI is time length which is named as n variable. The default time length for RSI is 14 bars. The trader can change the time length to achieve faster reacting or slower and noise-free RSI.

### 2.2.3 Stochastic RSI

Stochastic RSI is a combination of Stochastic Oscillator and RSI, the two early-stage momentum indicators. Stochastic Oscillator was developed by George Lane in the 1950s. Stochastic Oscillator measures the momentum of the price. The theory behind Stochastic Oscillator is momentum must become zero even it is momentarily and only then the trend can be changed. The Stochastic Oscillator is aiming to determine turning points so ideal entry and exit points can be spotted and profit is maximized. The Stochastic Oscillator has three parameters. The first one is %K, the second one is %D, and the smoothing parameter (Lane, 1984).

$$\%K = 100 \times \frac{Price_{close} - Price_{Lowest}}{Price_{Highest} - Price_{Lowest}}$$

**Equation 21:** %D calculation of the Stochastic Oscillator (Lane, 1984)

$$EMA_3(\%K) = \%D$$

**Equation 22:** Stochastic Oscillator %D calculation function (Lane, 1984)

The Stochastic RSI was developed and published by Tushar Chande and Stanley Kroll in 1994. Stochastic RSI uses RSI's embedded functions and Stochastic Oscillator's overbought and oversold scales together and generates easily readable, more responsive results. Stochastic RSI scale momentum graph 0 to 1. If the momentum is between 0.8 to 1, the value indicates the asset is overbought. When the momentum oscillator is lower than 0.2, the asset is oversold. (Chande & Kroll, 1994).

Stochastic RSI has four adjustable parameters. Since Stochastic RSI inherits both technical indicators embedded functions and capabilities, parameters are the same as the parent indicator. Default settings for RSI and Stochastic Length are 14 bars. Stochastic RSI records RSI levels for selected time lengths. The highest and lowest RSI values are used as inputs for Stochastic RSI.

$$StochRSI = \frac{RSI_{current} - RSI_{min}}{RSI_{max} - RSI_{min}}$$

**Equation 23:** Stochastic RSI formulation (Chande & Kroll, 1994)

### 2.3. Volatility Indicators

Volatility is essential for the very existence of trading. Volatility creates opportunities in the market. If volatility is equal to zero for an asset, no matter what strategy, technical indicator, or parameter settings of the indicators, it is impossible for the trader to make a profit. If volatility is very low, the trader would not be able to generate profit no matter which technical indicator setup and trading strategy are executed.

Standard deviation is a common method to calculate the volatility of a given dataset. For the financial terms of volatility, the required dataset is usually calculated with the logarithm taken asset price. The total volatility is the sum of the upward and downward movement of the asset price on the market. For example, if an asset, which we assume has 0% net change at the end of the day, performs a cumulative total of 2% positive and 2% negative price change has a total of 4% daily volatility. The higher the volatility, the more often the assets tend to diverge from the average value. The trend may change more frequently in highly volatile markets.

The volatility range is crucial for the trader. When a trader decides to open a position, a hint for potential maximum and minimum price gap allows the trader to set goals and stop-loss according to data in hands provided by volatility technical indicators but they do not determine or confirm support & resistances of an asset. Volatility indicators do not provide enough information for a trader to have an insight into the market. Volatility provides the possible range of the price change due to selected time length and volatility indicator parameter settings.

Volatility technical indicators have two main subtypes. The first one is oscillators that calculate and generate results as the average movement period of the asset like The Average True Range (ATR) technical indicator. The second subtype is band or channel generator indicators. The indicators of this subtype create estimated bands and channels to generate bands/channels to visualize support and resistance levels based on the market data as input. Bollinger Band, Keltner Channel, Donchian Channel are famous indicators of this subtype. (Maverick, 2020)

### 2.3.1 Keltner Channel

The study selected the Keltner Channel as the only volatility indicator that is suitable for the constructed trading algorithm due to its unique combination of volatility oscillator and channel generator volatility indicator. Keltner Channel uses the Average True Range (ATR)'s embedded function to plot upper, lower, and middle moving average lines and creates a channel. Keltner Channel was published by Chester W. Keltner in 1960. The indicator was not named by himself but became popular among traders and named Keltner by traders. (Keltner, 1973)

The original Keltner Channel uses the SMA of an asset price to calculate all three lines. Over the years, the Keltner Channel was modified by many developers to answer the needs of the traders. Most famous and one is developed by Linda Bradford Raschke with default 20 bar EMA for the middle line and 10 bar ATR values for lower and upper lines. Using EMA of the ATR instead of SMA improved the indicator's reaction and became suitable for fast pace trading. The Average True Range is a volatility indicator itself. ATR uses two parameters that are both absolute different between most previous time-division maximum and minimum closes. The parameter  $t$  is the selected time length. (Bhandari, 2017)

$$High = |Price_{High} - Price_{Previous\ Close}|$$

**Equation 24:** High-value function of the Average True Range (Welles, 1978)

$$Low = |Price_{Low} - Price_{Previous\ Close}|$$

**Equation 25:** Low-value function of the Average True Range (Welles, 1978)

$$TR = \max(High - Price_{Previous\ Close}) - (Low - Price_{Previous\ Close})$$

**Equation 26:** True Range function of the Average True Range (Welles, 1978)

$$ATR_t = \frac{ATR_{t-1} \times (n - 1) + TR_t}{n}$$

**Equation 27:** Average True Range general formula (Welles, 1978)

When the EMA line approaches the lower ATR line, two possible meanings can fathom out. The outcomes are the asset is either oversold which means the price will be corrected by the market over time or the trend is bearish. Due to the uncertainty of the outcome meaning, the Keltner Channel best performs as a part of multiple indicator setups. ATR function can be adjusted like a parameter by the trader in Keltner Channel technical indicator. Default  $t_1$  value is 20 bars and 10 bars for the  $t_2$ .

$$Line_{ATR} = EMA_{t_1} \pm (KC_{Multiplier} \times ATR_{t_2})$$

**Equation 28:** Keltner Channel ATR line generation formula (Bhandari, 2017).

When the ATR value is multiplied by a constant, the gap is increased direct proportionally between the EMA line and each ATR line. Higher the multiplier, the wider the channel is. A wide channel drawn with a high multiplier ATR covers more volatile assets. The trader can adjust the multiplier based on trading strategy and asset movements. Scalping day trading requires a lower multiplier close to the default value meanwhile long-term traders may choose to use Keltner Channel with a 2 or even higher ATR multiplier constant.

## 2.4 Volume Indicators

Volume indicators are the fourth class of technical indicators. Trading volume changes based on demand on an asset and usually in direct proportional order. XAU/USD is a global market that is influenced by a hundred major and minor news every trading day. XAU/USD market has one of the highest trading volumes. (Chen, 2020)

The study trading algorithm does not include volume elements for a signal generated due to the stable volume of the XAU/USD market. The market volume also has a very low effect other than news. Perform a study with volume indicators requires a news effect on the market itself. Volume technical indicators are not included among the technical indicators needed for the trading algorithm and backtesting scenario created in the study.

## CHAPTER III: STUDY METHODOLOGY

Financial trading is an ever-changing, constantly evolving area of science. Trading is open to customizations and different approaches. Unique approaches create both solutions for problems and new needs to satisfy at the same time. These needs of the trading are to improve the win rate, lower the transaction cost, and ultimately, increase the profit from trades. Most of the individual traders prefer to use common indicators with popular strategies. The reason behind this is the individual traders with a low budget are usually beginners or gamblers with a lack of knowledge and research. Due to that, many individual traders are blind in a market against highly advanced, experienced rivals.

Changing market situations creates a unique trading environment with a large number of major and countless minor factors affecting the market at any given time. In order to foresee the market with perfect accuracy, the trader needed to have an impeccable understanding of multiple subjects. The understanding includes all major and minor news that are affecting the market and exact knowledge of the rival traders' current positions and future moves. Any of these tasks are practically impossible to master. The trader may choose to concentrate on one of the tasks to gain upper hand in the market to open the next position in the correct direction in the right asset and before the others.

Making quick decisions is common in scalping day trading. The trader has a small window to decide and complete the trade. Trading is stressful and the stress cloud the trader's judgment. Although the designer is a human being, algorithms are taking over the management of trading activities so that real decisions can be made without the influence of stress and unpredictable human psychology as much as possible. An algorithm may perform better if designed robustly with well-prepared against many possibilities that may occur in the market.

Three research questions are aimed to be answered by this thesis study. Research questions are created based on applicability, measurability, and financial viability. Research questions are given below.

1. Can a small investor profit by using a day scalping day trading strategy on XAU/USD market with 10.000 \$ trading capital?
2. Which combination of indicators generates the highest win rate and profit in the selected scenario, strategy, and trading algorithm?

### 3. Can algorithmic trading be a reliable passive income for an individual?

To answer the research questions within the scope of the thesis study, the following steps have been determined as the main objectives. The thesis focused on four main objectives of the study:

- I. Create an algorithm for the scalping day trading strategy.
- II. Examine technical indicators and find suitable indicators to operate in the related algorithm.
- III. Backtesting of indicator combinations on real market data. Identifying promising combinations.
- IV. Evaluation of the indicator setup backtesting results due to ROR and Signal Accuracies to determine performances of the setups.

The design of an algorithm, which generates profit regularly and well-performing for a selected trading strategy requires a significant amount of work, technical knowledge, trading experience, setting optimizations of technical indicators. A well-performing algorithm needs to be designed for as many as possible situations. It is important to avoid false signal generation due to an algorithm bug that is triggered by the simultaneous usage of multiple indicators.

The technical indicators provide much-needed data based on inputs taken from the market and refined on embedded functions of them as results. By using technical indicators in combinations to confirm and support each other, the trader can make more accurate decisions compared to rely on a single indicator. Technical indicators also require much-needed fine-tuning of the settings to work compatibly and optimize the signal generation's speed and accuracy.

Success in trading requires a delicate balance between taking risks to generate profit and suffering losses from excessive risk than potential yield. A complete algorithmic trading system requires a stop-loss and portfolio management to regulate the risk is taking. In order to standardize the trading algorithm in the study, there are several trading limitations set. Portfolio management and stop-loss subjects are essential to trading. These two topics require a comprehensive and separate study for each one of them. Both portfolio management and stop-loss subjects are not part of optimization and the standardization approach taken for them. The research used static settings in every setup during the backtesting of the trading algorithm.

As a result of the implementation of the main objectives created to answer the research questions, it will be possible to question the thesis hypotheses. In order to answer the stated three questions of the thesis, two hypotheses were created to be tested for each period and two for total evaluation. Hypotheses are stated below.

H<sub>01</sub>: Scalping day trading is non-profitable with a low budget and has a high risk of whipsaw trades in the trending market.

H<sub>02</sub>: Scalping day trading is profitable with a low budget and has a low risk of whipsaw trades in the trending market.

H<sub>11</sub>: Scalping day trading is non-profitable with a low budget and has a high risk of whipsaw trades in a sideways market.

H<sub>12</sub>: Scalping day trading is profitable with a low budget and has a low risk of whipsaw trades in the sideways market situation.

H<sub>21</sub>: Scalping day trading is a reliable investment option that can be dependable under different market trends.

H<sub>22</sub>: Scalping day trading is not a reliable investment option that can be dependable under different market trends.

Answers are sought whether the trading setup of thesis hypotheses makes whipsaw trades in different market conditions and whether it is profitable.

In this chapter, the methods of measuring the reliability and profitability performance as a result of performance measurement with the win-rate of the original algorithm and the backtesting results of the profit are explained. This chapter is dedicated to trading algorithm design, indicator combination setups, backtesting periods of the XAU/USD FOREX market, and trading principles and limits of the study. Ten technical indicators total from three different classes of technical indicators are selected. These indicators are explained in Chapter II. In Chapter III, indicator setups are tested with backtesting to measure the performance of the setups on the XAU/USD's sideways and trending markets.



### 3.1 Algorithm Design

The algorithm itself is the backbone of algorithmic trading. The algorithm is affected by many factors related to the strategy, trading environment, and the trader's goals. A good trading algorithm should be able to adapt to many, and if can all, conditions like trends, choppy or stagnant quiet markets. For this study, the selected strategy is the scalping day trading strategy. Due to the needs of the scalping strategy, the designed algorithm requires to be responsive, opportunistic, and capable to detect small trends with a high win rate.

It is crucial to prevent false signals on each technical indicator's output and trading algorithm system entirely. The algorithm output is simple as a yes-no question. With the smallest deviation or logical error due to the design of the algorithm, technical indicator output can switch from positive-negative to neutral. This change of result in a single technical indicator changes the overall result of the trading algorithm completely.

Financial assets are generally shown in the two-axis graph. For the XAU/USD market it is asset price for the vertical axis and time for the horizontal axis. The short-term inflation of the chosen trading strategy and the potential opportunity cost from other viable investment options are so low, they are negligible. For this reason, the only axis to be predicted is the vertical axis, which is asset price. XAU/USD asset under the expose of many factors to affect the price movements. Using three different types of technical indicators provides three different types of information to replicate real-world physics.

A real object requires three variables to understand its movement. These are position, velocity, and acceleration. The difference between a financial asset and a real object is the real object carries energy while on move meanwhile, a financial asset does not carry the energy, and vertical position-asset price changes instantaneously. As long as the action is within the legal limits, the asset price is determined directly by the demand of the market. Demand produces a force that affects the price immediately. Financial assets are also limited by invisible boundaries generally both up and down. These invisible boundaries are dynamic support and resistance made out by the market itself by orders given. Support and resistance levels create a channel that the asset price generally moves sideways and complete small range trends unless the trend is strong enough already or the asset price effected by a new effect to create momentum to breakthrough. These levels act as natural borders for a sideways market.

The first technical indicator for the algorithm to check is the trend indicator. Trend indicator act as unit vector value  $j$ , which is +1 for positive and -1 for negative vertical axis direction. The output of the trend indicator is also similar to the unit vector. The trend indicator can produce either above zero or below assuming that output is equal to zero is very unlikely to happen.

Defining the direction of the asset is the most important objective of the trading algorithm. If the trend determination is flawed, the position opened is almost unlikely to generate profit in short term. Sideways trending assets are not profitable to open positions because the trader can only profit when the market is changing. If the market trend is sideways, the algorithm does not signal any position to open. The algorithm proceeds when the trend is either bearish or bullish.

The trend direction is important but it is not solely enough to decide to open a position or not. If the trend is weak, or currently losing strength opened position would be either profit too little or changing trend may cause losses. Determining the strength of a market trend is the momentum indicator class's objective. Momentum on financial asset act as acceleration for a physical object. It is most likely the position that is opened in the middle of an already occurring trend rather than an ideally stable quiet market. Momentum determines the rate of change of the asset price.

If the trend and momentum are in the same direction, the movement of the asset price will strengthen and accelerate. If the momentum is in the opposite direction to the trend, this may cause the trend to slow down or even change direction. Opening a position to a momentum losing trend is riskier than a momentum gaining trend. If the output of the momentum indicator is in a positive relationship with the trend direction, the algorithm proceeds to the next indicator. If the momentum indicator result is in negative correlation with the trend indicator, it means the trend is losing power or even change direction. In case the trend is losing momentum, the algorithm resets and starts from the beginning.

When the trend and momentum are in direct correlation, the trader's probability of making a profit from trading increases with the opened position. The volatility indicator is used to detection of the possible support and resistance levels to restrict price movements like a wall affects the real object.

The only volatility indicator selected for the study is the Keltner Channel with the ATR approach. Keltner Channel generates a signal according to the current price difference to the dynamic support and resistance levels or breakthrough potential from the channel based on the selected ATR multiplier setting value. The volatility indicator is essential to determine if there is enough gain to cover brokerage costs and generate net profit after all trading expenses.

Within the scope of the study, trading setups are created in all possible combinations by one indicator from all three different classes of technical indicators each. The setup includes one out of five trend indicators, one out of four momentum indicators, and the only volatility indicator, the Keltner Channel. The algorithm takes all three indicator outputs in sequence. All three of the algorithm requires to give green light to the algorithm as output to continue further. If at any stage, a technical indicator output is negative, the algorithm returns back to square one.

### **3.2 Indicator Signal Generation Strategies and Settings**

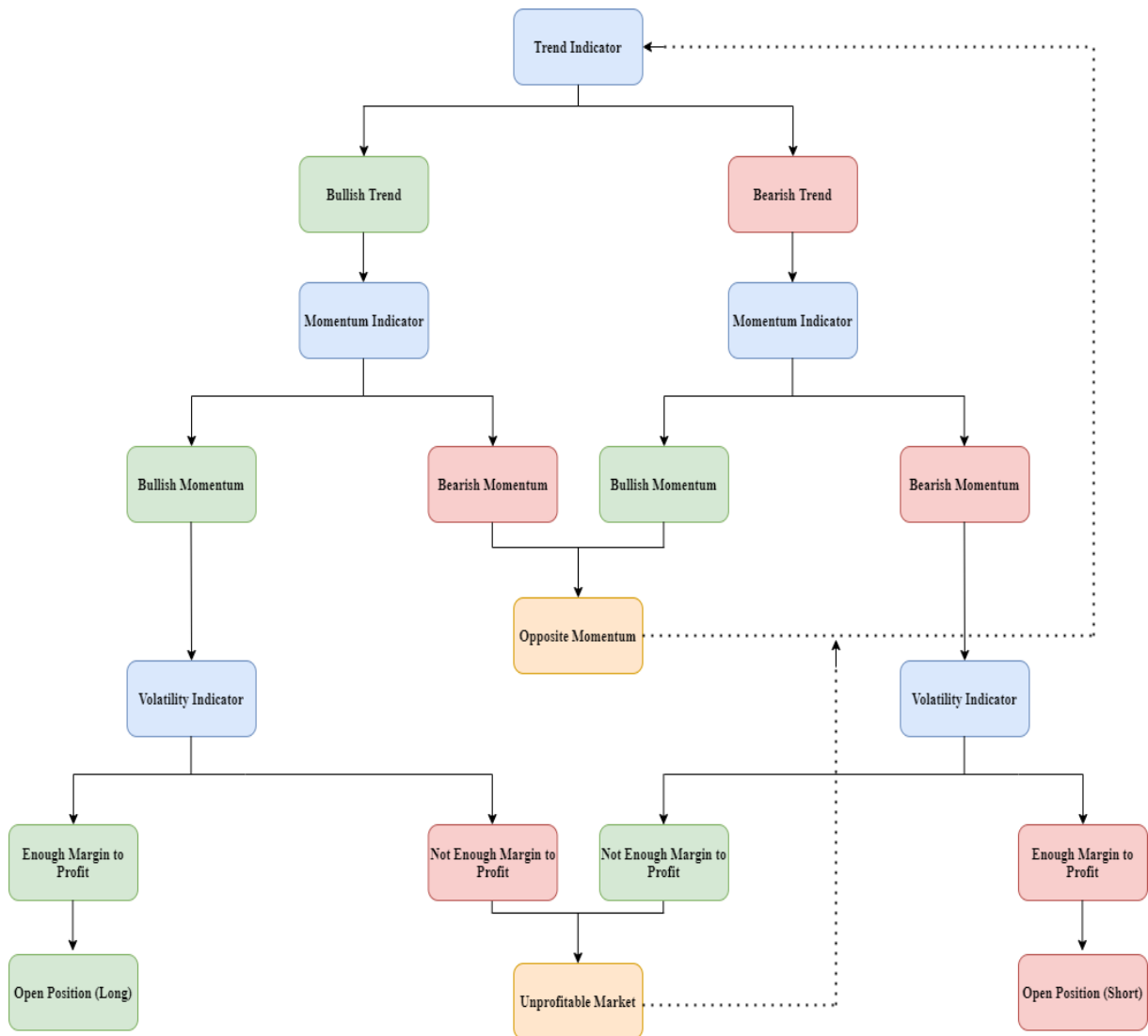
Technical indicators are the eyes and ears of the trader in the market. Technical indicators have their unique embedded functions. The indicators in the algorithmic trading setup can generate an accurate signal as final output together only if each technical indicator output is evaluated in-depth with precision. Signal generation is carried out by determining the situation delicately and categorize it. The creation of categories is based on the results produced by the technical indicators and should be thought through for different conditions to cover each one of them. It is important to keep the number of categories at a level that does not affect the result. If too many categories are created, the system becomes complicated and prone to software bugs without providing any additional advantage. If the number of categories is kept low, it is possible to encounter false signal generation this time more than acceptable.

It is possible to use some of the technical indicators with different strategies to generate signals. Some of the technical indicators even have opposite strategies for the same condition such as pullback and breakthrough strategies of the Keltner Channel. In this study, the same type of technical indicators uses the same sub-strategy for signal generation. Due to this condition, the performance of the technical indicator from the same subclass can be measured without a subclass strategy difference.

Tuning of the technical indicator settings is also crucial for signal generation accuracy, speed, and timing. Each technical indicator is fine-tuned to allow a fair comparison with other candidates in the same sub-class with no difference in setting. In this subtitle, signal generation conditions of ten technical indicators from three different types from dozens of technical indicators that are used in practice are examined. Technical indicators of the same class are set in the same settings and strategy-wise. A flowchart of each technical indicator's decision-making process is given in dedicated subtitles.

In this study, a unique trading algorithm suitable for the scalping day trading strategy is created. This strategy is based on generating a signal by evaluating the results of each indicator by determining the direction, momentum, and possible range of the asset in stages. The algorithm either proceeds or returns to the Trend Indicator stage and starts fresh according to the outputs of the momentum and volatility indicators. A flowchart of the simplified algorithm has shown in Figure 1 below.

The algorithm is separated into three stages. Stage I is for trend detection. Stage II is momentum measurement and Stage III is the section that estimates support and resistance levels of the market. The setup generates a buy/sell signal after Stage III only if the indicator results meet the requirements set by the author.



**Figure 1:** Basic Algorithm Flowchart of the Study

### 3.2.1 Trend Indicators Signal Generation Strategy and Settings

There are several strategies in the use of trend indicators in the real market. The Crossover strategy is common among moving average technical indicators that are using for trend determination. There are other sub-strategies for moving averages like the pullback strategy but the crossover strategy is selected for the trend indicator sub-strategy selected as trend indicators of the study. The reason for the selection is the duty of the trend indicators in this setup is solely detection of the trend direction rather than lookout for suitable buy/sell points.

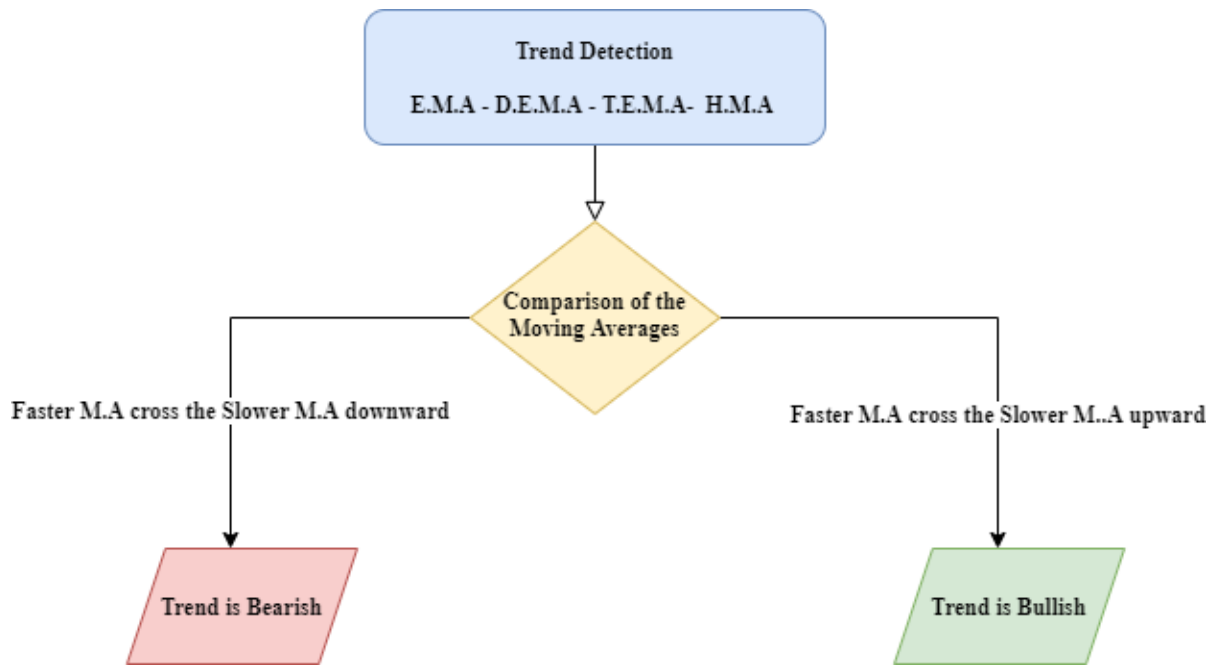
The Crossover strategy is a simple strategy that requires at least two moving averages with different time lengths. The higher the time length is the slower the technical indicator becomes. Trend changes are followed when the slow indicator and the fast indicator intersect and continue on their way. The slow indicator represents the long-term trend of the asset while the fast indicator tracks sudden changes and seeks out the trend's turning points. Short-term periods generates more signals than longer counterparts. A high number of signals also have a fatal flaw which is a higher chance of generation of false signals due to the asset price whipsaws.

Moving average crossover strategy has a very simple algorithm to generate signals. When the short-term moving average line goes above the long-term moving average line, the market trend is bullish and it is expected that the asset price will be increasing. If the short-term moving average line falls below the long-term moving average line, the market trend is bearish. The time length for each moving average is limited due to the trading strategy selected and study size. (El-Khodary, 2009)

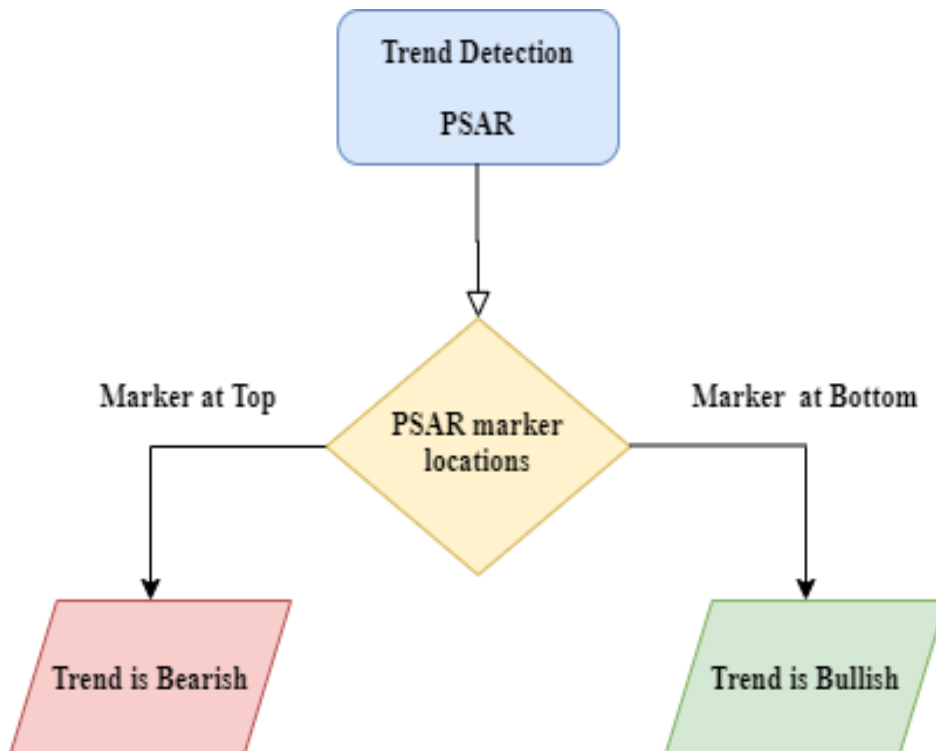
It is extremely important to remember that moving average technical indicators are lagging indicators. Lagging indicators uses previous data to provide information on the past, not the future. The trader can adjust both time lengths for their goals and desires. Within the scope of the study, all technical indicators have the same time length settings in order to be able to evaluate the technical indicator performances more accurately and equally.

Optimizing the setting of each technical indicator is vital for the performance maximization of the algorithmic trading setup that will be used in the real market. However, doing this optimization work in-depth for all candidate technical indicators is beyond the scope of the thesis. In the study, the time length of the trend indicators, the faster moving average was determined as 10, and the time length of the slower trend indicator as 25.

There are two different types of trend indicators in this study. Four of the five selected trend indicators are moving average technical indicators. There are two separate algorithms for Moving Averages and PSAR. Flowcharts of Trend Detections are given below with Figure 2 and Figure 3.



**Figure 2:** Trend Detection Algorithm Flowchart of Moving Average Trend Indicators



**Figure 3:** Trend Detection Algorithm Flowchart of PSAR Trend Indicator

### **3.2.2 Momentum - Oscillator Indicators Signal Generation Strategy and Settings**

Confirmation is crucial to achieving success when using a fast-moving average set with a crossover strategy. Momentum indicators are positioned to filter the signals generated by the trend indicators and eliminate the false ones. Momentum indicators have three strategies that come to the front of others, the crossover strategy, the momentum divergence strategy, and the zero line strategy.

As the study strategy for the momentum indicator, the zero line strategy is selected due to interoperability with trend and volatility indicators of the setup. The zero line strategy is a basic trading strategy for the momentum indicators. The scale of momentum indicator is separated into four zones, two above the middle line which either zero or half of the highest value. Extreme values of either side are considered as trending is gaining more strength, meanwhile, interior zones that are closer to the middle line are considered as more modest trend momentums. Strength gaining trends are ideal market situations for the trader to open a position and gain profit.

In order to confirm the sudden price changes rather than the long-term trend, the momentum indicator setting of the time length should be adjusted due to the short-term trend indicator's time length. Even though longer time length provides more dependable information with less noise, momentum change is crucial to observe frequently.

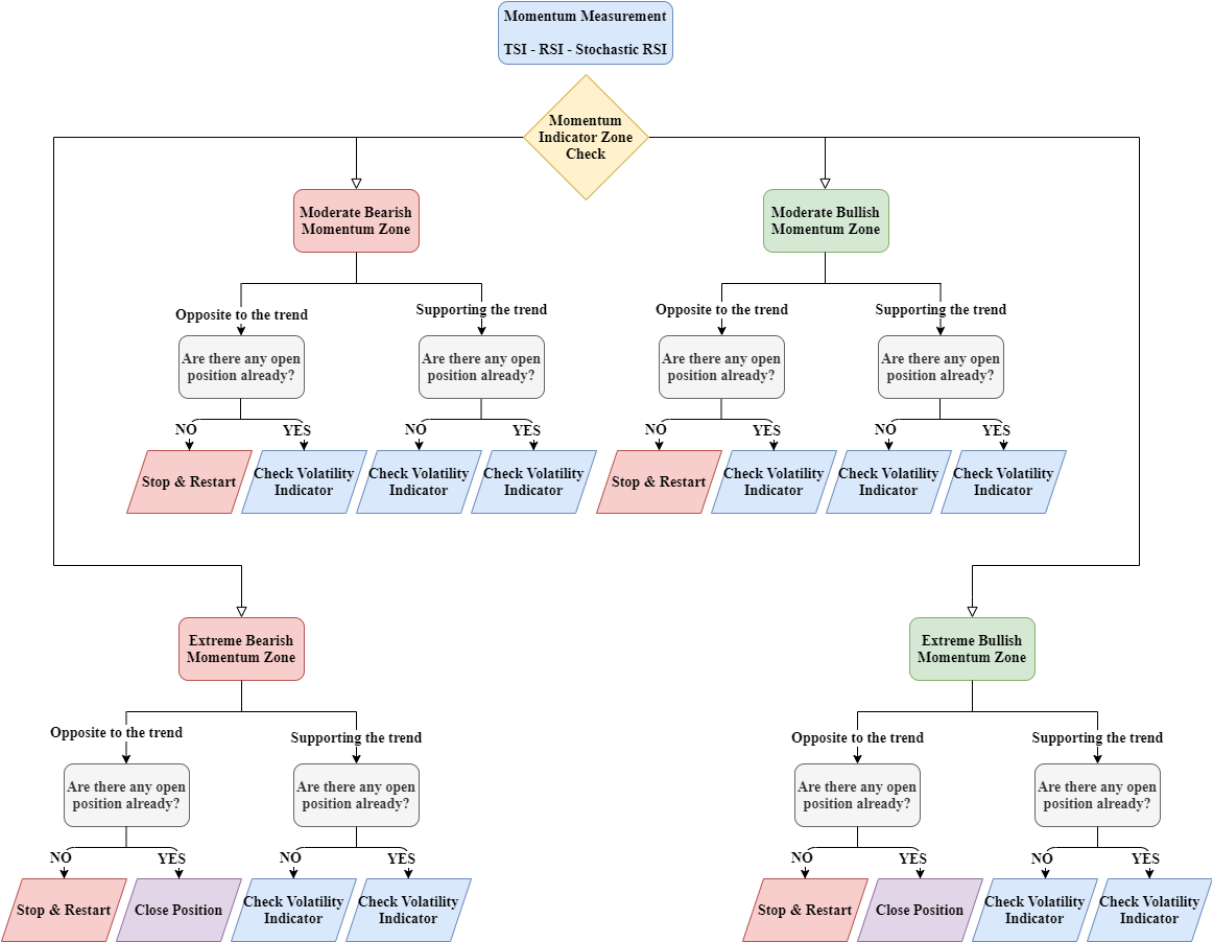
Tuning momentum indicators are harder than trend and volatility technical indicator counterparts due to the higher number of settings to optimize. Although all three candidate momentum-oscillator technical indicators have different variables and embedded functions, they have been tested by fine-tuning their settings as equally as possible.

Momentum can be in two ways like trend direction but also has magnitude. The momentum of an asset is classified into four due to direction and magnitude. The direction of momentum is either bearish or bullish. It is practically impossible that an asset's momentum to stay neutral other than momentarily.



Momentum indicators RSI and Stochastic RSI, momentum indicator results are separated into four brackets. First of all, is 0-30 momentum indicator values are named as extreme bearish, with means the momentum is very strong with decreasing prices. Moderate momentum values are zoned at two sides of 50. Bearish moderate momentum zone is limited between 30 and 50. The bullish side of the moderate momentum values are 50-70 and 70-100 is indicates the momentum is extreme with an uptrend.

The third and last momentum indicator, TSI has a -100 to 100 value scale. TSI brackets are expanded into the 200 point scale. -100 to -40 TSI momentum values are evaluated as extreme bearish. Values between -40 to 0 and 0 to 40 are marked as moderate bearish and moderate bullish momentums. A value higher than 40 indicates the momentum is extreme in the bullish direction.



**Figure 4:** Momentum Measurement Algorithm Flowchart

The momentum indicator is the most complex stage of the trading algorithm. The separation of the algorithm due to conditions executed mainly in the momentum stage. Different outputs have been created by comparing momentum with trend direction and the current position of the trader. There are four different outputs from the momentum stage of the trading algorithm. These outputs are close positions, hold positions, check volatility indicator, and stop trading.

If momentum is opposite to the trend and the trader does not have any open position, the algorithm stops the process and restarts from Stage I again. In two situations, extreme momentum in the opposite direction when the trader has open positions, the algorithm generates a close position signal to minimize losses.

The study algorithm generates a hold position signal once the momentum is supporting the trend and the trader has already opened positions that are currently winning, the hold position signal is generated to close the positions prematurely. Holding positions in such situations prevent loss of profit and increases net profit significantly.

In six situations, the output is “Check Volatility Indicator” and the algorithm proceeds to Stage III. “Check Volatility Indicator” is generated under three circumstances. The first one of the three is that the trader either opposite moderate momentum to the trend with an open position. The second situation is supporting moderate momentum to the trend with no position opened. The third and last situation to generate a “Check Volatility Indicator” requires extreme momentum that supports the trend with no position opened. If the trader already opened a position and experiences extreme opposite momentum, positions are immediately closed and act as a stop-loss.

### **3.2.3 Volatility Indicator Signal Generation Strategy and Settings**

Volatility indicators are developed to create a channel band by plotting top and bottom lines by taking previous data as input for their embedded function according to the selected time length of a financial asset. Top and bottom lines are usually drawn by SMA and EMA on many occasions. Famous Bollinger Band’s lines are plotted with multiple SMA with standard deviation (Bollinger, 2018).

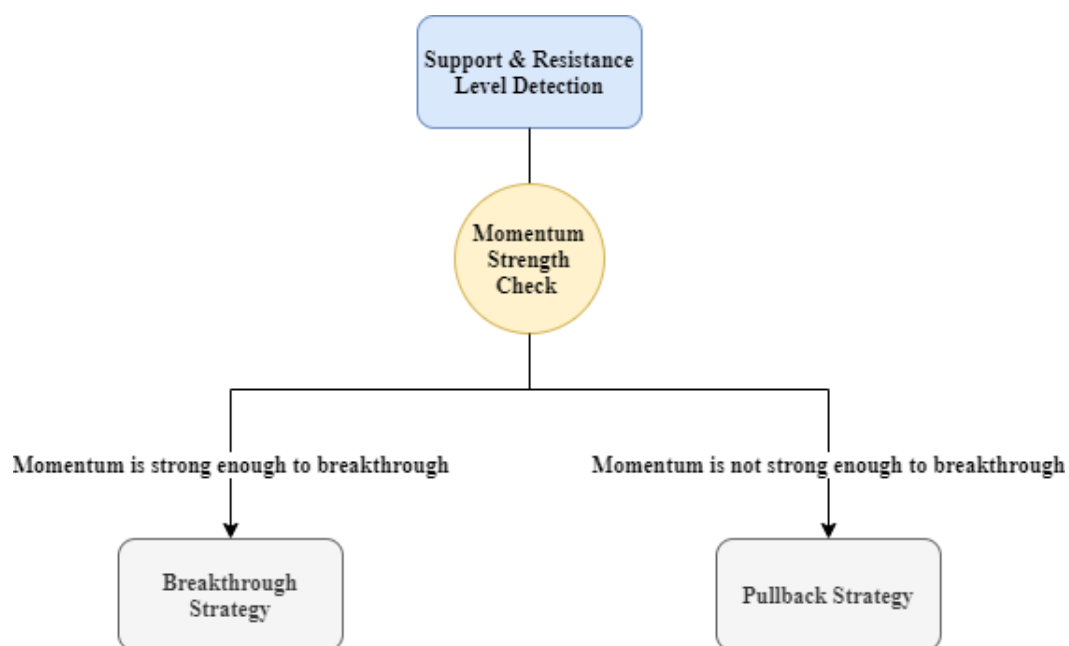
The scalping day trading is fast, short-term, and aiming to generate profits from price moves either is bullish or bearish. Because of the strategy, a volatility indicator is required to be dynamically monitoring the market and update the plots accordingly. Within the scope of this study, Keltner Channel is the only one among the other popular volatility indicators that are considered suitable for the scalping day trading strategy. The objective of the volatility technical indicator is the designed trading setup of the study, which is to margin determination.

### **3.2.3.1 Keltner Channel**

The third technical indicator of the setup is the Keltner Channel, which is the only volatility indicator selected for the study. The Keltner Channel draws ATR lines of the asset price. The lines can be used as dynamic resistance and support levels for the given moment based on selected time length to analyze previous market data and selected ATR multiplier settings.

Dynamic support and resistance levels change instantly according to price movements. While the majority of this change is made by trading bots that are operating by traders using the HFT strategy or illegal trading that aiming to manipulate the market, the magnitude of the change is generally less than the actual asset price change.

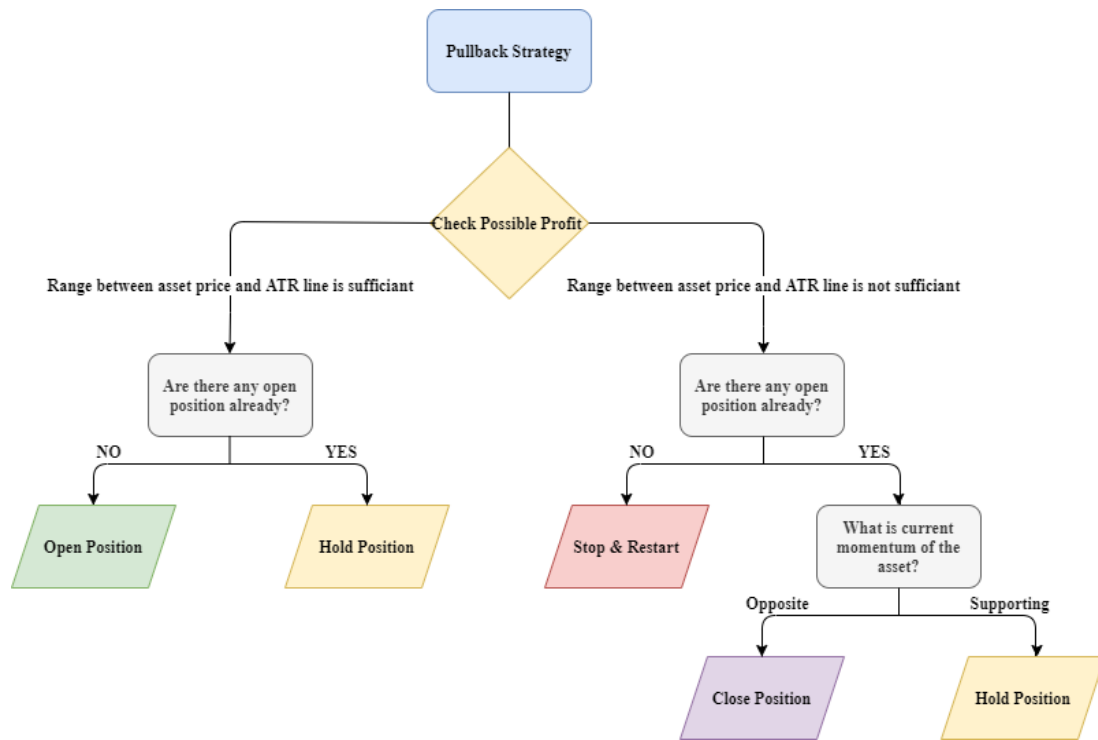
The Keltner Channel time length is equal to the trend indicator's long-term time length. The reason for this adjustment is that as a result of predicting, if the Keltner Channel set as fast trend indicator's time length, trades would be prone to be closed early before reaching stronger levels that it is more possible to affect the direction of the asset price. Keltner Channel with a 25-time length generates more stable and reliable ATR lines to use as a reference. ATR period is selected as 10 to cope with the fast trend indicator and momentum indicator. Keltner Channel multiplier expands ATR period lines and allows the trader to fine-tune the trading bot with the potential to seek out more viable open & close opportunities.



**Figure 5:** Support & Resistance Detection Algorithm Flowchart

Stage III support and resistance level detection has two separate indicator signal generation strategies and only one technical indicator selected for the study unlike one for Stage I and Stage II. Momentum strength is the parameter for which strategy to be used in the market under the circumstances at the time. The strategy to be used in the volatility indicator is selected according to whether the market momentum is moderate or in the extremum values on the momentum indicator's scale during the last two time bars. The pullback strategy is effective when there is a stable trend no matter the direction but the momentum is required to be moderate. If the trend is strong enough to step out of the extremum ATR lines, the breakthrough strategy would be the better choice to profit.

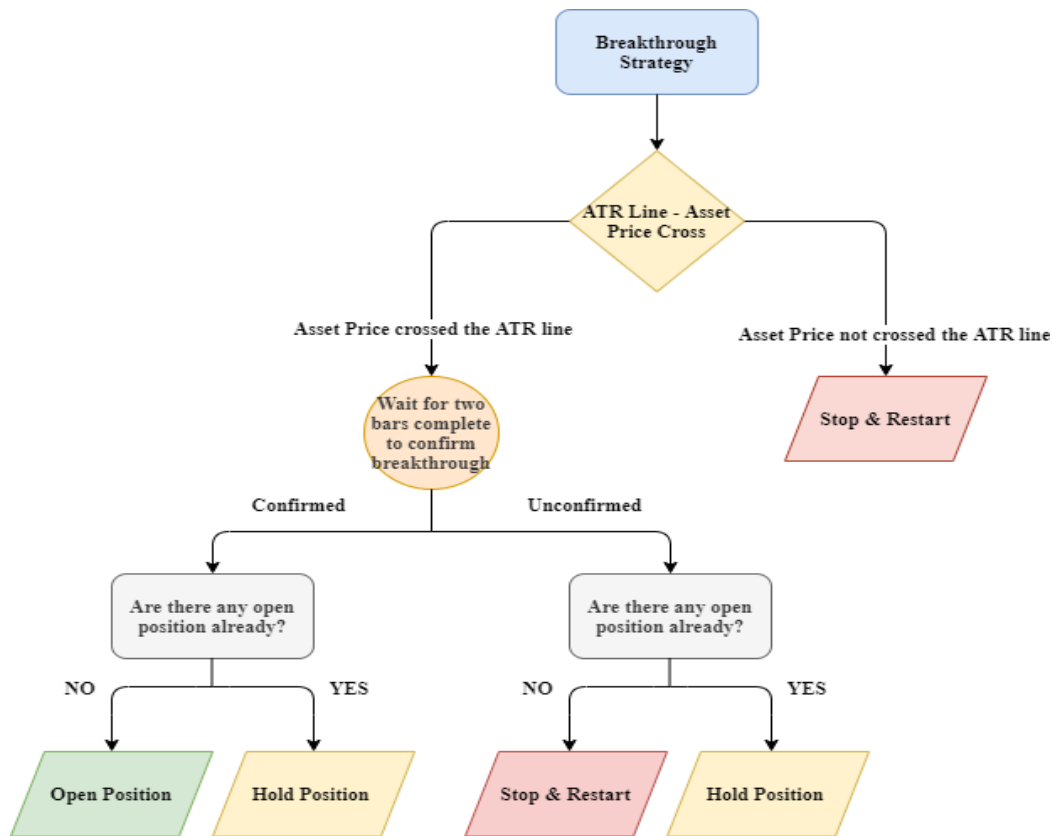
The pullback strategy assumes that the market will pull back the asset price to the middle line of the Keltner Channel as long as the asset is influenced by major news or significant momentum. The top and bottom ATR lines of the Keltner Channel are acting as a reference for stop loss and setting target prices to close positions. When asset price falls below the middle ATR line, the pullback strategy suggests opening a long position and open short if the asset price increases and passes the middle ATR line, so the trader can profit from oscillation. The pullback strategy also can be used for stop-loss. The stop-loss can be used by determining it with a smaller multiplier ATR plotted line or by the default approach which is a percentage difference from position opening price.



**Figure 6:** Pullback Strategy Algorithm Flowchart

The pullback strategy gives a signal to open the opposite direction of the current trend by thinking the asset price would pull back to the middle ATR line meanwhile the trend is strong and the asset price starts to change significantly without solid resistance-support to stop it. The pullback strategy first checks the possible profit margin, which is the difference between the next support-resistance level and the current asset price. The algorithm evaluates it based on brokerage fees and commissions plus net profit aimed and makes a decision.

After evaluating if the margin is enough or not, the algorithm checks open position status. If the range is sufficient and the trader not has opened the position already, the algorithm signals to open a new position and hold the positions if the trader already has opened. If the difference between the ATR line and the current price is insufficient with no opened position previously, the algorithm immediately stops by deciding that the current market is not suitable for trading and resets to start fresh from Stage I. In the case of having an open position, the algorithm checks momentum once again to decide whether to close the position to minimize loss or hold position if it is supporting the position. If the momentum is at an extreme zone, the pullback strategy would be ineffective and start to generate false signals.



**Figure 7:** Breakthrough Strategy Algorithm Flowchart

The breakthrough strategy is developed for the situation of the asset price is breakthrough the resistance or support level represented by the ATR lines. The price might move suddenly toward the next resistance-support level depending on the strength of the trend. Momentum – oscillator indicator plays important role in this strategy and it is virtually impossible to apply successfully if the Keltner Channel is used alone. (Mitchell, 2020)

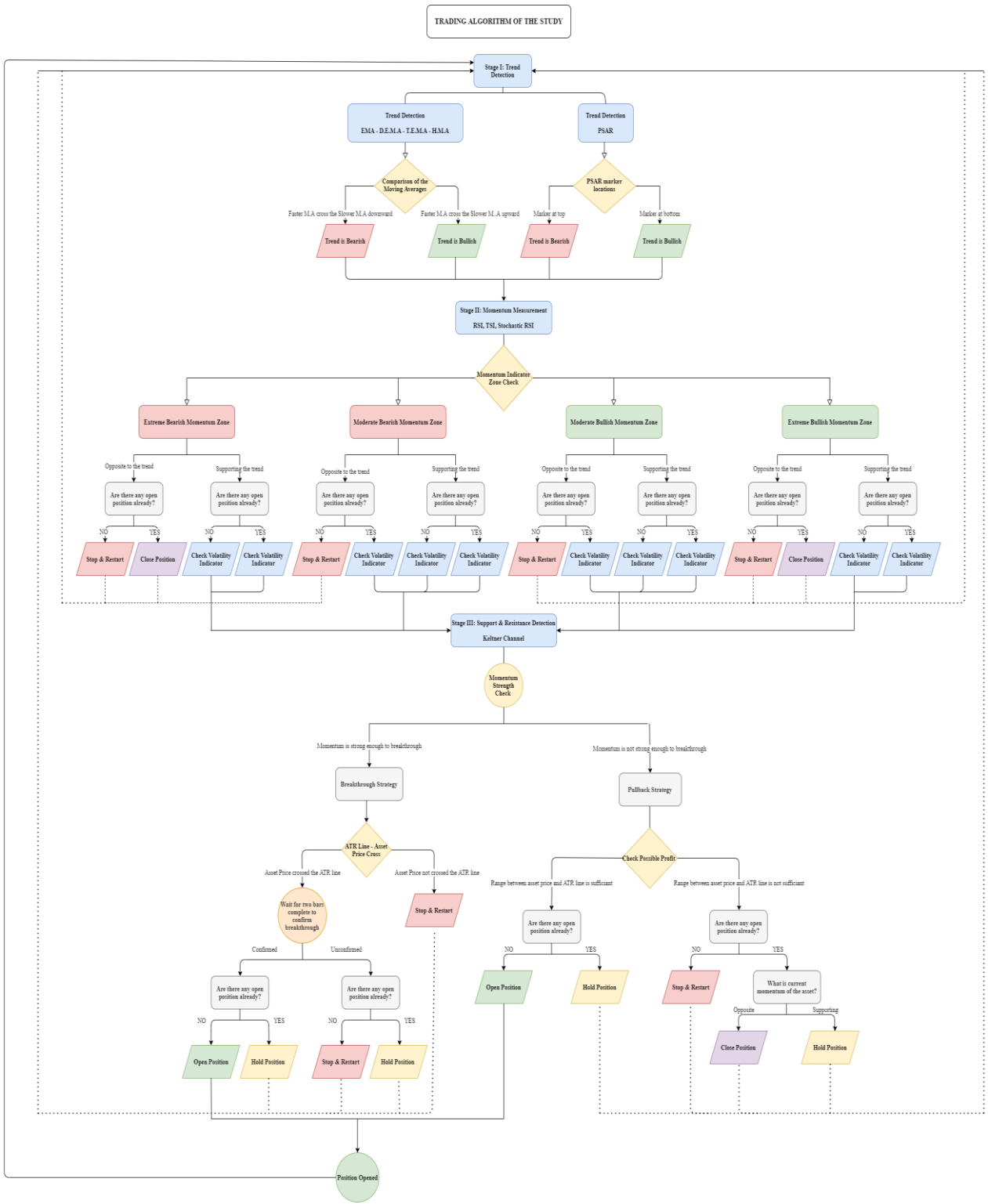
To activate the breakthrough strategy, the asset price is required to cross the extremum ATR lines first. Once the asset price overcome the support-resistance level, the market became choppy due to sharp price movements. Under such conditions, a breakthrough strategy is selected by the algorithm to prevent false signals and increase profit. Breakthroughs are the most profitable market situations if only the trader able to detect an open position with a favorable entry price.

Detecting the market is suitable for breakthrough or pullback strategy is a hard task to achieve successfully. In order to understand that the asset price is just overshoot extremum ATR lines for a short period and pullback to middle ATR line or it is the start of a breakthrough which is the perfect time to open position. The market momentum was observed for two-time bars. After the confirmation, the algorithm converts to a breakthrough strategy. During waiting for two bar confirmation periods, the trader may miss significant price movement and profit opportunity but it is necessary to select the correct strategy. Using the wrong strategy causes losses. It is more important to ensure long-term profitability in a sustainable approach than aiming for maximum profit with higher risk. Preventing losses is vital for trading.

After waiting for two bars to complete, the algorithm checks the current asset price and compares it to the extremum ATR line on the related side of the middle ATR line. If the breakthrough is confirmed and the trader does not have any already opened position, the algorithm signals to open position at the current asset price. On condition the trader has opened a position with supporting momentum, the algorithm generates a signal to hold the position.

If the breakthrough could not be confirmed after two bars, the algorithm checks current positions. Already opened position with unconfirmed breakthrough results as hold position so the trader may protect the advantage if the asset manages to overcome extremum ATR line. On the other hand, the algorithm stops the process and restarts since the current market is not suitable for the breakthrough strategy.

Study algorithm's each stage has explained and a detailed algorithm flowchart has been given. In Figure 8, the complete flowchart of the study trading algorithm is given below. The algorithm is designed to cover major possibilities without increasing complexity too much.



**Figure 8: Complete Trading Algorithm Flowchart**



### 3.3 Backtesting Periods

The best way to evaluate the performance of the brand-new algorithm on the selected trading strategy is to test it on the real market. Testing the algorithm with real money on the line is extremely risky. Testing it on the live market also takes too much time to get enough data to evaluate the performance to detect the problems to fix and optimize indicator settings. In order to test many different setups fast and efficiently instead of waiting for a long time, real market datasets from the past are used as training tracks. Using previous real market data as test tracks named as back-testing. It is important to avoid overfitting the trading setup or algorithm itself. By overfitting, backtesting is prone to deceive the trader by optimizing certain historical data specifically but does not perform well enough in the future. (Holland, 2013)

A solid trading algorithm needs to perform well in all types of market trends. Trading algorithms tend to perform better at trending markets against sideways. Due to the chaotic nature of the financial market, during the selected period, there are short periods of contrary and sideways price movements. The market trend is named by the direction that makes up most of the movement in that range, not over the entire period. Any selected time length hosts multiple shorter-term trends from bullish, bearish, or sideways trends together. In this study, each backtesting period is far greater than the position keeping of the scalping day trading strategy.

XAU/USD market has experienced both trending and sideways markets in the last five years. In order to test the trading algorithm of the study, a close to sixty-five-month time was subdivided into two. The data set is divided to represent each trend, not equal time lengths. Thus, the performance of the trading algorithm designed and indicator settings adjusted for the study can be measured in sideways, bearish and bullish trends.

Backtesting has been completed with sixty-five months of the real market data. The results of the backtesting provide sufficient information in terms of depth and amount of data to calculate efficiency, net profit and a win rate of the trading algorithm to be achieved. Figure 9 given below shows sixty-five months of XAU/USD market price graph subdivided into two periods, Period I, and Period II. Asset prices given below for stated market days are the highest and lowest asset prices on the market, not the closing prices.



**Figure 9:** XAU/USD price graph from 01.07.2015 to the 25.11.2020

It is important to understand that testing scalping day trading strategy for sixty-five month time length generates satisfactory data both in terms of amount and depth. The algorithm search for short-term opportunities without compromising long-term profit. During backtesting, the algorithm requires to react differently due to the market’s ever-changing situation, trend, and behavior for the highest profit generation.

### **3.3.1 Period I: 01.07.2015-31.12.2018**

Period I is a good example of a balanced sideways market with smaller bearish and bullish trends. Black lines show the exact dates of Period I’s boundaries. The first period of the study dates between 01.07.2015 to 31.12.2018. During the forty-two month time length, the global economy was recovered from the 2008 banking crisis triggered by subprime mortgage rating and the housing bubble of the USA and being stable in general terms (Duca, 2013).

From the start to the end of the first half of 2016 is a bullish trend meanwhile the second half of the year the price of Gold per ounce falls drastically. The years 2017 and 2018 have a sideways trend in a smaller price range compared to the previous and following years of the XAU/USD market.

Period I is selected as a testing ground to measure the capabilities of the trading setup on multiple market situations like stable, less choppy sideways trend and strong short term bullish and bearish trends. Even though the market is less fluctuant during Period I than Period II, the volume is still extremely high in comparison to the stocks. Volume is still large enough to complete lesser bearish and bullish trends. Due to the length of the period examined, it can be seen that the lesser trends continue for few days to few months. Longer and stronger trends can continue for years, as in Period II.

Figure 10 shows the XAU/USD market price during Period I. The price graph automatically sizes to the screen due to graph differences. Although the price movements seem strong when looking only at Figure 10, as it is framed on a narrower vertical axis due to smaller price changes by comparison to Period II. The lowest asset price of Period I is \$ 1046.54 per ounce on 03.12.2015 and the highest is \$ 1375.15 per ounce on 07.07.2016. The biggest price difference during Period I is 31.30%.



**Figure 10:** XAU/USD price graph from 01.07.2015 to the 31.12.2018

### 3.3.2 Period II: 01.01.2019-25.11.2020

The dates between 01.01.2019 and 25.11.2020 are named Period II. While the first half of 2019 was a sideways trend and relatively quiet market, in the second half the trend changed into bullish. In the last quarter of the year, the Covid-19 disease pandemic caused by the new coronavirus type SARS-CoV2, the XAU/USD market has entered a serious upward trend started from December 2019.

The bullish trend changed and asset price declined sharply between the 9<sup>th</sup> of March and 16<sup>th</sup> of March 2020. The asset price declined from 1703.60 \$ / ounce, the highest of the day to \$ 1451.41 per ounce the lowest of the day. The sharp decline was followed by quick compensation by the market back to \$ 1600 per ounce just in four days. After corrections, the XAU/USD market continued to bullish market, and the asset price breaks a new all-time high record, \$ 2075 per ounce on the 7<sup>th</sup> of August 2020.

After the record the market nose dive due to improving the situation of the daily new cases and loosening pandemic precautions mostly in Europe. The XAU/USD market enter a sideways trend and became relatively stable, relatively to previous quarters of the 2020 financial year. Especially in November of 2020, with the effect of white hope from vaccination researches for Covid-19, the market seems to be in a moderate bearish trend instead of moving back to a higher price than \$ 2000 per ounce.



**Figure 11:** XAU/USD price graph from start of 01.01.2019 to 25.11.2020

Period II provides a very convenient dataset to test how the trading algorithm setups perform in a bullish and choppy market at the same time. During Period II, sudden and strong price changes occurred, mostly with a bullish trend. The performance of the trading setup under such a market depends on its capability to react to sudden trend changes and it is tested harder than Period I and Period II. Choppy markets also suitable financial environment to test trading limitations set by the trade as principles to manage risk and the budget itself.

### **3.4 Trading Limitations**

Trading is a serious business and the trader needs to approach trading with discipline. Just like determining the strategy and technical indicators to be used, the management of the trading budget requires a preliminary study. Although the study for trade limitations are not in the scope of this study, trading limitations have been applied to ensure that the performance of the trading algorithm measurement is accurate as possible in real market conditions.

Trading is a risky practice. It is crucial to understand that the trader should not use the majority of their budget in active trading. No strategy can achieve a 100% success rate. Losses are inevitable in trading so the trader must be prepared to minimize the effect of losses. If the trader has an open position that is currently losing, the trading platform will demand the exact amount of money to cover loss so the trader can hold their positions open. If the trader does not have any deposit that is reserved to cover losses, the trader has to close some of the open positions for the current value. Because of the inevitable truth of facing losses in trading, the trader should have left a selected percentage of the budget as a deposit in case of a margin call to cover losses. The deposit for the potential loss coverage is named a margin deposit. A margin deposit is extremely crucial if the trader is using leverage to trade. Multiplied losses can be devastating.

The remaining budget after the margin deposit is allocated from the total budget called the active trading budget. The trader should not use the entire active trading budget for each trade. The trader can fall on the wrong side of the trend after a sudden change on market due to major demand created for any reason. Considering that sudden situations are temporary, it is also possible to gain an advantage from the asset price movement as an opportunity to reduce cost by opening new positions until the trader starts to win instead of closing existing positions as an act of stop-loss.

Opening more positions when the trader starts to lose is called the Martingale Strategy. Martingale Strategy requires an infinite amount of capital and starts with as little as possible for the first trade. Using a small percentage of the active trading budget allows the trader to make another move if needed, on the other hand, using too little of the trading budget significantly reduces possible profit to gain if the signal generated by the algorithm is correct. Martingale Strategy becomes extremely risky after a few losses with a high percentage of active trading capital. Martingale Strategy is also unsuitable for the scenario of the study since the total budget is very little to cover that type of strategy. (Mitzenmacher & Upfal, 2017)

The possibility of making a profit increases with using well-performing algorithms and budget management methods but the stop-loss method is an efficient way to cut losses before they became too much that affects the capital and trading capability. Stop-loss activates once the algorithm detects that the current position is losing (Yin, Zhang, & Zhuang, 2010). The stop-loss monitors the asset price instantly. When price changes, the stop-loss trails the changes if only the price movement is in the same direction as the opened position. In case of sudden price changes, asset price trailing stop-loss minimizes the losses suffered if the open position was already gaining profit. If the asset price moves to the opposite direction of the position, stop-loss remains at the price determined originally when the position has opened (Brown et al, 2010).

All three methods mentioned above are actively using by traders to ensure that the trading activity is less risky by preventing excessive losses. The algorithmic trading system requires to be reliable and sustainable in terms of profit generation. It has been stated that the optimization of these methods exceeds the scope of the study but all three methods are used in the study to obtain more realistic results.

In this study, leverage is not being used in FOREX XAU/USD algorithmic trading. Due to that, the active trading budget is equal to the capital budget. The trading algorithm uses 50% percent of the active trading budget per trade. The stop-loss cut the trading and close the positions if the algorithm output is opposite for both the trend indicator and the momentum indicator or crosses the opposite ATR line of the Keltner Channels.

### 3.5 Methodology of Analyses

Evaluating an academic study and interpretation of the data output is only possible with scientific methods. Backtesting results are complex and there are many metrics to consider. Among the results of an algorithm that is designed to operate in the financial markets, many important metrics can be taken into account, but two of them stand out.

Generating a profit is the goal of trading. Any other objective that is achieved becomes meaningless as well as lost as a result of trading. The profit ratio is the benchmark of the performance of the trading algorithm. Technical performance evaluation of the trading algorithm is not ideal to consider net budget change only.

The primary task of the trading algorithm is to generate buy & sell signals. Measurement of the signal accuracy provides crucial data to evaluate the performance of the algorithm as a setup. A Well designed and robustly coded algorithmic trading bot should have a low false signal rate. Signal accuracy shows the cumulative well-tuning of the trading setup.

#### 3.5.1. Rate of Return Test

Rate of Return (ROR) is the investment profit ratio over capital between selected periods. At the end of the period, it calculates the results of the commercial activities carried out compared to the total budget at the beginning of the period as a percentage change. The rate of return is the most common and easiest method to measure the performance of an investment. Since the budget of the study is small in terms of trading, the calculation method does not affect results significantly.

ROR is calculated for Period I, Period II, and Period III separately. Each calculation reveals the performance of the algorithm in different market trends in terms of financial success. It is not sufficient that the return gained from the trading activity is higher than the initial capital. ROR of the trading is expected to be higher than other returns from similar and lower-risk investment options.

$$\text{Rate of Return} = \frac{\text{Value}_{final} - \text{Value}_{initial}}{\text{Value}_{initial}}$$

**Equation 29:** Rate of Return formula (Freeman, Ohlson, & Penman, 1982)

If the ROR is lower than other low or similar risk investment instruments, the trading activity may be considered as non-viable and not a good choice, although it is profitable. In this study, low-risk interest-generating saving accounts are taken as a reference. If algorithmic trading setups are not bringing in more profit than a savings account, it is clear to say that the investor should prefer other financial instruments as saving or as an investment method.

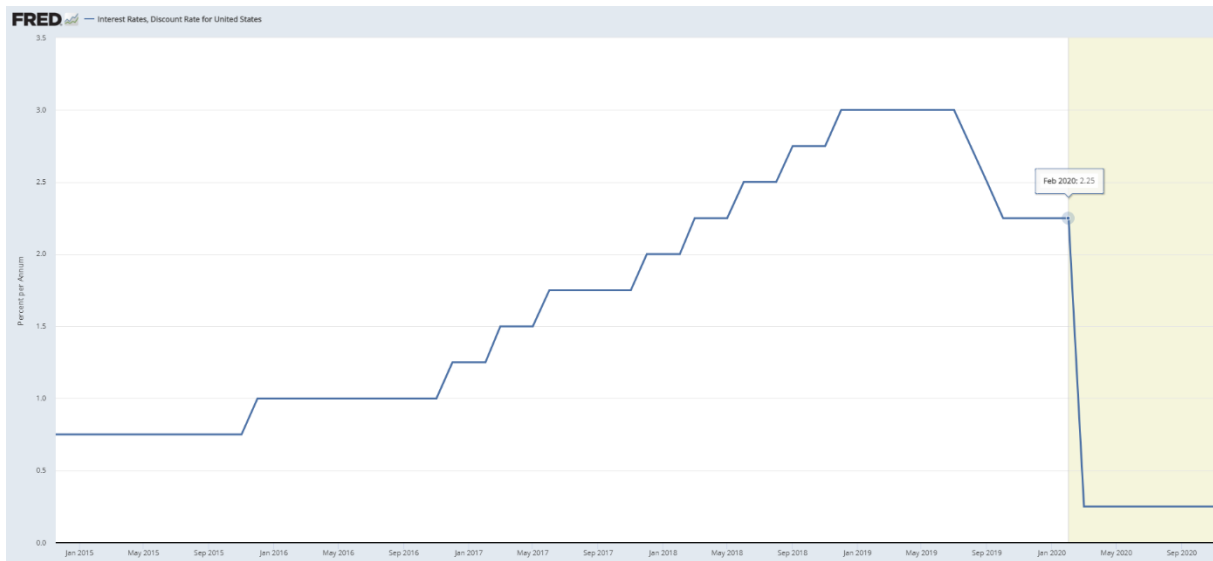
Individuals are usually choosing to invest their money in low-risk investment instruments such as savings accounts. For the designed algorithm to use in XAU/USD market to be considered as a viable passive income source or saving method, similar savings options must be compared. In this study, the trading algorithm's financial performance evaluation completed by comparing the ROR of the algorithmic trading with ROR of the saving account. Hypotheses of the study seek an answer to the question, is algorithmic trading a dependable investment method with low risk under different market trends?

Saving accounts are widely popular especially among individuals with a relatively small budget. Savings accounts offer guaranteed interest for the capital. Almost always, savings account interest rates are lower than the inflation of the country. Even though purchasing power decreases over time against inflation, individuals prefer them against other investment options. The physiological reason behind this is the money saved in years from their salaries is too hard to recover from any short-term losses so individuals choose to lose money in time inevitably rather than lose at any stage of the optional investing.

The savings account's interest rate is calculated by base interest regulated by the central bank of the country and interest rate plus the extra interest rate given by the bank based on its financial situation and marketing decisions. Within the scope of this study, the interest rates accounted by the central banks are taken as parameters. In the performance measurement of the designed algorithm, measurement is made for both USD and TRY with and without including exchange ratio changes over time and with and without interest rates in effect over all three periods of the study.



There are two economic evaluations for algorithm results in terms of savings performance. In both comparisons, the time value of money is included according to the interest data from central banks. The first one is the algorithmic trading results in the USD exchange compared with the USD savings account during the backtesting. Since the USD is the dominant currency in the global economy and is used as a reference unit in the XAU/USD market, calculations and evaluations are made based on the USD. TRY on the other hand is an example of volatile and prone to crisis country currency behavior.



**Figure 12:** Interest Rates for the USA 01.07.2015-30.11.2020 (Federal Reserve Bank of St. Louis, 2020)

The USD had different interest rates in 2013-2020 due to factors such as the effects of the crises in the past years and the Covid-19 pandemic. The USD interest rate moved between 3% and 0.25%. The period of interest rate decrease show as yellow-highlighted in Figure 12. The interest rates for the date range given in Table 1 are given below. The 12<sup>th</sup> root of the yearly interest rate gives the monthly interest rate. Weighted average interest rates of each year are calculated by using monthly interest rates and are given in Table 2. The cumulative interest rate of each period is calculated and given in Table 3.

**Table 1:** Interest Rate of USD 2015-2020 (Federal Reserve Bank of St. Louis, 2020)

<b>Period</b>	<b>Interest Rate (%)</b>
07.2015 – 11.2015	0.75
12.2015-11.2016	1.00
12.2016-02.2017	1.25
03.2017-05.2017	1.50
06.2017-11.2017	1.75
12.2017-02.2018	2.00
03.2018-05.2018	2.25
06.2018-09.2018	2.50
10.2018-11.2018	2.75
12.2019-06.2019	3.00
07.2019-08.2019	2.75
09.2019-08.2019	2.50
10.2019-02.2020	2.25
03.2019-11.2020	0.25

Overall interest rates are calculated and given in Table 2 below. The year 2015 has a low-interest rate due to a positive global economy and a half-year period. Each following year has increased interest rates. The Year 2020 forced FED to decrease interest rates to support firms and individuals against booming unemployment numbers due to the Covid-19 pandemic.

**Table 2:** Weighted Average Interest Rate of USD per Year

<b>Period</b>	<b>Weighted Average Interest Rate (%)</b>
01.07.2015 – 31.12.2015	0.39
01.01.2016 – 31.12-2016	1.02
01.01.2017 – 31.12.2017	1.62
01.01.2018 – 31.12.2018	2.22
01.01.2019-31.12.2019	2.75
01.01.2020 – 30.11.2020	0.56

Each period has different overall interest rates. The overall interest rate of the USD for sixty-five months is 8.85%. In terms of the USD-based savings, scalping strategy algorithmic trading must exceed 8.85% for it to be a viable investment-saving method.

**Table 3:** Overall Interest Rates of USD for Period I, Period II, and All Study Period

<b>Time Set</b>	<b>Overall Interest Rate of USD (%)</b>
Period I	5.34
Period II	3.32
All Study Period	8.85

Compared with the United States of America, the Republic of Turkey's economy is more volatile due to political, military, and financial reasons. This volatility is reflected in the interest rates and exchange rates. The exchange rate has dramatically increased in the monitored period of the study.



**Figure 13:** USD/TRY Exchange Rate 01.07.2015-25.11.2020

**Table 4:** Exchange Rate of USD/TRY per Period

<b>Time Set</b>	<b>USD/TRY</b>	<b>Change (%)</b>
<b>Period I Start</b>	2.7710	86.38
<b>Period I End</b>	5.1645	
<b>Period II Start</b>	5.1645	51.52
<b>Period II End</b>	7.8253	
<b>All Study Period Start</b>	2.7710	182.40
<b>All Study Period End</b>	7,8253	

The second evaluation, starting a budget of 10.000 USD at the date of 01.07.2015 converted to TRY from the USD/TRY rate on the same day to trade in FOREX until the end of 30.11.2020. The starting budget is equal to 27.700 TRY. If the trader had used USD savings account for the monitored period of the study, the budget would have reach 10.885 USD on 30.11.2020 with a total interest of 8.85%. By converting the last budget of 10.885 USD to TRY with a current exchange rate of 8.85%, 85.178,39 TRY is obtained. The increase of USD is 307.39% against Turkish Lira that is not invested in any investment instrument.



**Figure 14:** Interest Rates for Turkey 01.07.2015-30.11.2020 (Federal Reserve Bank of St. Louis, 2020)

**Table 5:** Interest Rate of TRY 2015-2020

Period	Interest Rate (%)
07.2015-05.2018	8.75
06.2018-09.2019	18.50
10.2019-11.2019	17.25
12.2019-05.2020	12.75
06.2020-11.2020	9

The trader may choose to use Turkish Lira savings without converting into any foreign exchange. Turkish Lira offers a high interest rate meanwhile suffer constant losses against other exchanges. Interest rates are given in Figure 14 and Table 4 below.

Yearly interest rates are calculated in the same way as the USD interest rates. The lowest interest rate of the TRY is 9% between 12.2016-05.2018 and the highest interest rate is 18.75% from 06.2018 to 09.2019. Interest rates of TRY have been given in Table 4. Weighted interest rates of each year and overall interest rate of Period I, Period II, and All Study Period are also given in Table 5 and Table 6.

**Table 6:** Weighted Average Interest Rate of TRY per Year

<b>Year</b>	<b>Weighted Average Interest Rate (%)</b>
01.07.2015 – 31.12.2015	4.28
01.01.2016 – 31.12.2016	8.75
01.01.2017 – 31.12.2017	8.75
01.01.2018 – 31.12.2018	14.33
01.01.2019 – 31.12.2019	17.80
01.01.2020 – 30.11.2020	10.97

**Table 7:** Overall Interest Rates of TRY for Period I, Period II, and All Study Period

<b>Time Set</b>	<b>Overall Interest Rate of TRY (%)</b>
Period I	41.00
Period II	30.72
All Study Period	84.32

Even the USD has a low-interest rate, the depreciated TRY lack behind in purchasing power over the years. The overall interest rate of the Turkish Lira in the study monitored period is 84.32%. If the trader chooses to invest in the Turkish Lira savings account, the final amount of the budget is 51.056,64 TRY. The USD saving account is much more advantageous with a 10.885 USD final budget compare to the TRY counterpart's 6.524,56 USD. TRY savings account is financially non-viable.

Another test for financial viability is the Buy & Hold strategy. The trader is assumed to open a gold long position and hold it until the end of the year 2020. For the calculation, the trader has bought 4 long contracts of gold for 10.000 \$ at the date of 01.07.2015 with the price of 1.168,40 \$. The trader sold closed the contracts at 24.11.2020 for 1.805,81 USD. Buy & Hold strategy generated 637.41 \$ per contract and 2.549,64 \$ in general, the trader has 12.549,64 \$ at the end which is 25.49% ROR.

The USD savings account has 10.885 \$ is significantly lower than the Buy & Hold strategy. TRY savings account performs even worse than the USD savings with 51.056,64 TRY as final capital, which is equal to 6.528,98 \$ with 34.71% loss. Due to that, the Buy & Hold a strategy is a viable option for a single investor with low capital from the start instead of a TRY or USD savings account.

Due to that, the Buy & Hold strategy is a viable option and has been set as minimum ROR that the trading algorithm of the study aiming to pass to be a viable option to invest in a study monitored over a sixty-five month period.

### 3.5.2. Signal Accuracy Test

The technical success of signal generation is measured by the percentage of correct signals. Signal accuracy is measured with a simple approach. The signal win rate is the total number of wins over total signal numbers. The goal for the signal win rate is to be as high as possible. While 100% success is impossible for trading activity, the signal win rate below 50% probability of the coin toss success is unacceptable.

$$\text{Signal Win Rate} = \frac{\text{Signal}_{\text{Win}}}{\text{Signal}_{\text{Total}}}$$

**Equation 30:** Ratio of Signal Win to Total Number of Signals

A clear prediction of what percentage of the signal win rate should depend on the stop-loss rate, the percentage of the profit on winning trades, the targeted total profit, the trader's risk management, and goals. For the trading algorithm to make a profit, the accuracy of the generated signals must be high, as well as the loss in false signal situations must be minimized. Even the number of false signals is low, if each loss for a false signal is more than profit gained from true signals, the final result is a loss.

The cost of false signals is a very important metric to follow which provides crucial data to optimize technical indicators of the setup. This means that the stop-loss of the setup is not performing well. The stop-loss failures can be caused by the algorithm itself or technical indicator settings.

### **3.6 Backtesting and Optimization of Algorithmic Trading Setups**

As the markets transformed into the digital, traders themselves switched to computers to gain the advantage of this revolution. Today, the majority of the trading activities are executed by software either partly or entirely. Most of the software languages are suitable for coding an algorithmic trading bot. In today's competition, traditional coding languages like C, C++ are fall short in terms of data processing and software operation speed. Processing power requirements may exceed personal computer limits.

The most important issues to be considered in coding are the prevention of logical errors and getting results as fast as possible. If logic errors are caused by bad coding that generates false signals, it can be devastating to the trading budget. Financial markets can be subject to very sudden and sharp changes. The trading bot needs to analyze and react before opportunities are missed or threats cause losses from open positions.

In recent years, the Python programming language has rapidly become one of the most popular among its peers due to its efficiency in optimization, data processing, machine learning subjects, and its ability to work on different platforms easily. Python is an efficient and fast working language. Python is also highly capable to work with big data. Because of these reasons, the Python programming language is selected for coding the trading algorithm's backtesting. Each technical indicator code is taken from the Finta python library. Finta is an open-source python library specified over trading indicators. Numpy and Pandas python libraries are used for linear algebra data science and big data analysis.



Dataset of sixty-five month with 5 minute period is simple but also quite big. The total length of the data set is 379176-time bars. The dataset includes the open, high, low, and close of each 5 minutes. The data set required is provided by İdeal Data Finansal Teknolojiler A.Ş. that is İstanbul based professional trading firm.

In order to run backtesting for the study algorithm and measure its performance, the first objective is to read data from a CSV file. After the read, the algorithm starts to as null, with no position open, and waits until a favorable market unfolds. The software checks each new time bar's values and opens or closes position based on the hlc3 source. The hlc3 source is a weighting model for moving averages which is the backbone of the study's trend indicators. Source type for trend indicators affects moving average lines and may cause harm to trading performance.

Technical indicators of the study produced outputs as Boolean. Each Boolean output is used as inputs in the algorithmic flowchart shown in Figure 8 and determined actions taken by the trading bot. Fifteen different technical indicator setups are tested with selected parameters that are stated in each indicators sections. Results are evaluated with ROR and Signal Accuracy.

The algorithm results are subdivided into two periods as sectoral performance but the account keeps as it is and trading continued. Trading software is extremely basic compare to professional counterparts which are not suitable to operate on the real market but acceptable to achieve results from static historical data. The main reason behind the unsuitableness is that the trading algorithm would be overwhelmed by advance professional trading bots. Source code is not published in the study.

## CHAPTER IV: RESULTS & CONCLUSION

### 4.1 Backtesting Results

The study was completed on a 379176-five minute time bars period. The length of the period is satisfying enough to produce dependable results. The dataset includes almost every possible market situation. The study includes a total of fifteen runs, each with a Trend Indicator, a Momentum Indicator, and Keltner Channel as Volatility Indicator. Results are given after the process of the raw setup outputs.

The data in the tables in this section have been simplified to keep the comprehensibility of the study high and have been given together so that all indicators can be compared more easily. The results obtained within the scope of the study were evaluated with both rates of return and signal accuracy tests in two separate periods. Results are inspected and processed with Excel Pivot Tables. With these evaluations, the performances of the indicator setups have been obtained and made comparable. Each indicator setup's results are given with the total number of trades, win rates on both long and short positions, highest win per contract and losses, and total trading budget changes.

While Signal Accuracy is maximum, it is aimed to find the trading algorithm indicator setup that gives the highest ROR. In order to achieve such a goal, ROR and Signal Accuracy correlation were examined.

Data outputs are given below with tables in this subsection of the study. After the presentation of the outputs, ROR and Signal Accuracy Tests are given below in sections 4.1.1 and 4.1.2. For ROR calculations, Profit outputs are required as inputs and are given in Table 8 below. Table 9 shows the average profit after backtesting of all time-lapse. The highest profit per contract is reached by DEMA-RSI-Keltner Channel Setup is 0.76 \$ and the lowest profit per contract is with EMA-TSI-Keltner Channel Setup is 0.11 \$.

Backtesting results show that the highest final budget is EMA-RSI-Keltner Channel indicator setup with 244.983,13 \$ meanwhile lowest one is HMA-TSI-Keltner indicator setup with 10.338,69. Although the gap between the best and worst-performing indicator setups is very high, it is obvious that some of them may be non-viable investment options for individual investors, both in terms of signal accuracy and rate of return. Evaluations on this issue were made in the conclusion section.

**Table 8:** Trading Budget at the end of Period I & Period II

<b>Indicator Setup</b>	<b>Final Budget of Period I (\$)</b>	<b>Final Budget of Period II (\$)</b>
EMA-RSI-Keltner	64.602,13	244.983,13
EMA-STOCHRSI-Keltner	13.081,19	12.453,95
EMA-TSI-Keltner	10.791,03	11.307,45
DEMA-RSI-Keltner	62.879,63	185.305,61
DEMA-STOCHRSI-Keltner	13.227,82	12.792,38
DEMA-TSI-Keltner	10.873,73	10.783,96
TEMA-RSI-Keltner	55.139,23	142.954,44
TEMA-STOCHRSI-Keltner	12.985,19	12.547,16
TEMA-TSI-Keltner	10.813,06	10.743,65
HMA-RSI-Keltner	48.006,81	113.760,01
HMA-STOCHRSI-Keltner	11.920,91	11.477,97
HMA-TSI-Keltner	10.583,27	10.338,69
PSAR-RSI-Keltner	62.658,48	184.214,41
PSAR-STOCHRSI-Keltner	13.225,14	12.792,23
PSAR-TSI-Keltner	10.961,91	10.854,42

**Table 9: Sum of Traded Contracts and Average Profit per Contract for Indicator Setups**

<b>Indicator Setup</b>	<b>Sum of Traded Contracts</b>	<b>Sum of Average Profit per Contract (\$)</b>
EMA-RSI-Keltner	312.716	0.75
EMA-STOCHRSI-Keltner	35.127	0.16
EMA-TSI-Keltner	11.963	0.11
DEMA-RSI-Keltner	301.630	0.76
DEMA-STOCHRSI-Keltner	33.460	0.18
DEMA-TSI-Keltner	9.564	0.17
TEMA-RSI-Keltner	236.415	0.75
TEMA-STOCHRSI-Keltner	22.739	0.24
TEMA-TSI-Keltner	4.060	0.34
HMA-RSI-Keltner	193.436	0.73
HMA-STOCHRSI-Keltner	17.419	0.20
HMA-TSI-Keltner	4.242	0.22
PSAR-RSI-Keltner	301.216	0.75
PSAR-STOCHRSI-Keltner	30.079	0.24
PSAR-TSI-Keltner	8.470	0.34

### 4.1.1 Signal Accuracy Test Results

With Signal Accuracy, the accuracy of the decisions made from the indicator setup is tested. Accuracy is linearly correlated with profitability and is the main reason for profitability. In addition, signal accuracy is the most important factor for the reliability and stability of the setup.

**Table 10:** Win Rates of Trading Setups for Period I, Period II, and Overall

<b>Indicator Setup</b>	<b>Win Rate–Period I (%)</b>	<b>Win Rate – Period II (%)</b>	<b>Win Rate – Overall (%)</b>
EMA-RSI-Keltner	74,87	76,48	75,45
EMA-STOCHRSI-Keltner	52,91	53,92	53,29
EMA-TSI-Keltner	50,59	49,73	53,29
DEMA-RSI-Keltner	74,57	76,42	75,24
DEMA-STOCHRSI-Keltner	53,39	54,73	53,89
DEMA-TSI-Keltner	51,12	51,42	51,24
TEMA-RSI-Keltner	75,53	77,01	76,07
TEMA-STOCHRSI-Keltner	55,25	57,45	56,07
TEMA-TSI-Keltner	54,46	55,51	54,87
HMA-RSI-Keltner	74,95	76,45	75,50
HMA-STOCHRSI-Keltner	52,57	54,78	53,40
HMA-TSI-Keltner	50,13	51,65	50,72
PSAR-RSI-Keltner	74,76	76,55	75,41
PSAR-STOCHRSI-Keltner	53,67	55,51	54,34
PSAR-TSI-Keltner	51,69	53,10	52,22

The primary goal of the study is to consistently pass 50% signal accuracy with the combination of trend & momentum indicators. This goal is critical to proving that the algorithm does not generate signals randomly. All fifteen indicator setups managed to exceed the 50% win-rate scale.

Signal accuracy can be seen as the most important output in the study as it directly affects the profit. With the high signal accuracy, both the profitability increases and the risk of the trader due to the uncertainty decreases. Among the overall trade numbers of the indicator setups examined within the scope of this study, the maximum was 12986 in the TEMA-RSI-Keltner setup and the minimum was 3355 trades in the EMA-TSI-Keltner setup. Equation 30 is used in Win-Rate calculations.

The Signal Accuracy results are grouped into three, due to their momentum indicators. RSI momentum indicator setups produce true signals higher than 75% changes. Stochastic RSI momentum indicator setups fall short with brackets between 56,07% to 53,29% and the TSI momentum indicator setups are just higher than 50% accuracy.

#### **4.1.2 Rate of Return Test Results**

The rate of return test is a percentage evaluation of how much net money the trading algorithm makes with the relevant setup. The formulation has given above at Equation 27. Trading results are compared with the 10.885 \$ limit which is the USD savings account average return rate and also with the Buy & Hold strategy. ROR of USD savings account is 8.85%.

During Period I, the market rich with trend diversities. Period I results shows a great deal of information about trading setup's behavior under mixed market conditions. To generate stable and dependable income under mixed conditions, the trading setup must detect trend changes and trade with caution to avoid major losses.

**Table 11:** Rate of Return of Trading Setups for Period I, Period II, and Overall

<b>Indicator Setup</b>	<b>ROR – Period I (%)</b>	<b>ROR – Period II (%)</b>	<b>ROR – Overall (%)</b>
EMA-RSI-Keltner	+546,02	+379,22	+2349,8
EMA-STOCHRSI-Keltner	+30,81	-4,79	+55,4
EMA-TSI-Keltner	+7,91	+4,79	+13,1
DEMA-RSI-Keltner	+528,80	+294,70	+2281,9
DEMA-STOCHRSI-Keltner	+30,23	-3,29	+60,2
DEMA-TSI-Keltner	+8,73	-0,83	+16,6
TEMA-RSI-Keltner	+451,39	+259,26	+1780,9
TEMA-STOCHRSI-Keltner	+29,85	-3,37	+55,3
TEMA-TSI-Keltner	+8,13	-0,65	+15,6
HMA-RSI-Keltner	+380,01	+236,96	+1417,7
HMA-STOCHRSI-Keltner	+19,21	-3,72	+34,0
HMA-TSI-Keltner	+5,83	-2,31	+9,2
PSAR-RSI-Keltner	+526,58	+294,00	+2268,7
PSAR-STOCHRSI-Keltner	+32,25	-3,28	+60,2
PSAR-TSI-Keltner	+9,61	-0,98	+18,2

Period II is a rare example of a market being straight bullish for nearly two years. This period tests setup's ability to seek out ideal entry and exit spots for trades. Data processing is exact with Period I. After processing, raw data shaped into a meaningful, readable output obtained. Trading account budget change given above at Table 8 for Period I, II. All trading setups start with 10.000 \$. Based on each budget, ROR is calculated and given above in Table 10 for Period I, II, and Overall trading session.

Although the return rates of the indicator setups in the periods vary at different rates due to the different market structures in Period I and Period II, it affects all of them. Since Period I covers 42 months and hosts more diverse trends, it offers more trading opportunities and more in-depth performance data compared to Period II. Therefore, Period I performance is more important than Period II performance.

In terms of ROR assessment, while all indicator setups are positive in Period I, a clustering of three stands out. It is seen that there are momentum indicators as the reason for this clustering. As the most complex and fastest reacting element of the trading algorithm, the performance of the momentum indicator is critical in detecting trade open and trade close points in the volatile market in Period I. This criticality shows the concrete results in the ROR table according to the success of the momentum indicator.

Among the momentum indicators, it is seen that RSI, then Stochastic RSI, and finally TSI were successful, respectively, based on ROR, and played the main role in addition to the effect of the trend indicator. Considering that the breakthrough strategy is frequently used in Period II, it can be said with confidence that only the RSI momentum indicator among the three momentum indicators works in harmony with this strategy. Setups using Stochastic RSI and TSI momentum indicators have negative RORs in Period II, while the RSI has ROR values between 236.96% and 379.22%.

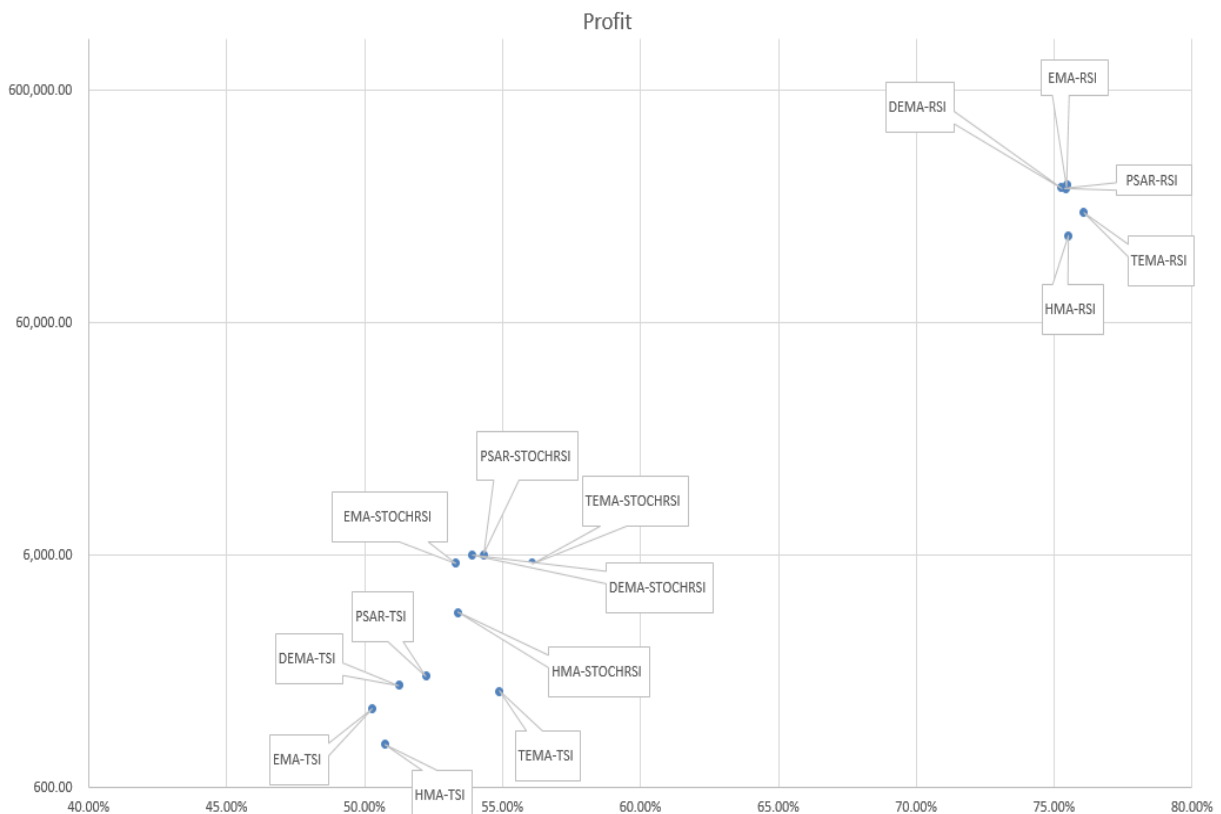


## 4.2 Correlation between Signal Accuracy and Rate of Return

Correlation between Signal Accuracy and ROR can be named linear easily since the ROR is increasing almost identically. Signal Accuracy directly affects ROR. If the Signal is a false one, one cannot expect ROR to increase.

Figure 15 shows that again there are three groups are formed based on momentum indicators. Setups with RSI are far more dependable and generate superior profits meanwhile setups with Stochastic RSI and TSI are close to another group. TEMA-TSI-Keltner Channel Indicator Setup has higher accuracy of signal generation but with less profit than most of the Stochastic RSI momentum setups.

Even though all indicators are regularly generating profit with a different amount in Period I, Period II is where the disintegration occurred. RSI momentum indicator setups have positive ROR's. Even though Signal Accuracy is increasing in Period II, most of the Stochastic RSI and TSI setups lost money.



**Figure 15:** Correlation between Signal Accuracy & Profit in Exponential Scale.

### 4.3 Discussion of Results

Algorithmic trading is a complex and multidisciplinary field that is extremely difficult to fully analyze. For a successful trading algorithm, it is necessary to have deep knowledge about mathematical, algorithmic, economical, market psychology, and news related to the trading market. Within the scope of this study, many of these areas were ignored in order to make the study dimension complete.

The backtesting results, in which five trend indicators, three momentum indicators, and one volatility indicator, tested with 379176 5-minute time bars in sixty-five months, were completed by choosing between two different trading strategies focused on momentum, are shared above. One of the things to consider after mathematical comparisons of results is that trend and momentum indicators should be compared within their classes.

To make a comparison among the trend indicators that will be next to the RSI-Keltner Channel duo, all five trend indicators have very satisfactory signal accuracies, with a difference of only 0.83% between the first one, TEMA, and the last one, DEMA. While four of the five trend indicators examined in the study were working with the classical moving average system, one was chosen as PSAR versus moving averages. Despite being the most classical and noisy trend indicators, EMA became the best performer as overall profit generation when used with RSI. However, when used with EMA Stochastic RSI and TSI, it has the lowest win-rate and average profit generation among the setups using the same momentum indicator.

Another prominent indicator among trend indicators is TEMA. When used with TEMA, RSI, Stochastic RSI, and TSI, it has the highest win rate compared to setups with the same momentum indicators. Despite having the highest win rate, it lags behind its counterparts in profit generation. The reasons for this need to be studied in-depth, but the first thing that comes to mind is that as a result of the rapid reaction of TEMA, the trend indicator frequently changes direction between the long-short positions and causes the positions to be closed much earlier than the ideal closing point.

When a comparison is made between momentum indicators, it can be seen that RSI has the most successful win rate and ROR by far. When comparing all setups, the top group which all RSI momentum indicator setups, also subdivided into two. Best performing set of all in terms of profit are EMA-RSI-Keltner Channel, DEMA-RSI-Keltner Channel and PSAR-RSI-Keltner Channel setups. TEMA-RSI-Keltner Channel setup has the highest win rate of all but lacks in terms of profit per contract.

Since Keltner Channel is used as a volatility indicator in all setups, Keltner Channel can only be compared with its two different strategies. The trading algorithm, which was under the dominance of the complex, frequently changing direction and pullback strategy in Period I, turned to the breakthrough strategy in the long position more frequently due to the steadily increasing global gold market in Period II.

Keeping in mind that the effect of the trend indicator cannot be ignored for the effective use of the Keltner Channel, it can be clearly stated that the most important criterion is the use of RSI among the three momentum indicators included in the study.

It should be kept in mind that more detailed, parametrically optimized, and sensitive scenario-based special tests are needed to choose the most ideal among the fifteen indicator setups. Despite this, it can be said that EMA-RSI-Keltner Channel, DEMA-RSI-Keltner Channel, and PSAR-RSI-Keltner Channel setups are one step ahead against the rest of the fifteen setups.

#### **4.4 Conclusion**

In this section, answering the four objectives of the study, three research questions, and six hypothesis questions stated at the beginning of the thesis work is included.

An algorithm suitable for the day trading strategy, which is the first of the four focuses of the study, is designed and clearly explained in Chapter III. The identification, examination, and explanation of technical indicators that will be suitable for use in the relevant algorithm have been completed. Selected technical indicators are included in Chapter II. Data, Ideal Data Financial Technologies Inc. It is provided as a .txt file taken from candlestick charts in 5 minutes high, low, open, close format and is real data. On this data, backtesting was performed with software that was originally written in Python 3.5 software language and benefited from online libraries, and the results were obtained.

The results obtained at the end of the backtesting, which was completed on real historical data by sticking to the determined trading algorithm, were compared in Chapter IV with a focus on ROR and Signal Accuracy, and the setup performances were evaluated.

The first research question is whether a small trader with \$10,000 can profit by scalping day trading strategy in the XAU/USD market. The answer to this question is positive, with a steady profit in all setups. Among the fifteen trading setups, the setups that show the best signal accuracy and ROR are the EMA-RSI-Keltner Channel, DEMA-RSI-Keltner Channel, and PSAR-RSI-Keltner Channel setups in the study algorithm.

It has been seen that the potential return potential in the study results is extremely high especially in the setups using RSI, and Signal Accuracy is over 75% in RSI setups. According to the results of the study, it is thought that algorithmic trading can be a reliable passive income method with a detailed trading algorithm design in a way that the decisions to be made for possible conditions are determined without leaving any gaps and a good technical indicator combination is preferred.

The study hypotheses consist of three questions that are expected to be answered positively or negatively. The first set of the hypothesis questions is “Scalping day trading is non-profitable with a low budget and has a high risk of whipsaw trades in the trending market or not?” The answer to this question is that stable returns are possible and the  $H_{02}$  hypothesis is true due to positive ROR’s of indicator setups during Period II of the study. Since  $H_{01}$  is the opposite of the  $H_{02}$  hypothesis, it is false.

Even though the  $H_{02}$  hypothesis is true, one should be aware of the nature of trading is always risky and the trader can lose money under any circumstances. Breakthrough strategy is vital and effective under such a market.

In the second set of hypothesis questions, “Scalping day trading is non-profitable with a low budget and has a high risk of whipsaw trades in a sideways market or not” is questioned. According to the results of the study, algorithmic trading in a sideways trend can give even better results than the Trending market, and it has positive ROR in all indicator setups. For this reason, it is revealed that the  $H_{12}$  hypothesis is true. Due to that,  $H_{11}$  is false.

A sideways market is where the pullback strategy of the trading algorithm is used heavily as the main strategy. It is crucial to detect support and resistances at sideways markets and trade between them without increasing the risk.

In the last set of hypothesis questions, "Scalping day trading is a reliable investment option that can be dependable under different market trends or not" is questioned. In Period I and Period II, almost every condition that can be experienced in a market have been tested. Therefore, it is concluded that algorithmic trading can be a reliable investment option with the correct indicator setup and parameter adjustments. Therefore,  $H_{21}$  is true and  $H_{22}$  is false.

While it is not possible to eliminate the risks in trading, there are ways to minimize them. This involves using well-complemented tools to evaluate market data while writing algorithms to cover as many conditions as possible. In this study, major paths that the market can lead into have been covered on an algorithm to prevent such losses.

In this study, indicator parameters were selected at the beginning based on a common approach among traders with 25 periods on slow and 10 periods on fast indicators. Keltner Channel's ATR values are set to 1.5. Future studies are required to improve setup performances and find optimal values to operate.

Backtesting results are promising especially with RSI Momentum indicator setups. Very satisfying Signal Accuracy obtained that is higher than 75% win rate on a total number of trades with 0.73 \$ profit per contract at all setup combinations that RSI is included. The gap between EMA-RSI-Keltner Channel, DEMA-RSI-Keltner Channel, and PSAR-RSI-Keltner Channel Setups are very little and hard to observe under backtesting runs, it is unclear to define superior one. In terms of raw profit, EMA-RSI-Keltner Channel is the winner but EMA falls short against DEMA and PSAR when it is combined with other momentum indicators. Due to that, EMA-RSI-Keltner Channel needed to be examined under more specific scenarios to confirm that the result is not a coincidence.

Although the backtesting performance is promising, algorithmic trading performance in live trading is predicted to be significantly lower for the respective setups. In live trading, it is not possible to open and close positions at the desired price by entering an instant order first, and to perform perfectly every time. With the increase in the number of contracts, the costs will not increase from the fixed price, but the deviations will increase gradually due to the contracts opened and/or closed one after the other. As the number of contracts increases, it is highly possible that the market itself will be affected and that it will affect the market on the basis of instant price, which is not experienced in backtesting but inevitable in live trading.

Also, trading bots suffers from a weakness albeit illegal, it is possible for the bot to be damaged by other investors by generating false signals by designing opposing algorithms. For this reason, hiding the trading bot's pattern can also become an important factor to improve safety and sustainability.

It is mathematically possible to reach a serious budget increase in the long term by excluding the human factor, ensuring discipline, and targeting a stable sufficient profit margin, and it is mathematically possible and observed at the end of the study. Reducing portfolio risk by profit-taking a certain percentage of the profit obtained as a result of trading is also a part of professional trading. Within the scope of this study, profit-taking has been ignored and it is not realistic in this regard. It is both unrealistic and bad for portfolio risk management for an investor starting at \$10,000 to never use or need the money accumulated in this account for 5 years. The trader is generally expected to shift his profits towards less risky investment options.

Another factor that will affect the results in the Study is that the commissions of the trading agent are not included in the calculation. Considering that commissions are taken per trade, varying from broker to broker and that these commission rates are indexed to the contract unit price, it should not be ignored that in some setups, even at the end of a profitable sale, there may be a net loss. In these calculations, users are required to charge a cost equal to the product of the price of the transaction and the number of contracts, according to the commission rates of their brokers. Since the commission rates of each intermediary are different, the commission rates have been ignored.

In order to obtain the perfect trading bot, it is necessary to construct a technical indicator combination that can give much more sensitive and more immediate responses in a chaotic trading environment, but which is stable enough not to be affected by market noise and tested in live trading for a long time.

XAU/USD is a huge market influenced by global news and shaped by economic, political, social, and technological news. Evaluation of the relevant news is essential for a trading bot that can take quick, accurate, and correct decisions on all these issues affecting this market. In order to evaluate the news, there is a need for state-of-the-art software on machine learning and artificial intelligence. Although it is not possible to deal with these issues in terms of budget, time, and difficulty within the scope of the thesis, it is thought that these issues should not be ignored in order to make progress in the relevant field.

The main idea of the thesis study is that the combination of the RSI-Keltner Channel is suitable for scalping day trading when combined with pullback and breakthrough strategies. Although the trend indicator is indispensable for the algorithm, they can produce results that are close to each other. For this reason, it requires further study to determine which of the trend indicators is ideal for this trading approach.

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## ATTACHMENT 1: Backtesting Result Tables

**Table 12:** Number of Trades and Percentages of EMA–RSI–Keltner Channel Setup

Period	Number of Loss Trades	Percentage of Loss Trades (%)	Number of Win Trades	Percentage of Win Trades (%)	Number of Zero Trades	Percentage of Zero Trades (%)
<b>I</b>	2310	24,91	6944	74,87	21	0,23
<b>II</b>	1221	23,36	3997	76,48	8	0,15

**Table 13:** Period I Win & Lose Values of EMA–RSI–Keltner Channel Setup

PERIOD I	Average Profit Value (\$)	Maximum Loss Value (\$)	Maximum Win Value (\$)
<b>Long Loss</b>	-4,14	-105,00	0
<b>Long Profit</b>	9,23	0	174,92
<b>Short Loss</b>	-4,25	-88,40	0
<b>Short Profit</b>	9,28	0	108,94

**Table 14:** Period II Win & Lose Values of EMA–RSI–Keltner Channel Setup

PERIOD II	Average Profit Value (\$)	Maximum Loss Value (\$)	Maximum Win Value (\$)
<b>Long Loss</b>	-21,44	-405,72	0
<b>Long Profit</b>	47,86	0	943,32
<b>Short Loss</b>	-25,53	-287,07	0
<b>Short Profit</b>	57,88	0	1176,41

**Table 15:** Trading Capital Budget Change of EMA–RSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	64.602,13	+546,02
<b>II</b>	64.602,13	244.983,13	+379,22

**Table 16:** Number of Trades and Percentages of EMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	2472	46,83	2793	52,91	14	0,17
<b>II</b>	1458	45,95	1711	53,92	4	0,05

**Table 17:** Period I Win & Lose Values of EMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,22	-43,64	0
<b>Long Profit</b>	3,05	0	66,16
<b>Short Loss</b>	-2,12	-21,83	0
<b>Short Profit</b>	3,01	0	32,37

**Table 18:** Period II Win & Lose Values of EMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,42	-84,72	0
<b>Long Profit</b>	4,06	0	58,89
<b>Short Loss</b>	-3,95	-41,07	0
<b>Short Profit</b>	5,42	0	84,04

**Table 19:** Trading Capital Budget Change of EMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	13.081,19	+30,81
<b>II</b>	13.081,19	12.453,95	-4,79

**Table 20:** Number of Trades and Percentages of EMA–TSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	1004	49,22	1032	50,59	4	0,20
<b>II</b>	660	50,19	654	49,73	1	0,08



**Table 21:** Period I Win & Lose Values of EMA–TSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,33	-32,73	0
<b>Long Profit</b>	2,96	0	49,62
<b>Short Loss</b>	-2,30	-16,37	0
<b>Short Profit</b>	3,08	0	20,65

**Table 22:** Period II Win & Lose Values of EMA–TSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,01	-38,53	0
<b>Long Profit</b>	3,64	0	51,06
<b>Short Loss</b>	-3,48	-24,97	0
<b>Short Profit</b>	4,71	0	63,03

**Table 23:** Trading Capital Budget Change of EMA–TSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	10.791,03	+7,91
<b>II</b>	10.791,03	11.307,45	+4,79

**Table 24:** Number of Trades and Percentages of DEMA–RSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	2304	25,22	6811	74,57	19	0,21
<b>II</b>	1210	23,42	3948	76,42	8	0,15

**Table 25:** Period I Win & Lose Values of DEMA–RSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-4,10	-105,00	0
<b>Long Profit</b>	9,18	0	174,70
<b>Short Loss</b>	-4,21	-88,40	0
<b>Short Profit</b>	9,16	0	108,94

**Table 26:** Period II Win & Lose Values of DEMA–RSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-20,60	-396,90	0
<b>Long Profit</b>	46,89	0	917,12
<b>Short Loss</b>	-25,42	-277,96	0
<b>Short Profit</b>	57,12	0	1143,60

**Table 27:** Trading Capital Budget Change of DEMA–RSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	62.879,63	+528,80
<b>II</b>	62.879,63	185.305,61	+294,70

**Table 28:** Number of Trades and Percentages DEMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	2323	46,35	2676	53,39	13	0,26
<b>II</b>	1332	45,17	1614	54,73	3	0,10

**Table 29:** Period I Win & Lose Values of DEMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,21	-43,64	0
<b>Long Profit</b>	3,10	0	66,16
<b>Short Loss</b>	-2,08	-15,79	0
<b>Short Profit</b>	3,04	0	32,37

**Table 30:** Period II Win & Lose Values of DEMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,36	-84,72	0
<b>Long Profit</b>	4,12	0	62,00
<b>Short Loss</b>	-3,86	51,33	0
<b>Short Profit</b>	5,71	0	84,04

**Table 31:** Trading Capital Budget Change of DEMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	13.227,82	+30,23
<b>II</b>	13.227,82	12.792,38	-3,29

**Table 32:** Number of Trades and Percentages DEMA–TSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	802	48,69	842	51,12	3	0,18
<b>II</b>	476	48,37	506	51,42	2	0,20

**Table 33: Period I Win & Lose Values of DEMA–TSI–Keltner Channel Setup**

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,36	-32,73	0
<b>Long Profit</b>	3,22	0	49,62
<b>Short Loss</b>	-2,30	-13,19	0
<b>Short Profit</b>	3,30	0	20,65

**Table 34: Period II Win & Lose Values of DEMA–TSI–Keltner Channel Setup**

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,69	-21,10	0
<b>Long Profit</b>	3,76	0	51,06
<b>Short Loss</b>	-3,34	30,85	0
<b>Short Profit</b>	5,33	0	63,03

**Table 35: Trading Capital Budget Change of DEMA–TSI–Keltner Channel Setup**

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	10.873,73	+8,73
<b>II</b>	10.873,73	10.783,96	-0,83

**Table 36:** Number of Trades and Percentages TEMA–RSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	2004	24,29	6231	75,53	15	0,18
<b>II</b>	1082	22,85	3647	77,01	7	0,15

**Table 37:** Period I Win & Lose Values of TEMA–RSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,79	-96,92	0
<b>Long Profit</b>	8,50	0	174,70
<b>Short Loss</b>	-3,88	-76,87	0
<b>Short Profit</b>	8,45	0	100,56

**Table 38:** Period II Win & Lose Values of TEMA–RSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-18,16	-326,34	0
<b>Long Profit</b>	38,94	0	759,90
<b>Short Loss</b>	-21,33	-216,51	0
<b>Short Profit</b>	46,52	0	940,29

**Table 39:** Trading Capital Budget Change of TEMA–RSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	55.139,23	+451,39
<b>II</b>	55.139,23	142.954,44	+259,26

**Table 40:** Number of Trades and Percentages TEMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	1532	44,52	1901	55,25	8	0,23
<b>II</b>	863	42,45	1168	57,45	2	0,10

**Table 41:** Period I Win & Lose Values of TEMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,15	-29,15	0
<b>Long Profit</b>	3,29	0	66,16
<b>Short Loss</b>	-2,05	-14,16	0
<b>Short Profit</b>	3,23	0	32,37

**Table 42:** Period II Win & Lose Values of TEMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-1,01	-84,72	0
<b>Long Profit</b>	4,15	0	58,89
<b>Short Loss</b>	-3,64	-41,07	0
<b>Short Profit</b>	6,00	0	84,04

**Table 43:** Trading Capital Budget Change of TEMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	12.985,19	+29,85
<b>II</b>	12.985,19	12.547,16	-3,37

**Table 44:** Number of Trades and Percentages TEMA–TSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	784	45,54	427	54,46	0	0
<b>II</b>	222	44,49	277	55,51	0	0



**Table 45:** Period I Win & Lose Values of TEMA–TSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,49	-21,86	0
<b>Long Profit</b>	3,93	0	49,62
<b>Short Loss</b>	-2,38	-11,92	0
<b>Short Profit</b>	3,63	0	20,65

**Table 46:** Period II Win & Lose Values of TEMA–TSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,81	-21,10	0
<b>Long Profit</b>	4,74	0	51,06
<b>Short Loss</b>	-3,46	-30,85	0
<b>Short Profit</b>	6,56	0	63,03

**Table 47:** Trading Capital Budget Change of TEMA–TSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	10.813,06	+8,13
<b>II</b>	10.813,06	10.743,65	-0,65

**Table 48:** Number of Trades and Percentages HMA–RSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	1936	24,87	5834	74,95	14	0,18
<b>II</b>	1050	23,35	3438	76,45	9	0,20

**Table 49:** Period I Win & Lose Values of HMA–RSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,45	-88,84	0
<b>Long Profit</b>	7,65	0	136,22
<b>Short Loss</b>	-3,64	-69,18	0
<b>Short Profit</b>	7,73	0	92,18

**Table 50:** Period II Win & Lose Values of HMA–RSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-15,47	-264,60	0
<b>Long Profit</b>	32,64	0	655,08
<b>Short Loss</b>	-17,92	218,61	0
<b>Short Profit</b>	38,56	0	787,81

**Table 51:** Trading Capital Budget Change of HMA–RSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	48.006,81	+380,01
<b>II</b>	48.006,81	113.760,01	+236,96

**Table 52:** Number of Trades and Percentages HMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	1332	47,28	1481	52,57	4	0,14
<b>II</b>	755	45,10	917	54,78	2	0,12

**Table 53:** Period I Win & Lose Values of HMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,14	-29,15	0
<b>Long Profit</b>	3,25	0	66,16
<b>Short Loss</b>	-2,13	-14,16	0
<b>Short Profit</b>	3,18	0	32,37

**Table 54:** Period II Win & Lose Values of HMA–STOCHRSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,30	-84,72	0
<b>Long Profit</b>	3,98	0	58,89
<b>Short Loss</b>	-1,07	23,69	0
<b>Short Profit</b>	5,27	0	84,04

**Table 55:** Trading Capital Budget Change of HMA–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	11.920,91	+19,21
<b>II</b>	11.920,91	11.477,97	-3,72

**Table 56:** Number of Trades and Percentages HMA–TSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	380	49,74	383	50,13	1	0,13
<b>II</b>	233	48,14	250	51,65	1	0,21

**Table 57:** Period I Win & Lose Values of HMA–TSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,50	-21,86	0
<b>Long Profit</b>	3,46	0	49,62
<b>Short Loss</b>	-2,44	13,19	0
<b>Short Profit</b>	3,20	0	20,65

**Table 58:** Period II Win & Lose Values of HMA–TSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,78	-21,10	0
<b>Long Profit</b>	4,73	0	51,06
<b>Short Loss</b>	3,66	17,77	0
<b>Short Profit</b>	6,22	0	63,03

**Table 59:** Trading Capital Budget Change of HMA–TSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	10.583,27	+5,83
<b>II</b>	10.583,27	10.338,69	-2,31

**Table 60:** Number of Trades and Percentages PSAR–RSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	2281	25,02	6816	74,76	20	0,22
<b>II</b>	1206	23,30	3962	76,55	8	0,15

**Table 61:** Period I Win & Lose Values of PSAR–RSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-4,07	-105,00	0
<b>Long Profit</b>	9,12	0	174,70
<b>Short Loss</b>	-4,22	-88,40	0
<b>Short Profit</b>	9,10	0	108,94

**Table 62:** Period II Win & Lose Values of PSAR–RSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-20,34	-388,08	0
<b>Long Profit</b>	46,90	0	917,12
<b>Short Loss</b>	-25,79	-276,77	0
<b>Short Profit</b>	56,13	0	1143,60

**Table 63:** Trading Capital Budget Change of PSAR–RSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	62.658,48	+526,58
<b>II</b>	62.658,48	184.214,41	+294,00

**Table 64:** Number of Trades and Percentages PSAR–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	2091	46,09	2435	53,67	11	0,24
<b>II</b>	1160	44,38	1451	55,51	3	0,11

**Table 65:** Period I Win & Lose Values of PSAR–STOCHRSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,08	-29,15	0
<b>Long Profit</b>	3,11	0	66,16
<b>Short Loss</b>	-2,08	-15,79	0
<b>Short Profit</b>	3,11	0	32,37

**Table 66:** Period II Win & Lose Values of PSAR–STOCHRSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,17	-84,72	0
<b>Long Profit</b>	4,14	0	62,00
<b>Short Loss</b>	-3,91	-51,33	0
<b>Short Profit</b>	5,74	0	84,04

**Table 67:** Trading Capital Budget Change of PSAR–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	13.225,14	+32,25
<b>II</b>	13.225,14	12.792,23	-3,28

**Table 68:** Number of Trades and Percentages PSAR–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	2091	46,09	2435	53,67	11	0,24
<b>II</b>	1160	44,38	1451	55,51	3	0,11



**Table 69:** Period I Win & Lose Values of PSAR–STOCHRSI–Keltner Channel Setup

<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,08	-29,15	0
<b>Long Profit</b>	3,11	0	66,16
<b>Short Loss</b>	-2,08	-15,79	0
<b>Short Profit</b>	3,11	0	32,37

**Table 70:** Period II Win & Lose Values of PSAR–STOCHRSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-3,17	-84,72	0
<b>Long Profit</b>	4,14	0	62,00
<b>Short Loss</b>	-3,91	-51,33	0
<b>Short Profit</b>	5,74	0	84,04

**Table 71:** Trading Capital Budget Change of PSAR–STOCHRSI–Keltner Channel Setup

<b>Period</b>	<b>Starting Trading Capital (\$)</b>	<b>Trading Capital End of Period I (\$)</b>	<b>Change Percentage (%)</b>
<b>I</b>	10.000	13.225,14	+32,25
<b>II</b>	13.225,14	12.792,23	-3,38

**Table 72:** Number of Trades and Percentages PSAR–TSI–Keltner Channel Setup

<b>Period</b>	<b>Number of Loss Trades</b>	<b>Percentage of Loss Trades (%)</b>	<b>Number of Win Trades</b>	<b>Percentage of Win Trades (%)</b>	<b>Number of Zero Trades</b>	<b>Percentage of Zero Trades (%)</b>
<b>I</b>	697	48,10	749	51,69	3	0,21
<b>II</b>	408	46,90	462	53,10	0	0

**Table 73:** Period I Win & Lose Values of PSAR–TSI–Keltner Channel Setup

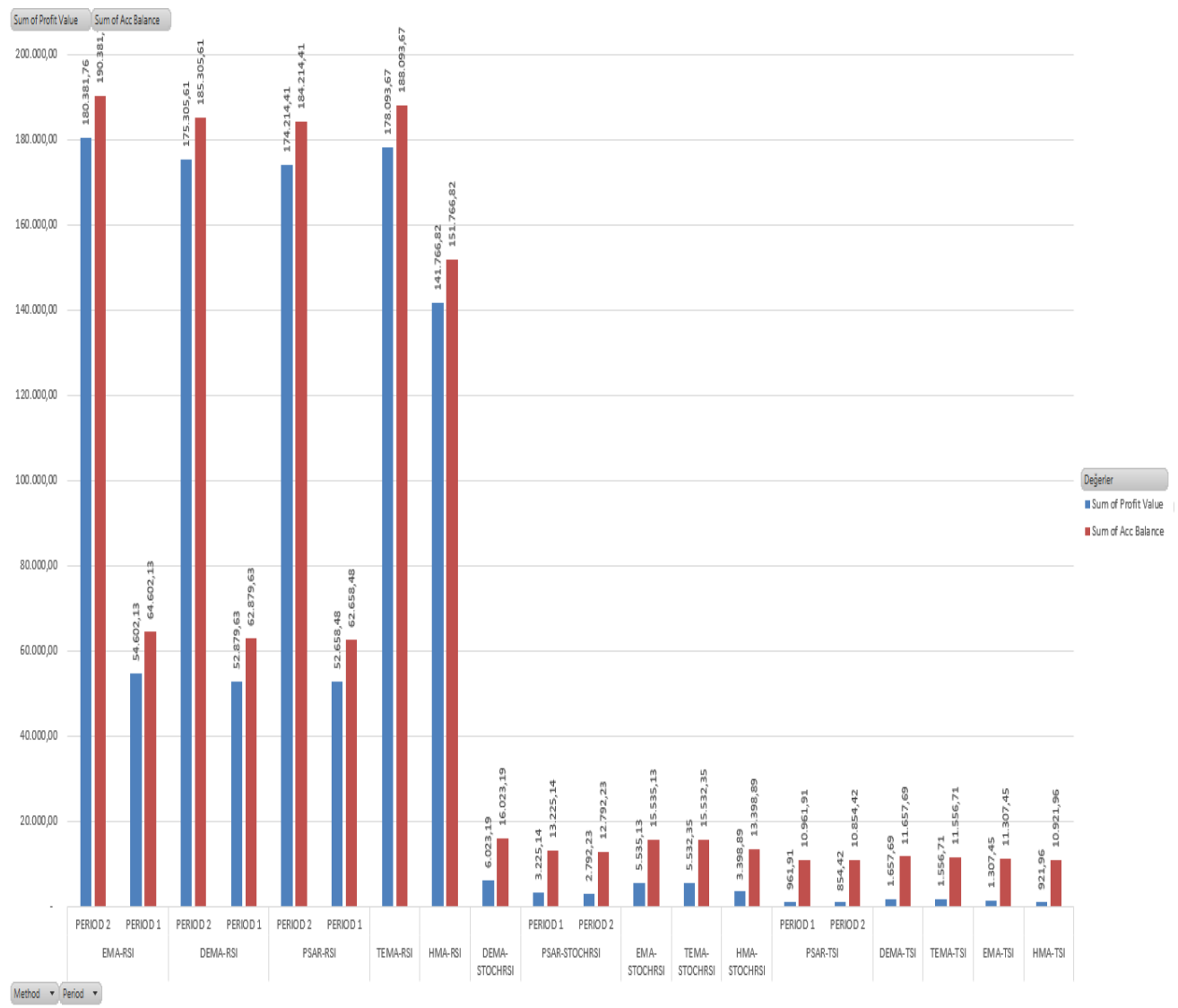
<b>PERIOD I</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,18	-21,86	0
<b>Long Profit</b>	3,24	0	49,62
<b>Short Loss</b>	-2,24	-13,19	0
<b>Short Profit</b>	3,44	0	22,23

**Table 74:** Period II Win & Lose Values of PSAR–TSI–Keltner Channel Setup

<b>PERIOD II</b>	<b>Average Profit Value (\$)</b>	<b>Maximum Loss Value (\$)</b>	<b>Maximum Win Value (\$)</b>
<b>Long Loss</b>	-2,56	-21,10	0
<b>Long Profit</b>	3,61	0	51,06
<b>Short Loss</b>	-3,33	-20,52	0
<b>Short Profit</b>	5,84	0	63,03

**Table 75:** Trading Capital Budget Change of PSAR–TSI–Keltner Channel Setup

Period	Starting Trading Capital (\$)	Trading Capital End of Period I (\$)	Change Percentage (%)
I	10.000	10.961,91	+9,61
II	10.961,91	10.854,42	-0,98



**Figure 16:** Profit Values of Indicator Setups for Period I & Period II