APPLICATION OF TECHNICAL ANALYSIS IN THE FOREX MARKET: COMPARISON OF TECHNICAL TRADING RULES IN DEVELOPED AND EMERGING MARKETS

Lelei Elaine Cherop
101373

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DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the Research Project contains no material previously published or written by another person except where due reference is made in the Research Project itself.

LELEI ELAINE CHEROP ..... [*Name of Candidate*]

..... [*Signature*]

10/02/2021 ..... [*Date*]

This Research Project has been submitted for examination with my approval as the Supervisor.

GILLIAN KIMUNDI ..... [*Name of Supervisor*]

..... [*Signature*]

10th Feb 2021 ..... [*Date*]

Strathmore Institute of Mathematical Sciences

Strathmore University

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ABSTRACT

This paper examines the application of technical analysis in the forex market. It particularly looks at the comparison of technical trading rules in developed and emerging markets. In order to assess the performance, three momentum-based indicators are chosen, namely Moving Average Convergence Divergence, Relative Strength Index and Moving Average Crossover, while one volume indicator is chosen, namely Money Flow Index. To gauge the performance of the indicators, the parameters of each of the indicators is subjected to seven currency pairs which were, EUR/USD, GBP/USD, USD/JPY and USD/CNY for developed markets and USD/ZAR, USD/MXN and USD/TRY for emerging markets. The daily closing prices of each of the currency pairs are used, and based on the parameters of the individual indicator, a buy or sell signal is conveyed by the indicator, and the profit or loss, of each of the signals is measured and summed up so that comparison of performance is possible. Daily closing prices from 2005-2020 are used. The findings suggest emerging markets are more profitable than the developed markets.

INTRODUCTION

A central question within the financial market is how participants determine the direction of future prices. These market participants are categorized into two distinct classes: fundamentalists and chartists. Although the methods used in both classes are not mutually exclusive, they are often not used simultaneously due to their different approaches. Fundamentalists study the economy as well as other relevant variables such as prices to obtain the intrinsic value of a given security. Chartists, on the other hand, solely rely on the behavior of historical prices to determine future price movement. They use technical analysis to search for well-known patterns which will determine their trade decision. According to Pring (2002) , he describes technical analysis as an art, whereby trend reversals are identified early, allowing one to ride on it till evidence of a reversal is proven.

The quotation above expresses the idea that the methods used by technical analysts take advantage of the market psychology. Textbooks such as Pring (2002), outline the behavior of technical analysts. Technical analysis follows three principles. The first principle is that price discounts everything else in the market, hence there is no requirement for researching price fundamentals.

The second principle states that price trends are predictable and observable. A major slogan within the technical analysts is 'The trend is your friend'. This implies that traders can make profit when they buy in an uptrend and sell in a downtrend. The third principle is that history is inclined to repeat itself, showing repeating patterns within the chart.

Within the field of technical analysis, there are two main practices: charting and mechanical analysis. Charting involves graphing historical prices to predict future trend Neely (2011). Chartists look for patterns like head-and-shoulders or support and resistance levels to guide them in making profitable trades. On the other hand, mechanical analysis involves developing trading systems to generate buy and sell signals. When these systems are automated, they trade on behalf of the practitioner, to eliminate human emotion while trading.

Technical analysts use these principles to govern their trading decisions. However, there are some practitioners who are against using technical analysis and favor general theories, for instance, the Efficient Market Hypothesis (EMH), specifically the weak-form, which implies that prices move in a random walk and all accessible information is accommodated in the current prices Fama, (1970). They believe it is not possible to earn excess risk- adjusted profits using technical trading rules (TTRs), which implies that asset returns cannot be predicted based on available information.

(Lo, 2004) proposed the AMH to capture the anomalies in the EMH. It modifies the latter's view on the behavior of prices. The adaptive market hypothesis contains three tenets regarding the financial market. The first one is that opportunities will normally prevail in financial markets. Analysts are then able to exploit these opportunities to become profitable. The second one is that the learning and competition forces will slowly dissolve profit opportunities. This implies that the simple trading rules would diminish providing profits due to increased use by market participants. The third one is that more composite strategies last longer than those that are simple, in line with Olson's conclusion stated above.

(Olson, 2004) optimizes MA rule portfolios from 1971-2000 and examines them in successive 5-year periods that are out of sample. Results show a decline in the returns towards the 1990s. He then concludes, without explicitly mentioning the adaptive market hypothesis (AMH), that to be profitable in the currency market, more complicated trading rules are required.

In the forex market, fundamentalists rely on the study and analysis of a given country's economic data such as GDP, employment and interest rate decision and assume the corresponding changes in the respective currency prices. This limits its ability in forecasting future prices since it involves macroeconomic analysis and event announcements. Thus, the use of technical analysis is greater than that of fundamental analysis.

To avoid subjectivity involved in interpreting charts, analysts choose to create mechanical rules to trade on their behalf. However, several papers scrutinize the stability of technical analysis. Previous studies were performed in the securities market and the analysts speculate that data snooping may have been behind previous profits. Data snooping is a problem that will arise when a researcher decides to test rules, consciously or subconsciously on part of or the entire previously tested dataset. This problem is dealt with by suggesting an automated rule selection procedure and minimized trader contribution.

This would in turn select rules that perform favorably throughout some in-sample period, then assess their performances out of sample. Another problem arising from the testing procedures was data mining, which implied that the profitability of TTRs would begin to diminish once tested out of their original sample.

Data mining is the likelihood for researchers to test numerous rules and base the final inference on the most profitable ones, meaning the unsuccessful results are disregarded while the favorable ones are assumed to imply that the trading rule strategies are profitable. (White, 2000) releases a reality check which lets one adjust the significant levels as a function of the number of possible rules observed.

In this paper, the aim is to review technical trading rules. In particular, the comparison between simple rules between the developed and emerging markets over time.

PROBLEM STATEMENT

Previous studies related to technical analysis use stock market data to test the profitability of TTRs. Those that use forex market data seek to compare the most profitable indicator by comparing two or more indicators or compare technical and fundamental (buy and hold) strategy. Some researchers conclude that the forex market is adaptive rather than efficient. This is after testing simple TTRs and observe declining profits over time. However, these research papers concentrate on developed markets. This creates a gap regarding the evidence of profitability of technical analysis in emerging markets and this paper seeks to close that gap. Consequently, the intention of this research is to compare the profitability of technical analysis in developed vs emerging markets. It will compare USD/CNY (the Dollar against the Chinese Yuan), EUR/USD (the Euro against the Dollar), USD/JPY (the Dollar against the Yen) and GBP/USD (the Pound against the Dollar) to USD/MXN (the Dollar against the Mexican Peso), USD/TRY (the Dollar against the Turkish Lira) and USD/ZAR (the Dollar against the South African Rand). In this paper, a broader look into technical indicators is taken. The indicators are classified into 3 main groups namely: momentum, oscillators, and volume indicators. The paper will look at volume and momentum indicators, take a simple trading rule from each group and compare it across the indicated currency pairs.

Research questions

1. Which technical analysis indicators (momentum and volume) are more profitable in developed and emerging currency markets?

2. Are combined trading rules more stable and profitable than individual trading rules over time? If so, how?

Research objectives

1. To compare which technical analysis indicators (momentum vs volume) are more profitable in developed and emerging currency markets.

2. To investigate whether combined trading rules are more stable and profitable than individual trading rules over time.

The MA crossover, the Moving Average Convergence Divergence (MACD) and the Relative Strength Index (RSI) will be used as the momentum indicators whereas the Money Flow Index and will be used as the volume indicator.

For developed markets, this study will look at USD/CNY USD/JPY, EUR/USD and GBP/USD and for emerging markets, USD/MXN, USD/TRY, USD/ZAR will be considered.

The beneficiaries of this paper are technical analysts in the financial market, or traders, who will gain an insight of technical trading rules and their profitability in the forex market.

LITERATURE REVIEW

Theoretical Review

The Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) is credited to Paul A. Samuelson and Eugene F. Fama. Fama (1970) described an efficient market as one with a number of reasoned investors who are determined to forecast future market prices, and information is readily available to every market participant. The participants' competitiveness leads to a situation where actual prices of the individual securities accommodate the information available based on historical events and present events which the market anticipates to take place. Put differently, in an efficient market, the actual prices of a security are a good approximation of its underlying value.

Fama highlighted three levels of market efficiency: A market is strong-form efficient if all information, both public and private, historical and present, accurately reflects in the value of a share. In this market, traders will not be able to exploit private information such as unreleased news of a company to gain abnormal returns in the market. For example, if the market value is lower than the intrinsic value based on pre released news, the ones holding the private information will take advantage of the pricing anomaly by selling the shares, making the price drop till it is at equilibrium with the private information, after which they will exit the market since there would be no more incentives to trade.

A market is semi-strong efficient if all relevant public information, both past and present, is fully contained in the market prices. Examples of public information are financial statements and announcements. In this market, the participants cannot profit by exploiting new public information. A market is weak-form efficient if the market prices only contain historical information. This implies that market participants will not be able to gain abnormal profits by looking at price charts. Moreover, observing historical patterns will not give patterns which can be exploited. In other words, the present prices are independent from previous prices and patterns. This supports the 'Random walk theory'.

Technical analysis is centered on the study of historical price patterns to make profits. In this market, it would therefore be impossible to gain consistent profits since present and past prices are not correlated.

History of technical analysis

Charles Dow formulated Dow's theory which would then be the foundation of technical analysis. Dow's theory, which was written between 1900-1902 is the first one to explain the trends of the stock market. Over the years, the market has undergone a lot of changes, but the basic tenets remain relevant.

The first tenet is the market discounts all news. Any accessible information in the market is already contained in the prices. This implies that this theory operates on the EMH.

Secondly, the market has three trends. Primary trend, which is the major trend indicating the long-term direction, either bull or bear. These trends last for a number of years. The secondary trend is considered corrections of the major trend, for instance, a pullback in an uptrend or a rally within a downtrend. These trends can last either a few weeks or a few months. Lastly, the minor trend indicates the daily fluctuations of the market. These trends go against the secondary trend. They last less than three weeks and are considered noise.

The third one is that primary trends have three phases. The first phase is the onset of a primary trend in either of the markets (bull or bear). In a bull market, the phase is known as the accumulation phase, where participants get in the market to buy securities. In a bear market, traders will sell, and the phase will be known as distribution phase. The public participation phase, which is the second phase, is in both markets, whereby more participants enter the market, resulting in a significant change in the prices i.e., higher prices in the bull market and lower prices in the bear market. The excess phase in the bull market (panic phase in the bear market) is the third phase. In this phase, there are excess participants in the market either buying or selling, which could result in great speculation. It is ideal for investors to exit at this phase.

The fourth tenet is that indices confirm each other. This suggests that the movement of indices should match to signal a new trend. The fifth tenet is that trends are confirmed by volume. The trend in the market needs to be backed by trading volumes. The relationship between volume and price is direct in an upward trend and inverse in a downward trend. Lastly, trends linger until a reversal is confirmed. Since a primary trend reversal may be misinterpreted as a secondary trend, caution should be taken to ensure reversals are confirmed before placing a trade.

Early technical analysis primarily involved charting since computers could not perform statistical analysis yet. They presented a new perspective on the market as a tide with highs and lows on a chart regardless of the particulars of a company. John Magee and Robert wrote *Technical Analysis of Stock Trends* which is considered the 'Bible of technical analysis'. Magee would chart stock data to identify patterns and shapes such as triangles and head-and-shoulders. These patterns would be used to signal price direction. For example, an ascending triangle pattern is a bullish pattern with a defined area of resistance. Breakout from this area would signal a move higher. (Magee & Edwards, 2007)

William Hamilton applied the Dow theory by making forecasts. He applied new rules in the theory such as combining the railroad average and the industrial average. The averages had to be moving in the same direction for a trend to be confirmed and a prediction to be made. (Hamilton, 1922)

Robert Rhea transformed the Dow theory into practice in the financial market. He related volume to price movement while trading and relied on chart patterns such as double tops and double bottoms. (Rhea, 1932)

Edson Gould was a practicing market analyst between early 1920s and late 1970s. He studied Dow theory and developed speed resistant lines. These lines were different from traditional trend lines which are based on troughs and peaks. Instead, the first line, which may cut through prices, extended from low to high in an uptrend and high to low in a downtrend. The second line would be from the highest to the 2/3 point and the third line would be from the highest to the 1/3 point in a downtrend. they were used to estimate support or resistance levels as well as define a trend.

Empirical review

This section examines previous research on technical analysis and market efficiency in the stock and FX markets.

(Lucak, Brorsen, & Irwin, 1988) were one of the first authors of modern study of technical analysis. they used parameter optimization. Twelve popular commodities, metals, and financials were picked. They Examined 12 technical trading systems which activate buy and sell signals regardless of market news. They only considered trend following systems due to their strong base on economic theory. Their results concluded that four technical trading rules, counting the dual moving average crossover and the price channel, give statistically significant returns of 1.89%-2.78% throughout 1978-1984 that do not seem to be risk adjusted. The four trading systems were those that traders were expected to use. The other two are directional parabolic and MII Price channel. These results challenge the efficient market hypothesis and question our comprehension of price movement in speculative markets.

(Brock, Lakonishok, & LeBaron, 1992) examined two simple and popular trading rules, the moving average and trading range break (support and resistance levels) on the Dow Jones Index from 1897-1986. In the first method, signals are created by two moving averages, a long period, and a short period. In the second method, signals are created as stock prices hit new highs and lows.

Bootstrap techniques were used to test for statistical significance. Their results provided strong support for technical strategies. Buy signals were observed to regularly give higher returns compared to sell signals. Moreover, they were less volatile than sell signals. He concludes that the conclusions made by earlier studies that observed technical analysis to be pointless may have been hasty, since his results show that technical rules have predictive power.

(Levich & Thomas, 1993) presented new evidence on profitability of technical trading rules in the foreign exchange market using currency futures as their data over the period 1976-1990. The currencies were GBP, CAD, DEM, JPY, and CHF. Their results suggested that simple trading rules led to unusually high profits.

However, after dividing the 15-year period into three 5-year periods, the profitability of some trading rules diminished in the 1989-1990 though they generally remained positive and significant. They argue that the profitability of trend following rules may result from excessive speculation which causes price to temporarily follow a trend that is not aligned with fundamental information. They also suggest that speculative markets are not liquid enough for prices to adjust to equilibrium fast. While commercial banks are active in intra-day trading, less capital is needed for longer term positions.

(Neely, Weller, & Dittmar, 1997) tested profitability of technical analysis in the foreign exchange market. They used genetic programming techniques to find trading rules which were tested on six exchange rates: USD/DEM, GBP/USD, USD/CHF, USD/JPY, DEM/YEN and GBP/CHF over the period 1981-1995. The calculated betas for the returns according to various benchmark portfolios provide no confirmation that the returns yielded risk adjusted profits. They measured transaction costs based on an approach by (Levich & Thomas, 1993) who considered 0.05% to be reasonable. Their results showed that excess returns were significantly positive in all cases. However, there was some limitation to their analysis. Various features under the researcher's control such as length of training, size of initial generation and selection periods were not optimized. This opens a gateway for further research.

(Sullivan, Timmerman, & White, 1999) dealt with data snooping problems by replicating previous results on new of data, as suggested by several studies in the economic literature. They provide an extensive profitability test across all technical trading rules. They examine Brock, Lakonishok, & LeBaron (1992) and apply the rules to 100 years of daily data on the Dow Jones. The bootstrap approach was introduced by Efron (1981). However, White (2000), presented a new procedure to correct for data-snooping which was used in this research to evaluate the performance of technical trading rules. They came up with three conclusions. The first one was that the out of sample results may not be illustrative because of the unusual large one-day movement on October 19, 1987. Although they do not outrightly reject the argument, they propose that the precise evaluation of trading rules may have been due to the large out-of-sample period (3291).

Second, the 7,846 trading rules selected may have come from a larger pool of trading rules. If this is true, then the adjusted p-value is biased towards zero under the impression that the used rules are those that performed well in the historical sample period.

The third conclusion is that the best technical rule may have produced superior performance, but the markets have become more efficient hence eroding possible gains from such rules. This conclusion seems to align with the AMH which suggests on using more complex strategies which would persist longer than simple ones.

(Chang & Osler, 1999) look at a common trading signal, the head-and-shoulders pattern. They evaluate this pattern using daily dollar exchange rates: USD/JPY, USD/DEM, USD/CAD, USD/CHF, USD/FRF and GBP/USD, from 1973-1994 using two criteria for rationality; profitability and efficiency. Out of the six currencies tested, only two pairs, USD/JPY and USD/DEM were profitable hence satisfied the first condition of rationality. However, the head-and-shoulders pattern was dominated by simpler trading strategies (oscillators and momentum rules). This makes the pattern inefficient as a trading rule since one can incorporate information only by using the simple trading rules. When the profits were tested to find out whether they were excess returns, no point estimate was statistically significant from zero. In conclusion, the profits seemed unlikely to represent compensation for bearing risk.

(Martin, 2001) examines the performance of moving average trading rules of currencies in developing countries and traverses the connection between profitability and exchange rate technical trading rules in the forex market of developing countries. Taking transaction costs at 0.50%, results show that eight of 12 countries produce statistically significant out-of-sample returns. They also showed that profit opportunities can come from using the moving average trading rules in the spot foreign exchange markets for developing country currencies.

(Olson, 2004) reoptimizes portfolios of moving average rules in successive 5-year periods, from 1971-2000 and examines them in successive out of sample periods. He tested 18 currencies over a longer period than in those in his past studies. Results showed that the returns declined from 1970s to around zero in the 1990s. Olson argues that the returns from 1970s and 1980s might have been a reflection of temporary inefficiency which is being rectified.

He then concludes that one may require more complex trading rules which may represent temporary inefficiencies that will be removed once spotted. Though he did not explicitly cite the AMH, Olson's conclusion presents a different view of price behavior. Previous studies indicated that the excess returns gained in the foreign exchange market rendered it inefficient. However, the inefficiency may have been temporary, hence the conclusion.

(Kozhan & Salmon, 2012) used tick-by-tick data on GBP/USD and examined using algorithms. Results show that a trading rule based on a genetic algorithm earns significant returns after transaction costs, but they disappear by 2008. They suggest that the results come from a massive rise in the volume of algorithmic trading. When time variation in the returns was examined, it was apparent that genuine returns have been existing and perhaps still exist for more complex rules. This finding is in line with the AMH given that the rise in algorithmic trading and decline of profits.

(Okunev & White, 2003) examined the performance of momentum trading strategies in the currency markets. They examined both long and short MA rules across eight currencies and concluded that profitability was in this market as well as the equity markets. The technical trading rules used do not require frequent trading, which makes them suitable for a passive investor. They concluded that a very simple momentum strategy has been profitable for the past twenty years, so it may continue being profitable.

The results therefore indicated that there is potential for investors to gain risk adjusted profits and the performance was not due to risk since the returns did not show the risk characteristics of an asset impacted by time varying risk premia. However, this is not evidence that the foreign exchange markets are efficient. This result is consistent with, Levich & Thomas (1993), Neely, Weller, & Dittmar (1997), and Brock, Lakonishok, & LeBaron (1992). This paper questions the validity of the AMH since it uses a simple technical trading rule whose profits did not erode over time.

(Vajdaa, 2014) questions the performance of 'old' technical indicators in the forex market since they were created for the equity markets. He uses the Moving Average Convergence Divergence (MACD) indicator to try answer this question. He also tests whether the indicators will generate good trading entries in times of crisis. He used major currency pairs as they would help see the strategy performance during the crisis.

Results showed that the number of trading positions was lower, but not by a significant amount. This keeps the old indicators useful in the markets since they still bring out profit opportunities.

(Li & Zhu, 2014) researched on the profitability of volume indicators by using the volume weighted moving average (VWMA) consisting of the simple moving average (MA) and volume based on stocks in China's share market. They tested whether the trading points showed by the technical indicators are effective. Results showed that the VWMA is more reliable than the MA which led to the conclusion that using technical indicators with volume information in an analysis is more effective than only using price index.

They realized the benefits of including volume in technical analysis; issued more trading signals, reduced average drawdown and improved investment returns. However, based on the amount of research papers on the indicator, this branch of technical indicators is not widely used despite its benefits. This may be because it does not use price.

(Tsang, W, & Chong, 2009) assessed the profitability of the On-Balance Volume (OBV) indicator, which is calculated using the closing price and the trading volume of a stock. Although the volume of a stock contains useful information on the market that cannot be fully reflected by price information, modern trading strategies rarely add volume as a key factor in creating trading signals which may bring mixed results of performance.

Results concluded that the OBV cannot beat the buy and hold strategy except in the Frankfurt DAX index but only by a slight margin using the 50-day rule. The OBV trading rule deemed to be comparatively more effective in the Chinese markets than in US and European markets. After considering transaction costs, the OBV trading rule still emerged effective.

An important finding in this paper is that the OBV returns gradually diminished over time in developed markets. This could imply that those markets have become increasingly efficient over time if the profitability of a trading rule is used as a proxy for testing market efficiency.

Over the years, both early and recent studies exhibit evidence of profitability of TTRs. Most of the early studies suggest that investors can get excess returns, making them more likely to exploit the market. However, these studies showed problems such as data snooping bias, risk and transaction cost estimation and ex-post selection of trading rules.

These concerns may have been due to price anomalies in the forex market which could create inaccurate results that reduce the successfulness of the TTRs. Recent studies indicate less volatility and more consistency in the forex market over time due to less discovery of arbitrage opportunities.

Although the papers highlighted above are not exhaustive in the world of technical trading rules, they present a general idea of price performance in the financial markets. In sum, excess returns were available in the past, before the popularity of technical trading rules, which challenged the EMH. When the trading rules gained popularity (moving average rules), profits diminished, but not for complex trading rules which seem to suggest that the forex market follows the adaptive market hypothesis since profits are still available.

METHODOLOGY

Research design

The design used in this research proposal is exploratory since hypothesis tests are being carried out to check for profitability of technical analysis using various trading tools in emerging and developed markets.

Population and sampling

This research will use the spot prices of currency pairs. The pairs selected are based on popularity in the developed and emerging markets, which will in turn provide a good outlook on technical performance and profitability. For developed markets, this study shall examine USD/CNY (the Dollar against the Chinese Yuan), USD/JPY (the Dollar against the Yen), EUR/USD (the Euro against the Dollar) and GBP/USD (the Pound against the Euro). For emerging markets, USD/MXN (the Dollar against the Mexican Peso), USD/TRY (the Dollar against the Turkish Lira) and USD/ZAR (the Dollar against the South African Rand) shall be considered. These currencies will help provide a global capture since every continent is covered.

Data collection

Data sources

The data used in this research will be daily currency pair prices. They will be sourced from Refinitiv.

Data analysis

Historical currency data will be analyzed from October 2005- October 2020 as a whole, and in three 5-year subsamples. Since the performance of technical analysis is being compared between the two markets (developed and emerging), the methods used will be the same across. For momentum indicators, the MACD, RSI and Moving Average Crossover will be used. For volume indicators, the money flow index will be used. These indicators will then be tested individually across both markets.

Trading rules

Trading rules are needed to bring out buy and sell signals.

MACD (Moving Average Convergence Divergence)

This indicator shows the relationship between two moving averages, a short one and a fast one. It is calculated by subtracting the long-term exponential moving average (EMA), say 26 from the short term EMA, say 12. The 9 EMA is known as the signal line which is used when confirming buy and sell signals If the MACD crosses above the signal line, it gives a bullish confirmation while if it crosses below the signal , it gives a bearish confirmation.

The 12 and 26 period MACD is used in this paper. A buy signal is generated when the MACD level crosses 0 upwards and a sell signal is generated when the MACD level crosses 0 downwards.

The Formula for MACD Is:

MACD=12-Period EMA − 26-Period EMA

whereby:

$$EMA_t = \left[V_t \times \left(\frac{s}{1+d}\right)\right] + EMA_y \times \left[1 - \left(\frac{s}{1+d}\right)\right]$$

Where:

EMA_t=EMA today

V_t= Value today

EMA_y= EMA yesterday

s= smoothing factor : [2/(time period + 1)]

d= number of days

RSI (Relative strength Index)

This indicator calculates the size of price changes to show whether the price of an asset is overbought or oversold. Normally, if the RSI is above 70 then it overbought and may signal a reversal. If it is below 30, then it is oversold and may signal a reversal.

In this paper, A buy signal is generated when the indicator crosses the 50-level going upwards and a sell signal is generated when the indicator crosses the 50-level going downwards.

The 2-step formula for RSI is:

$$RSI_{\text{step 1}} = 100 - \left[\frac{100}{1 + \frac{Average\ gain\ of\ 14\ days}{Average\ loss\ of\ 14\ days}}\right]$$

$$RSI_{\text{step 2}} = 100 - \left[\frac{100}{1 + \frac{(Prevous\ average\ gain\ x\ 13) + Current\ gain}{-((Prevous\ average\ loss\ x\ 13) + Current\ loss)}}\right]$$

Moving average crossover

Moving average crossovers are used to identify trend directions. Two different periods of moving averages are chosen, a fast and a slow one. A buy signal is triggered when the fast crosses the slow upwards and a sell signal is triggered when the fast crosses the slow downwards.

The 14-day Exponential moving average (EMA) and the 50-day smooth moving average (SMA) will be used as the MA crossover for this paper. A buying signal is generated when the 14 EMA crosses the 50 SMA upwards and a sell signal is generated when the 14 EMA crosses the 50 SMA downwards.

The formula for SMA is:

$$SMA = \frac{A_1 + A_2 + \cdots + A_n}{n}$$

Where:

A= Average in period n

n= number of periods

The formula for EMA is:

$$EMA_t = \left[V_t \times \left(\frac{s}{1+d}\right)\right] + EMA_y \times \left[1 - \left(\frac{s}{1+d}\right)\right]$$

Where:

EMA_t =EMA today

V_t= Value today

EMA_y = EMA yesterday

s= smoothing factor : [2/(time period + 1)]

d= number of days

Money Flow Index

This indicator is similar to the RSI with the exception that it considers volume. It compares the strength of positive and negative money flow to show the strength of a trend. If the indicator goes above 80, then the asset is overbought while if it goes below 20 then the asset is oversold.

A buy signal is generated when the MFI crosses the level 50 going upwards and a sell signal is generated when the MFI crosses the 50-level going downwards.

The formula for MFI is:

$$MFI = \frac{100 - 100}{1 + MFR}$$

Where:

MFR= $\frac{14\ period\ positive\ money\ flow}{14\ period\ negative\ money\ flow}$

Raw Money Flow = Typical Price * Volume

Typical Price = $\frac{High+Low+Close}{3}$

Profit and Loss Calculations

Profit and loss calculations will be done by computing subsequent returns from the generated buy and sell signals from the trading rules, indicating whether it is a buy or a sell. The opening balance, which will be the same throughout each analysis, will be compared to the closing balance at the end of each analysis period to assess the profitability of each trading indicator across the seven currencies mentioned in this paper. The size of the total profits and losses will also be compared, to assess the magnitude of profitability of the trading rules applied in the currencies.

Moreover, the ending balances of the trading rules will be compared to that of a buy-and-hold rule to check the performance and confirm whether it is better to use the former approach to trading or the latter. For the buy-and-hold rule, a trade will be opened at the beginning of the analysis and closed at the end. Profit factors will be calculated, by dividing the gross profits with the gross losses. The annual Sharpe ratio, which is the risk adjusted return per year, will indicate whether the trade was a good investment. A figure greater than 1 is acceptable, while those greater are considered good investments. The average win-loss ratio calculated by dividing the winning trades over losing trades will indicate the success rate to the investor.

DATA ANALYSIS AND FINDINGS

INTRODUCTION

The data was analyzed according to the following objectives:

1. To compare which technical analysis indicators (momentum vs volume) are more profitable in developed and emerging currency markets.

2. To investigate whether combined trading rules are more stable and profitable than individual trading rules over time.

To gain an understanding of the analysis, an outline of the trades will be provided to describe how they are managed.

Outline of a trade

Technical indicators are used to provide signals to a trader so that they make decisions on whether to buy or sell. The indicators used in this analysis are MACD, RSI, MA Crossover and MFI. Once the signal is presented, a trade is taken if it aligns with the parameters put in place. The trades are on an Order-cancels-Order basis, whereby an incoming sell order will be opened and simultaneously close an ongoing buy order and vice versa.

The profit and loss of each trade was obtained by getting the difference between their closing and opening balance. For uniformity, all trades were taken with 1 lot size with the starting balance of 100,000 USD.

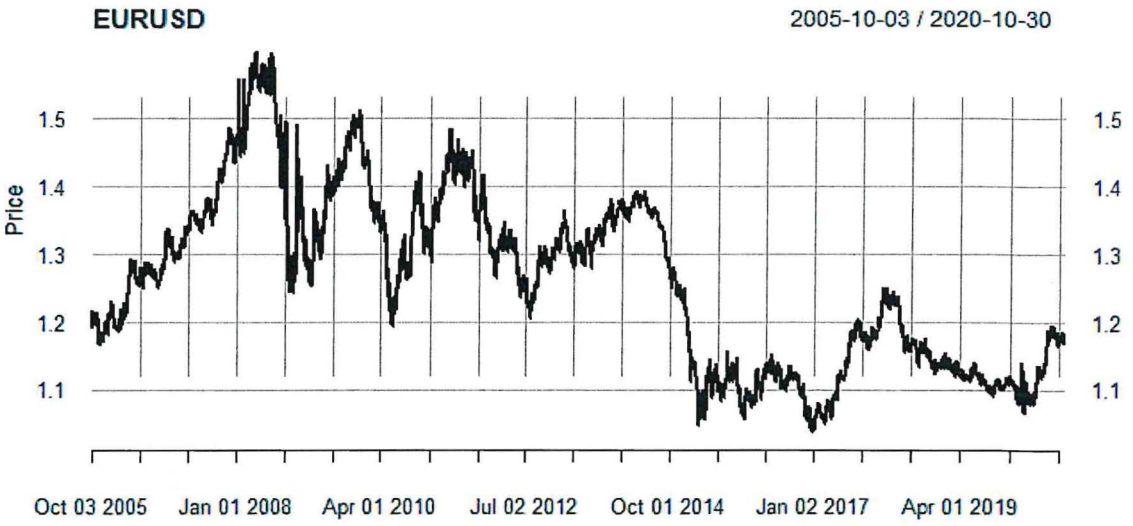
Data analysis

EURUSD

Descriptive analysis

EURUSD	
Min. :2005-10-03	Min. :1.039
1st Qu.:2009-07-09	1st Qu.:1.137
Median :2013-04-17	Median :1.272
Mean :2013-04-17	Mean :1.263
3rd Qu.:2017-01-23	3rd Qu.:1.357
Max. :2020-10-30	Max. :1.599

EUR/USD graph



This graph above indicates the price movement from October 2005 to October 2020. There is a steady rise in price from October 2005 to February 2008, after which made a sharp decline in response to the financial market crisis. The price declines from Oct 2014, indicating the strengthening of the US economy.

We then compare the results of the technical trading rules used in this paper. With the rules and formulas in place, below is the summary of the trading rules used in this currency pair.

EURUSD	MACD	RSI	CROSSOVER	MFI	BUY & HOLD
No. Trades	51	329	263	166	1
Gross Profits	60,334	194,030	759,722	111,085	-
Gross Losses	-66,919	-178,570	-799,225	-117,046	-
Profit Factor	0.901	1.08	0.95	0.95	-
Ann. Sharpe	-0.588	0.36	-1.86	-0.278	-
Avg.WinLoss.ratio	1.29	1.46	1.11	1.27	-
End Equity	7,892	15,460	39,503	5,961	97,658

EURUSD was only profitable when RSI used, as indicated by its profit factor which is greater than 1. This could be due to the number of trades it took, as it is the highest. However, its ending balance using all indicators as well as the buy and hold strategy is less than the initial equity of $100,000. This concludes that the indicators were all not as profitable in this currency pair, given all annual Sharpe ratios are below 1.

GBPUSD

Descriptive analysis

GBPUSD	
Min. :2005-10-03	Min. :1.149
1st Qu.:2009-07-09	1st Qu.:1.336
Median :2013-04-17	Median :1.558
Mean :2013-04-17	Mean :1.558
3rd Qu.:2017-01-23	3rd Qu.:1.654
Max. :2020-10-30	Max. :2.108

GBP/USD graph

This graph above indicates the price movement from October 2005 to October 2020. There is a steady rise in price from October 2005 to February 2008. It then made a sharp decline in response to the financial market crisis. The price bounced around the mean of 1.55 then resumed declining from 2014 after talks of 'Brexit' started.

We then compare the results of the technical trading rules used in this paper. With the rules and formulas in place, below is the summary of the trading rules used in this currency pair.

GBPUSD	MACD	RSI	CROSSOVER	MFI	BUY & HOLD
No. Trades	50	329	253	163	1
Gross Profits	87,561	230,744	1,322,666	148,757	-
Gross Losses	-71,436	-203,369	-917,113	-108,005	-
Profit Factor	1.22	1.13	1.44	1.37	-
Annual Sharpe	-1.1	-0.63	-1.87	-1.58	-
Avg.WinLoss.ratio	1.9	1.21	0.99	1.01	-
End Equity	16,125	27,374	40,919	40,752	54,070

The profit factors of all indicators are greater than 1 but the negative annual Sharpe ratio indicates that they are poor investments, at least not with the mentioned indicators. Their ending balance is less than the initial equity, further indicating that the indicators are not profitable.

USDJPY

Descriptive analysis

			JPY
Min.	:2005-10-03	Min.	: 75.74
1st Qu.	:2009-07-09	1st Qu.	: 93.95
Median	:2013-04-17	Median	:107.15
Mean	:2013-04-17	Mean	:103.56
3rd Qu.	:2017-01-23	3rd Qu.	:113.36
Max.	:2020-10-30	Max.	:125.63

USD/JPY graph

This graph above indicates the price movement from October 2005 to October 2020. Price bounces around 115 from October 2005 to February 2008, after which declines steadily in response to the increased unemployment rate and the financial market crisis. It begins to rise from July 2012 to reflect the strengthening of the dollar.

We then compare the results of the technical trading rules used in this paper. With the rules and formulas in place, below is the summary of the trading rules used in this currency pair.

USDJPY	MACD	RSI	CROSSOVER	MFI	BUY & HOLD
No Trades	47	316	269	164	1
Gross Profits	6,869,400	14,753,094	8,902,569	9,903,502	-
Gross Losses	-6,255,899	-13,387,496	-7,633,816	-9,028,598	-
Profit Factor	1.09	1.1	1.17	1.1	-
Ann. Sharpe	-0.47	1.44	1.6	1.33	-
Avg.WinLoss.ratio	1.76	1.54	1.65	1.86	-
End Equity	61,350	1,365,599	1,268,752	974,902	90,304

RSI gives the highest number of trades out of all indicators. It also gives off the largest ending equity. All profit factors are greater than 1 which indicates a positive ending balance. Given a positive annual Sharpe ratio, RSI, Crossover and MFI are good investments on USDJPY.

USDMXN

Descriptive analysis

			USDMXN
Min.	:2005-10-03	Min.	: 9.867
1st Qu.	:2009-07-09	1st Qu.	:12.235
Median	:2013-04-17	Median	:13.240
Mean	:2013-04-17	Mean	:14.815
3rd Qu.	:2017-01-23	3rd Qu.	:18.564
Max.	:2020-10-30	Max.	:25.336

USD/MXN graph

This graph above indicates the price movement from October 2005 to October 2020. The price bounces around the first quarter, 12.23. It does not indicate a drastic movement in response to the financial crisis unlike the major currency pairs. The price stabilizes around 13.2 then continues on a steady rise from 2012 indicating the strengthening of the dollar.

We then compare the results of the technical trading rules used in this paper. With the rules and formulas in place, below is the summary of the trading rules used in this currency pair.

USDMXN	MACD	RSI	CROSSOVER	MFI	BUY & HOLD
No. Trades	49	336	266	124	1
Gross Profits	1,382,980	3,076,880	16,756,515	1,953,699	-
Gross Losses	-760,150	-2,388,121	-15,184,622	-1,404,405	-
Profit Factor	1.82	1.29	1.1	1.39	-
Ann. Sharpe	2.56	0.865	0.29	1.25	-
Avg.WinLoss.ratio	2.64	1.93	2.12	1.75	-
End Equity	622,830	688,760	1,571,893	574,595	153,628

All indicators have a profit factor greater than 1, indicating profitability. They also have ending balances greater than the beginning equity and positive Sharpe ratios which indicates that they are good investments.

USDZAR

Descriptive analysis

			USDZAR
Min.	:2005-10-03	Min.	: 5.940
1st Qu.	:2009-07-09	1st Qu.	: 7.438
Median	:2013-04-17	Median	: 9.908
Mean	:2013-04-17	Mean	:10.455
3rd Qu.	:2017-01-23	3rd Qu.	:13.487
Max.	:2020-10-30	Max.	:19.249

USD/ZAR graph

This graph above indicates the price movement from October 2005 to October 2020. The general trend of this currency shows an upward trend. The financial crisis did not have as great an impact as it did with the major currencies, indicated by the ranging price around 2007-2008. It then starts to rise from 2012 as the dollar strengthens.

We then compare the results of the technical trading rules used in this paper. With the rules and formulas in place, below is the summary of the trading rules used in this currency pair.

USDZAR	MACD	RSI	CROSSOVER	BUY & HOLD
No. Trades	59	304	262	1
Gross Profits	1,432,058	2,963,147	16,359,941	-
Gross Losses	-1,213,239	-2,454,818	13,903,735	-
Profit Factor	1.18	1.2	1.17	-
Ann. Sharpe	0.86	0.76	0.69	-
Avg.WinLoss.ratio	2.14	1.75	2.10	-
End Equity	218,819	508,329	2,456,206	165,672

Profit factors greater than 1 indicate the profitability of all indicators in USDZAR. Their positive annual Sharpe ratios confirm that they are good investments. The ending balance is also greater than the beginning balance which further indicate that the trading rules are profitable. USDZAR analysis does not include MFI due to unavailability of data.

USDTRY

Descriptive analysis

			USDTRY
Min.	:2005-10-03	Min.	:1.142
1st Qu.	:2009-07-09	1st Qu.	:1.508
Median	:2013-04-17	Median	:1.861
Mean	:2013-04-17	Mean	:2.693
3rd Qu.	:2017-01-23	3rd Qu.	:3.506
Max.	:2020-10-30	Max.	:8.298

USD/TRY graph

This graph above indicates the price movement from October 2005 to October 2020. The price ranges around 1.5 from 2012. This shows that the financial crisis did not impact this currency. A steady rise begins from 2014 as the dollar is strengthening.

We then compare the results of the technical trading rules used in this paper. With the rules and formulas in place, below is the summary of the trading rules used in this currency pair.

USDTRY	MACD	RSI	CROSSOVER	MFI	BUY & HOLD
No. Trades	43	301	262	126	1
Gross Profits	585,998	937,392	4,188,388	678,797	-
Gross Losses	-158,175	-380,033	-2,842,014	-196,541	-
Std.Dev.Trade.PL	38,034	12,645	60,762	16,943	-
Profit Factor	3.70	2.47	1.47	3.45	-
Ann. Sharpe	4.15	2.32	1.34	3.59	-
Avg.WinLoss.ratio	6.25	3.21	2.31	4.05	-
End Equity	537,057	589,800	1,360,299	567,080	196,629

The profit factors and the annual Sharpe ratios are greater than 1, indicating the profitability of the indicators in USDTRY. The ending balance in all indicators are also greater than the beginning balance, which shows that the rules were profitable.

USDCNY

Descriptive analysis

			USDCNY
Min.	:2005-10-03	Min.	:5.863
1st Qu.	:2009-07-09	1st Qu.	:6.346
Median	:2013-04-17	Median	:6.766
Mean	:2013-04-17	Mean	:6.773
3rd Qu.	:2017-01-23	3rd Qu.	:6.936
Max.	:2020-10-30	Max.	:8.085

USD/CNY graph

This graph above indicates the price movement from October 2005 to October 2020. The decline in price of the currency pair from October 2005 to October 2014 is a result of the Yuan being put under a managed floating regime. The currency pair price then rises from 2014 as the dollar strengthens.

We then compare the results of the technical trading rules used in this paper. With the rules and formulas in place, below is the summary of the trading rules used in this currency pair.

USDCNY	MACD	RSI	CROSSOVER	MFI	BUY & HOLD
No. Trades	31	325	275	141	1
Gross Profits	178,400	299,400	1,650,307	205,740	-
Gross Losses	-52,560	-275,450	-1,164,113	-165,760	-
Profit Factor	3.40	0.92	1.42	0.24	-
Ann. Sharpe	5.41	0.23	1.66	0.8	-
Avg.WinLoss.ratio	5.37	1.67	1.16	2.04	-
End Equity	125,840	23,950	486,625	39,980	122,064

The profit factor in MACD and Crossover are greater than 1 which indicates that they are profitable. The annual Sharpe ratio for MACD and Crossover are also greater than one which shows that they are good investments as confirmed in their ending balance being greater than the beginning balance. The buy and hold strategy is profitable due to the upward trend of the price of USDCNY.

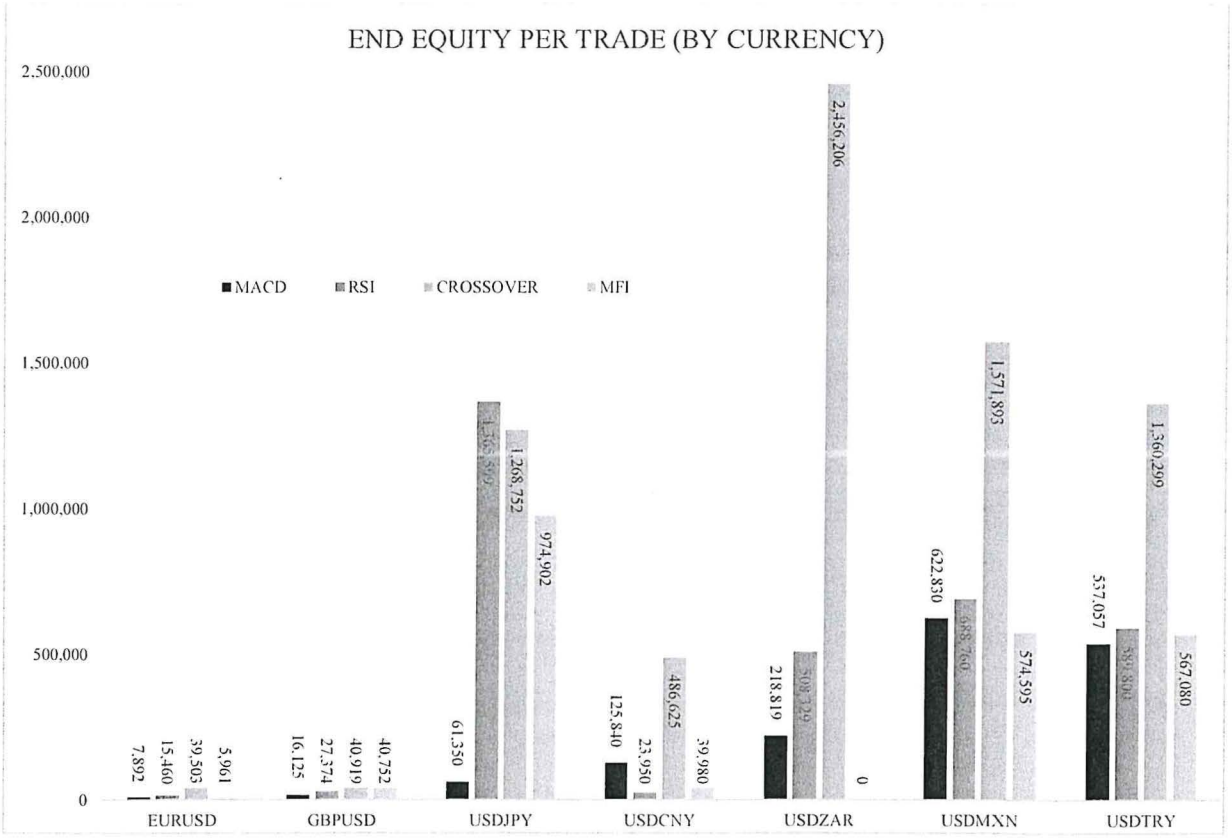
OVERALL PERFORMANCE

CURRENCY	TOTAL PROFITS
EURUSD	0
GBPUSD	0
USDJPY	3,260,907
USDCNY	298,459
USDZAR	2,849,026
USDMXN	3,111,706
USDTRY	2,750,865

INDICATOR	TOTAL PROFITS
MACD	889,913
RSI	2,519,272
CROSSOVER	1,503,270
MFI	180,025

END EQUITY PER TRADE (BY CURRENCY)

INDICATOR	EURUSD	GBPUSD	USDJPY	USDCNY	USDZAR	USDMXN	USDTRY
MACD	7,892	16,125	61,350	125,840	218,819	622,830	537,057
RSI	15,460	27,374	1,365,599	23,950	508,329	688,760	589,800
CROSSOVER	39,503	40,919	1,268,752	486,625	2,456,206	1,571,893	1,360,299
MFI	5,961	40,752	974,902	39,980	-	574,595	567,080

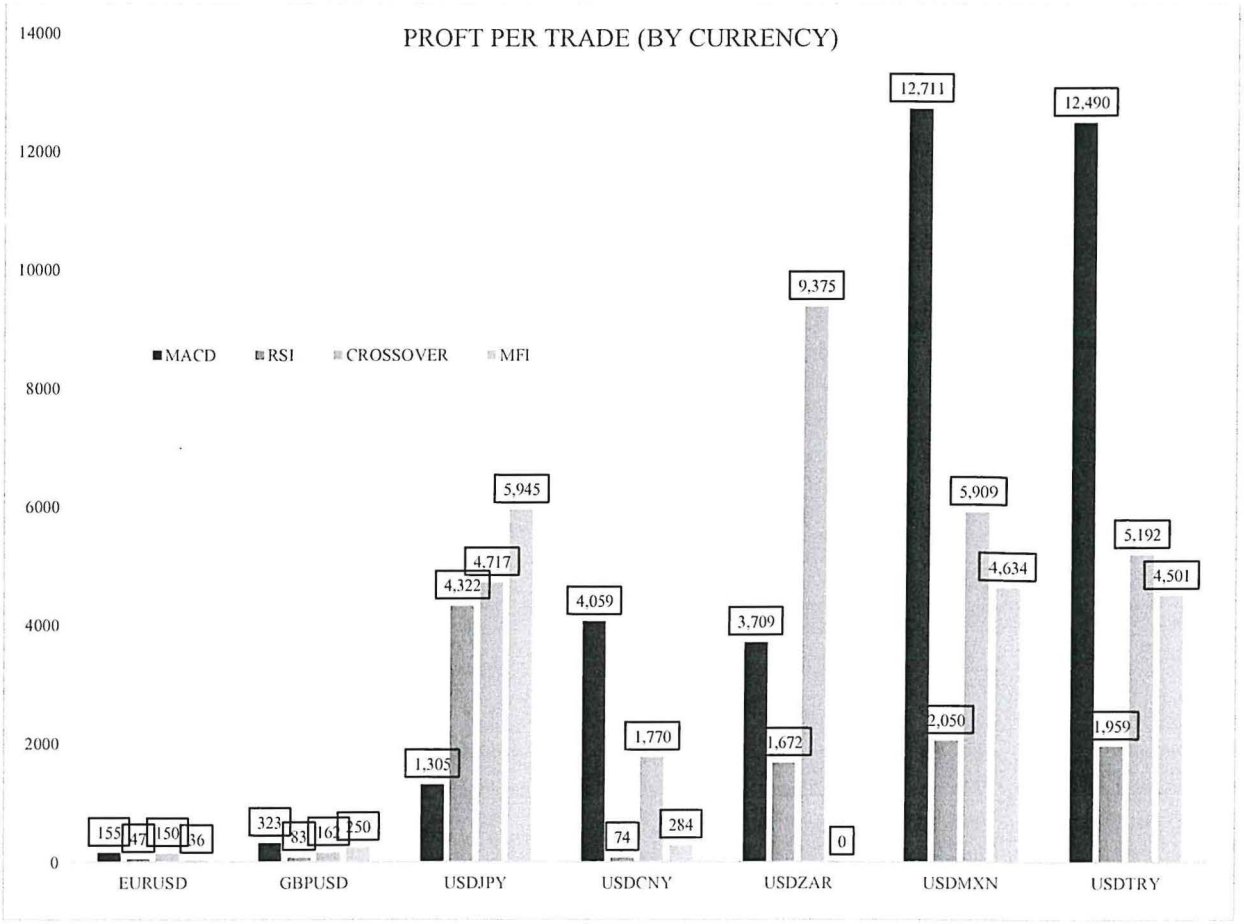


With regards to total profits, RSI is leading. However, after breaking down the end equity by currencies, it only leads in USDJPY and performs poorly in USDCNY. Its performance in the developed markets is weak while that of the emerging markets is relatively better. The crossover indicator is highest in EURUSD,GBPUSD, USDCNY, USDZAR, USDMXN and USDTRY. This indicates that it has performed well both in developed and emerging markets. It shows significantly higher results in emerging than developed markets.

MACD is the poorest performing in GBPUSD,USDJPY, USDZAR and USDTRY. When compared to emerging markets, the MACD results in developed market are weak, which makes the performance in the former market better. MFI is the weakest in EURUSD and USDMXN. When comparing both markets, its performance in emerging markets shows higher results.

PROFIT PER TRADE

INDICATOR	EURUSD	GBPUSD	USDJPY	USDCNY	USDZAR	USDMXN	USDTRY
MACD	155	323	1,305	4,059	3,709	12,711	12,490
RSI	47	83	4,322	74	1,672	2,050	1,959
CROSSOVER	150	162	4,717	1,770	9,375	5,909	5,192
MFI	36	250	5,945	284	-	4,634	4,501



After breaking down the profit per trade by currency, RSI is the poorest performing in GBPUSD, USDZAR, USDMXN, USDTRY and USDCNY. Besides USDJPY, its performance in the developed markets is weak while that of the emerging markets is relatively stronger. The crossover indicator is highest in EURUSD and USDZAR and shows significantly higher results in emerging than developed markets. MACD is the best performing in USDCNY, USDMXN and USDTRY. When compared to emerging markets, the MACD results in developed market are low, which makes the performance in the former market better. MFI is the weakest in EURUSD and after comparing both markets, its performance in emerging markets shows higher results.

COMBINED TRADING RULES

To test whether combined trading rules are more stable and profitable than individual rules, momentum indicators were paired and tested across all currency pairs. The tables below show the results.

MACD-RSI

MACD&RSI	EURUSD	GBPUSD	USDJPY	USDCNY	USZDAR	USDMXN	USDTRY
No. Trades	3	-	-	1	1	-	1
Gross Profits	5,041	-	-	49,550	265,000	-	38,770
Gross Losses	-1,516	-	-	0	0	-	0
Profit Factor	3.32	-	-	-	-	-	-
Ann. Sharpe	-0.22	-	-	-	-	-	-
Avg.WinLoss.ratio	0.33	-	-	-	-	-	-
End Equity	4,111	-	-	149,550	365,000	-	138,770

MACD-CROSS

MACD&CROSS	EURUSD	GBPUSD	USDJPY	USDCNY	USDZAR	USDMXN	USDTRY
No. Trades	-	8	1	1	3	1	4
Gross Profits	-	66,136	16,504,092	606,630	13,955,327	14,117,310	1,395,529
Gross Losses	-	-68,432	0	0	0	0	-76,650
Profit Factor	-	0.966	-	-	-	-	18.20
Ann. Sharpe	-	-0.187	-	-	9.37	-	9.97
Avg.WinLoss.ratio	-	0.966	-	-	-	-	6.06
End Equity	-	2,652	16,504,092	606,630	13,955,327	14,117,310	3,079,853

RSI-CROSS

RSI&CROSS	EURUSD	GBPUSD	USDJPY	USDCNY	USDZAR	USDMXN	USDTRY
No. Trades	41	50	37	35	28	50	42
Gross Profits	313,182	337,999	24,721,904	665,740	4,851,776	6,617,340	1,779,080
Gross Losses	-335,873	-249,930	-21,854,402	613,650	-1,809,570	-2,354,810	-164,259
Profit Factor	0.93	1.35	1.13	1.08	2.6	2.8	10.83
Ann. Sharpe	-0.22	1.10	0.42	-0.62	4.57	3.42	3.68
Avg.WinLoss.ratio	1.19	1.72	1.19	1.03	3.09	2.39	11.914
End Equity	16,910	88,068	27,655,501	52,090	2,551,825	4,262,530	1,614,821

END EQUITY PER TRADE

INDICATOR	EURUSD	GBPUSD	USDJPY	USDCNY	USDZAR	USDMXN	USDTRY
MACD&RSI	4,111	-	-	149,550	365,000	-	138,770
MACD&CROSS	-	2,652	16,504,092	606,630	13,955,327	14,117,310	3,079,853
RSI&CROSS	16,910	88,068	27,655,501	52,090	2,551,825	4,262,530	1,614,821

USDJPY shows the pest performance in both MACD&CROSS and RSI&CROSS while EURUSD shows the weakest performance in MACD&RSI and RSI&CROSS.

PROFIT PER TRADE

INDICATOR	EURUSD	GBPUSD	USDJPY	USDCNY	USDZAR	USDMXN	USDTRY
MACD&RSI	1,370	-	-	149,550	365,000	-	138,770
MACD&CROSS	-	332	16,504,092	606,630	13,955,327	14,117,310	769,963
RSI&CROSS	412	1,716	747,716	1,488	91,137	85,251	38,448

Combined rules have a smaller number of trades than individual rules and are also more profitable. There are missing results in some currencies i.e., GBPUSD and USDJPY in MACD&RSI and EURUSD in MACD&CROSS. This is because the structure of the prices did not allow for a buy or sell signal to be created hence, no trades were taken. This may indicate that combined trading rules are less stable than individual trading rules, as this did not happen when dealing with the indicators individually. The best performing indicator is MACD&CROSS, with profits in the millions followed by RSI&CROSS then MACD&RSI due to its missing results.

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

DISCUSSION

Certain conditions and considerations were used to form decisions on trading i.e., enter and exit rules. It also used the Order-cancels-Order principle, whereby an incoming buy signal would close an existing sell order and open a buy order and vice versa. Another consideration was that there is no adding onto positions once the trade is opened. For example, if a buy signal is generated and the trade is opened, another incoming buy signal will be ignored. Instead, the original trade is left to run. Lastly, there is no stop loss or take profit. This is because of the Order cancels Order trading principle.

In this paper, the investor is assumed to trade with an initial balance of $100,000 with a volume of 1 lot per trade.

CONCLUSION

There is a difference in profits and losses across the currency pairs and indicators. Some seem to have performed better than others in emerging and developed markets. However, since profitable opportunities are still existing, this research aligns with Martin (2001) and White (2003). Due to differences in number of trades taken, profitability will be calculated on the basis of trades taken for each indicator. The best performing currency in terms of profit per trade is USDMXN while the worst is EURUSD and GBPUSD. The best performing indicator is RSI while the worst is MFI. In conclusion, including volumes in an analysis does not ensure more profits than not including it, as shown by the profits between RSI and MFI. These two indicators are compared because MFI is similar to RSI with the exception that it considers volume. Therefore, this research is in contrast with Li & Zhu (2014). Moreover, combined rules performed better than individual rules. After comparing the ending balance of EURUSD, GBPUSD, USDJPY, USDZAR, USDTRY and USDMXN, the emerging markets seem to be more profitable than the developed markets. However, the combined rules were less stable than the individual, as shown by their inability to find trading opportunities in currencies such as GBPUSD and USDJPY in MACD&RSI and EURUSD in MACD&CROSS.

RECOMMENDATIONS

From the analysis above, an on-going trade could be profitable. However, since the trades are carried out on an Order-cancels-Order basis, a trade that is currently profitable may not remain so when closed. Therefore, take-profit orders should be put for a more effective trading strategy. Similarly, incorporating stop loss levels would ensure that the loss is capped, and the trading capital is protected. Using different indicators for different currency pairs may give better results by reducing risk and maximizing profit since the analysis showed that the indicators performed differently when used on different currency pairs. Indicator parameters may also be changed to give better results. For example, instead of using a 14-day RSI, a 21-day RSI could be used to change the indicator performance.

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